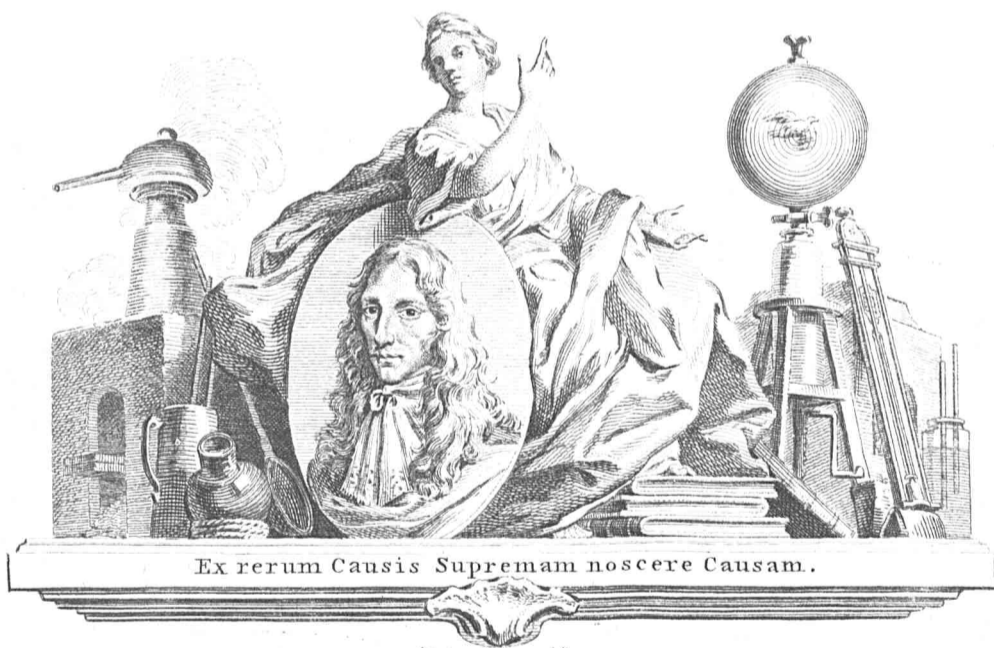


THE
WORKS
OF THE HONOURABLE
ROBERT BOYLE.



VOLUME II.

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J. Goussier inv. et delin.

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T O
THE RIGHT HONOURABLE
J O H N Earl of ORRERY,
T H I S
S E C O N D V O L U M E
O F T H E
W O R K S
O F
The Honourable *R O B E R T B O Y L E*

Is humbly dedicated,

By his LORDSHIP'S

Most devoted and

Most obedient Servant,

Andrew Millar.

EXPERIMENTS AND CONSIDERATIONS TOUCHING COLOURS.

First occasionally written, among some other *Essays*, to
a Friend; and now suffer'd to come abroad as

The BEGINNING of an
EXPERIMENTAL HISTORY of
COLOURS.

The PREFACE.

HAVING, in convenient places of the following treatise, mentioned the motives, that induced me to write it, and the scope I proposed to my self in it, I think it superfluous to entertain the reader now with what he will meet with hereafter. And I should judge it needless, to trouble others, or my self, with any thing of preface; were it not, that I can scarce doubt, but this book will fall into the hands of some readers, who being unacquainted with the difficulty of attempts of this nature, will think it strange that I should publish any thing about colours, without a particular theory of them. But I dare expect, that intelligent and equitable readers will consider on my behalf, that the professed design of this treatise is to deliver things rather historical than dogmatical, and consequently, if I have added divers new speculative considerations and hints which perhaps may afford no despicable assistance towards the framing of a solid and comprehensive hypothesis, I have done at least as much as I promised, or as the nature of my undertaking exacted. But another thing there is, which if it should be objected, I fear I should not be able so easily to answer it; and that is, that in the following treatise (especially in the third part of it) the experiments might have been better marshalled, and some of them delivered in fewer words. For I must confess, that this Essay was written to a private friend, and that too by snatches, at several times, and places, and (after my manner) in loose sheets, of which I oftentimes had

not all by me that I had already written, when I was writing more; so that it needs be no wonder if all the experiments be not ranged to the best advantage, and if some connexions and consecutions of them might easily have been mended: especially since, having carelessly laid by the loose papers, for several years after they were written, when I came to put them together to dispatch them to the press, I found some of those I reckoned upon, to be very unseasonably wanting. And to make any great change in the order of the rest was more than the printer's importunity, and that of my own avocations (and perhaps also considerable sollicitations) would permit. But though some few preambles of the particular experiments might have (perchance) been spared, or shortened, if I had had all my papers under my view at once; yet in the most of those introductory passages, the reader will (I hope) find hints, or advertisements, as well as transitions. If I sometimes seem to insist long upon the circumstances of a trial, I hope I shall be easily excused by those, that both know how nice divers experiments of colours are, and consider, that I was not barely to relate them, but so as to teach a young gentleman to make them. And if I was not sollicitous to make a nicer division of the whole treatise, than into three parts, whereof the one contains some considerations about colours in general; the other exhibits a specimen of an account of particular colours, exemplified in whiteness and blackness; and the third, promiscuous experiments about the remain-

The P R E F A C E.

ing colours (especially red) in order to a theory of them: If, I say, I contented myself with this easy division of my discourse, it was perhaps, because I did not think it so necessary to be curious about the method or contrivance of a treatise, wherein I do not pretend to present my reader with a compleat fabrick, or so much as model; but only to bring in materials proper for the building. And if I did not well know, how ingenious the curiosity and civility of friends makes them, to persuade men by specious allegations, to gratify their desires; I should have been made to believe by persons very well qualified to judge of matters of this nature, that the following experiments will not need the addition of accurate method and speculative notions to procure acceptance for the treatise that contains them. For it hath been represented, that in most of them, as the novelty will make them surprizing, and the quickness of performance, keep them from being tedious; so the sensible changes, that are effected by them, are so manifest, so great, and so sudden, that scarce any will be displeas'd to see them, and those that are any thing curious will scarce be able to see them, without finding themselves excited to make reflections upon them. But though with me, who love to measure physical things by their use, not their strangeness, or prettiness, the partiality of others prevails not to make me over-value these, or look upon them in themselves as other than trifles; yet I confess, that ever since I did divers years ago shew some of them to a learned company of *Virtuosi*, so many persons of differing conditions, and even sexes, have been curious to see them, and pleas'd not to dislike them, that I cannot despair, but that by complying with those that urge the publication of them, I may both gratify and excite the curious, and lay perhaps a foundation, whereon either others or my self may in time superstruct a substantial theory of colours. And if *Aristotle*, after his master *Plato*, have rightly observed admiration to be the parent of philosophy, the wonder, some of these trifles have been wont to produce in all sorts of beholders, and the access they have sometimes gained even to the closets of ladies, seem to promise, that since the subject is so pleasing, that the speculation appears as delightful as difficult, such easy and recreative experiments, which require but little time, or charge, or trouble in the making, and when made are sensible and surprizing enough, may contribute more than others, (far more important, but as much more difficult) to recommend those parts of learning (chymistry and corpuscular philosophy) by which they have been produced, and to which they give testimony even to such kind of persons, as value a pretty trick more than a true notion, and would scarce admit philosophy, if it approached them in another dress. Without the strangeness or endearments of pleasantness to recommend it, I know, that I do but ill consult my own advantage in the consenting to the publication of the following treatise: for those things, which,

whilst men knew not how they were performed, appeared so strange, will, when the way of making them, and the grounds on which I devised them, shall be publick, quickly lose all, that their being rarities, and their being thought mysteries, contributed to recommend them. But it is fitter for mountebanks than naturalists to desire to have their discoveries rather admired than understood; and for my part I had much rather deserve the thanks of the ingenious, than enjoy the applause of the ignorant. And if I can so far contribute to the discovery of the nature of colours, as to help the curious to it, I shall have reach'd my end, and sav'd my self some labour, which else I may chance to be tempted to undergo in prosecuting that subject, and adding to this treatise, which I therefore call a history, because it chiefly contains matters of fact, and which history the title declares me to look upon but as begun. Because though that above a hundred, not to say a hundred and fifty experiments, (some loose, and others interwoven amongst the discourses themselves) may suffice to give a beginning to a history not hitherto, that I know, begun by any; yet the subject is so fruitful, and so worthy, that those, who are curious of these matters, will be far more wanting to themselves than I can suspect, if what I now publish prove any more than a beginning. For, as I hope my endeavours may afford them some assistance towards this work, so those endeavours are too much unfinished to give them any discouragement, as if there were little left for others to do towards the history of colours.

FOR (first) I have been willing to leave unmentioned the most part of those phænomena of colours, that nature presents us of her own accord, (that is, without being guided or over-ruled by man;) such as the different colours, that several sorts of fruits pass through before they are perfectly ripe, and those that appear upon the fading of flowers and leaves, and the putrefaction (and its several degrees) of fruits, &c. together with a thousand other obvious instances of the changes of colours. Nor have I much meddled with those familiar phænomena, wherein man is not an idle spectator; such as the greenness produced by salt in beef much powdered, and the redness produced in the shells of lobsters upon the boiling of those fishes: for I was willing to leave the gathering of observations to those, that have not the opportunity to make experiments. And for the same reasons, among others, I did purposely omit the lucrative practice of tradesmen about colours; as the ways of making pigments, of blanching wax, of dying scarlet, &c. though to divers of them I be not a stranger, and of some I have my self made trial.

NEXT; I did purposely pass by divers experiments of other writers that I had made trial of, (and that not without registering some of their events) unless I could some way or other improve them, because I wanted leisure to insert them, and had thoughts of prosecuting the work once begun of laying together those I had

examined by themselves, in case of my not being prevented by others diligence. So that there remains not a little, among the things that are already published, to employ those, that have a mind to exercise themselves in repeating and examining them. And I will not undertake, that none of the things delivered, even in this treatise, though never so faithfully set down, may not prove to be thus far of this sort, as to afford the curious somewhat to add about them. For I remember, that I have somewhere in the book itself acknowledged, that having written it by snatches, partly in the country and partly at unseasonable times of the year, when the want of fit instruments, and of a competent variety of flowers, salts, pigments, and other materials made me leave some of the following experiments, (especially those about emphatical colours) far more unfinished than they should have been, if it had been as easy for me to supply what was wanting to compleat them, as to discern. Thirdly, to avoid discouraging the young gentleman I call *Pyrophilus*, whom the less familiar and more laborious operations of chymistry would probably have frightened, I purposely declined, in what I writ to him, the setting down any number of such chymical experiments, as, by being very elaborate or tedious, would either require much skill, or exercise his patience. And yet that this sort of experiments is exceedingly numerous, and might more than a little enrich the history of colours, those that are versed in chymical processes will, I presume, easily allow me.

AND (lastly) for as much as I have occasion more than once in my several writings to treat either purposely or incidentally of matters

relating to colours, I did not, perhaps, conceive my self oblig'd, to deliver in one treatise all that I would say concerning that subject.

BUT to conclude, by summing up what I would say concerning what I have, and what I have not done, in the following papers; I shall not (on the one side) deny, that considering, that I pretended not to write an accurate treatise of colours, but an occasional essay to acquaint a private friend with what then occurred to me of the things I had thought or tried concerning them; I might presume I did enough for once, if I did clearly and faithfully set down, though not all the experiments I could, yet at least such a variety of them, that an attentive reader, that shall consider the grounds on which they have been made, and the hints that are purposely (though dispersedly) couched in them, may easily compound them, and otherwise vary them, so as very much to increase their number. And yet (on the other side) I am so sensible both of how much I have, either out of necessity or choice, left undone, and of the fruitfulness of the subject I have begun to handle; that though I had performed far more than it is like many readers will judge I have, I should yet be very free to let them apply to my attempts that of *Seneca*, where having spoken of the study of nature's mysteries, and particularly of the cause of earth-quakes, he subjoins; *Nulla res consummata est dum incipit. Nec in hac tantum re omnium maxima ac invovitissima, in qua etiam cum multum actum erit, omnis aetas, quod agat, inveniet; sed in omni alio negotio, longè semper à perfecto fuisse principia.*

L. Annæi
Senecæ
Natur.
Quæst. I.
6. c. 5.

The Publisher to the Reader.

Friendly Reader,

HERE is presented to thy view one of the abstrusest as well as the genteelest subjects of natural philosophy, the *Experimental History of Colours*; which, though the noble author be pleased to think but begun, yet I must take leave to say, that I think it so well begun, that the work is more than half dispatched. Concerning which I cannot but give this advertisement to the reader, that I have heard the author express himself, that it would not surprize him, if it should happen to be objected, that some of these experiments have been already published, partly by chymists, and partly by two or three very fresh writers upon other subjects. And though the number of these experiments be but very small, and though they be none of the considerablest, yet it may on this occasion be further represented, that it is easy for our author to name several men, (of whose number I can truly name my-

self) who remember either their having seen him make, or their having read his accounts of the experiments delivered in the following tract several years since, and long before the publication of the books, wherein they are mentioned. Nay, in divers passages (where he could do it without any great inconvenience) he hath struck out experiments, which he had tried many years ago, because he since found them divulged by persons, from whom he had not the least hint of them. Which yet is not touched, with design to reflect upon any ingenious man, as if he were a plagiarist: for, though our generous author were not reserved enough in shewing his experiments to those that expressed a curiosity to see them (amongst whom a very learned man hath been pleased publicly to acknowledge it several years ago *;) yet the same thing may be well enough lighted on by persons, that know nothing of one

* He that desires more instances of this kind and matter, that according to this doctrine may much help the theory of colours, and particularly the force both of sulphureous and volatile, as likewise of alcalizate and acid salts, and in what particulars colours likely depend not in their causation from any salt at all; may beg his information from Mr. Boyle, who hath some while since honoured me with the sight of his papers concerning this subject, containing many excellent experiments, made by him for the elucidation of this doctrine, &c. Dr. R. Sharrock, in his ingenious and useful *History of the Propagation and Improvement of Vegetables*, published in the year 1660.

The Publisher to the Reader.

one another. And especially chymical laboratories may many times afford the same phenomenon, about colours, to several persons, at the same or differing times. And as for the few phenomena mentioned in the same chymical writers, as well as in the following treatise, our author hath given an account, why he did not decline rejecting them in the annotations upon the 47th experiment of the third part. Not here to mention, what he elsewhere saith, to shew what use may be justifiably made of experiments not of his own devising by a writer of natural history, if, what he employs of other mens, be well examined or verified by himself.

IN the mean time, this treatise is such, that there needs no other invitation to peruse it, but that 'tis composed by one of the deepest and most indefatigable searchers of nature, which, I think the world, as far as I know it, affords. For mine own part, I feel a secret joy within me, to see such beginnings upon such themes, it being demonstratively true, *mota facilius moveri*; which causeth me to entertain strong hopes, that this illustrious virtuoso and restless inquirer into nature's secrets will not stop here, but go on and prosper in the disquisition of the other principal colours, green, red, and yellow. The reasoning faculty set once afloat will be carried on, and that with ease; especially, when the productions thereof meet, as they do here, with so greedy an entertainment at home and abroad. I am confident, that the ROYAL SOCIETY, lately constituted by his most Excellent Majesty for improving *Natural Knowledge* will judge it their interest to exhort our author to the prosecution of this argument; considering, how much it is their design and business to accumulate a good stock of such accurate observations and experiments, as may afford them and their offspring genuine matter to raise a masculine philosophy upon, whereby the mind of man may be ennobled with the knowledge of

solid truths, and the life of man benefited with ampler accommodations, than it hath been hitherto.

OUR great author, one of the pillars of that illustrious corporation, is constantly furnishing large symbols to this work; and is now fallen, as you see, upon so comprehensive and important a theme, as will, if insisted on and compleated, prove one of the considerablest pieces of that structure. To which if he shall please to add his treatise of heat and flame, as he is ready to publish his experimental accounts of cold; I esteem, the world will be obliged to him for having shewed them both the right and left-hand of nature, and the operations thereof.

THE considering reader will by this very treatise see abundant cause to solicit the author for more. Sure I am, that of whatever of the productions of his ingeny comes into foreign parts (where I am happy in the acquaintance of many intelligent friends) is highly valued; and to my knowledge, there are those among the French, that have lately begun to learn English, on purpose to enable themselves to read his books, being impatient of their translation into Latin. If I durst say all I know of the elogies received by me from abroad concerning him, I should perhaps make this preamble too prolix, and certainly offend the modesty of our author.

WHEREFORE I shall leave this, and conclude with desiring the reader, that if he meet with other faults besides those, that the Errata take notice of (as I believe he may) he will please to consider both the weakness of the author's eyes, for not reviewing, and the manifold avocations of the publisher for not doing his part; who taketh his leave with inviting those, that have also considered this nice subject experimentally, to follow the example of our noble author, and impart such and the like performances to the now very inquisitive world. Farewel.

H. O.



THE
EXPERIMENTAL HISTORY
OF
COLOURS
BEGUN.

THE FIRST PART.

CHAP. I.

1. I HAVE seen you so passionately addicted, *Pyrophilus*, to the delightful art of limning and painting, that I cannot but think myself obliged to acquaint you with some of those things that have occurred to me concerning the changes of colours. And I may expect that I shall as well serve the Virtuosi in general, as gratify you in particular, by furnishing a person, who, I hope, will both improve my communications, and communicate his improvements, with such experiments and observations as may both invite you to inquire seriously into the nature of colours, and assist you in the investigation of it. This being the principal scope of the following tract, I should do that which might prevent my own design, if I should here attempt to deliver you an accurate and particular theory of colours; for that were to present you with what I desire to receive from you; and, as far as in me lay, to make that study needless, to which I would engage you.

2. WHEREFORE my present work shall be but to divert and recreate, as well as excite you by the delivery of matters of fact, such as you may for the most part try with much ease, and possibly not without some delight. And lest you should expect any thing of elaborate or methodical in what you will meet with here, I must confess to you before-hand, that the seasons I was wont to chuse to devise and try experiments about colours, were those days, wherein having taken physic, and finding my self as unfit to speculate, as unwilling to be altogether idle, I chose this diversion as a kind of mean betwixt the one and the other. And I have the less scrupled to set down the following experiments, as some of them came to my mind, and as the notes wherein I had set down the rest, occurred to my hands; that by declining a methodical way of delivering them, I might leave you and my self the greater liberty and convenience to add to them, and transpose them as shall appear expedient.

3. YEA, that you may not think me too reserved, or look upon an inquiry made up of mere narratives, as somewhat jejune, I am content to premise a few considerations, that now offer themselves to my thoughts, which

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relate in a more general way, either to the nature of colours, or to the study of it. And I shall insert an essay, as well speculative as historical, of the nature of whiteness and blackness, that you may have a specimen of the history of colours, I have sometimes had thoughts of; and if you dislike not the method I have made use of, I hope you, and some of the Virtuosi your friends, may be thereby invited to go thorough with red, blue, yellow, and the rest of the particular colours, as I have done with white and black, but with far more sagacity and success. And if I can invite ingenious men to undertake such tasks, I doubt not but the curious will quickly obtain a better account of colours, than as yet we have, since in our method the theoretical part of the inquiry being attended; and as it were interwoven with the historical conjectures, the philosophy of colours will be promoted by the indisputable experiments.

CHAP. II.

1. TO come then in the first place to our more general considerations, I shall begin with saying something as to the importance of examining the colours of bodies. For there are some, especially chymists, who think that a considerable diversity of colours does constantly argue an equal diversity of nature, in the bodies wherein it is conspicuous; but I confess I am not altogether of their mind: for not to mention changeable taffaties, the blue and golden necks of pigeons, and divers water-fowl, rainbows natural and artificial, and other bodies, whose colours the philosophers have been pleased to call not real, but apparent and fantastical; not to insist on these, I say, (for fear of needlessly engaging in a controversy) we see in parrots, goldfinches, and divers other birds, not only that the contiguous feathers which are probably as near in properties as place, are some of them red, and others white, some of them blue, and others yellow, &c. but that in the several parts of the self-same feather there may often be seen the greatest disparity of colours. And so in the leaves of tulips, july-flowers, and some other vegetables, the several leaves, and even the several

C

parts

parts of the same leaf, although no difference have been observed in their other properties, are frequently found painted with very different colours. And such a variety we have much more admired in that lovely plant which is commonly, and not unjustly called the *Marvel of Peru*; for of divers scores of fine flowers, which in its season that gaudy plant does almost daily produce, I have scarce taken notice of any two that were dyed perfectly alike. But though, *Pyro*, such things as these, among others, keep me from daring to affirm that the diversity and change of colours does always argue any great difference or alteration betwixt, or in the bodies, wherein it is to be discerned; yet that oftentimes the alteration of colours does signify considerable alterations in the disposition of parts of bodies, may appear in the extraction of tinctures, and divers other chymical operations, wherein the change of colours is the chief, and sometimes the only thing, by which the artist regulates his proceeding, and is taught to know when 'tis seasonable for him to leave off. Instances of this sort are more obvious in divers sorts of fruits, as cherries, plums, &c. wherein, according as the vegetable sap is sweetned, or otherwise ripened, by passing from one degree to another of maturation, the external part of the fruit passes likewise from one to another colour. But one of the noblest instances I have met with of this kind, is not so obvious; and that is the way of tempering steel to make gravers, drills, springs, and other mechanical instruments, which we have divers times both made artificers practise in our presence, and tried our selves after the following manner. First, the slender steel to be tempered is to be hardened by heating as much of it as is requisite among glowing coals, till it be glowing hot, but it must not be quenched as soon as it is taken from the fire, (for that would make it too brittle, and spoil it) but must be held over a basin of water, till it descend from a white heat to a red one, which as soon as ever you perceive, you must immediately quench as much as you desire to harden in the cold water. The steel thus hardened will, if it be good, look somewhat white, and must be made bright at the end, that its change of colours may be there conspicuous; and then holding it so in the flame of a candle, that the bright end may be, for about half an inch or more, out of the flame, that the smoak do not stain or sully the brightness of it, you shall after a while see that clean end, which is almost contiguous to the flame, pass very nimbly from one colour to another, as from a brighter yellow, to a deeper and reddish yellow, which artificers call a sanguine; and from that to a fainter first, and then a deeper blue. And to bring home this experiment to our present purpose, it is found by daily experience, that each of these succeeding colours argue such a change made in the texture of the steel, that if it be taken from the flame, and immediately quenched in the tallow (whereby it is settled in whatever temper it had before) when it is yellow, it is of such a hardness as makes it fit for gravers,

drills, and such like tools; but if it be kept a few minutes longer in the flame till it grow blue, it becomes much softer, and unfit to make gravers for metals, but fit to make springs for watches, and such like instruments, which are therefore commonly of that colour: and if the steel be kept in the flame, after this deep blue hath disclosed itself, it will grow so soft, as to need to be new hardened again, before it can be brought to a temper fit for drills or penknives. And I confess, *Pyro*, I have taken much pleasure to see the colours run along from the parts of the steel contiguous to the flame, to the end of the instrument; and succeed one another so fast, that if a man be not vigilant, to thrust the steel into the tallow at the very nick of time, at which it has attained its due colour, he shall miss of giving his tool the right temper. But because the flame of a candle is offensive to my weak eyes, and because it is apt to either black or sully the contiguous part of the steel which is held in it, and thereby hinder the change of colours from being so long and clearly discern'd, I have sometimes made this experiment by laying the steel to be tempered upon a heated bar of iron, which we find also to be employed by some artificers in the tempering of such great instruments, as are too big to be soon heated sufficiently by the flame of a candle. And you may easily satisfy your self, *Pyro*, of the differing hardness and toughness, which is ascribed to steel tempered at different colours, if you break but some slender wires of steel so tempered, and observe how they differ in brittleness, and if with a file you also make trial of their various degrees of hardness.

2. BUT, *Pyrophilus*, I must not at present any further prosecute the consideration of the importance of experiments about colours, not only because you will in the following papers find some instances, that would here be presented you out of their due place, of the use that may be made of such experiments, in discovering in divers bodies what kind the salt is, that is predominant in them; but also because a speculative Naturalist might justly enough alledge, that as light is so pleasing an object, as to be well worth our looking on, though it discovered to us nothing but it self; so modified light, called colour, were worth our contemplation, though by understanding its nature we should be taught nothing else. And however, I need not make either you or my self excuses for entertaining you on the subject I am now about to treat of; since the pleasure *Pyro* takes in mixing and laying on of colours, will I presume keep him, and will (I am sure) keep me from thinking it troublesome to set down, especially after the tedious processes (about other matters) where-with I fear I may have tired him, some easy, and not unpleasant experiments relating to that subject.

3. BUT, before we descend to the more particular considerations we are to present you concerning colours, I presume it will be seasonable to propose at the very entrance a distinction;

distinction; the ignorance or neglect of which, seems to me to have frequently enough occasioned either mistakes or confusion in the writings of divers modern philosophers. For colour may be considered, either as it is a quality residing in the body that is said to be coloured, or to modify the light after such or such a manner; or else as the light it self, which so modified, strikes upon the organ of sight, and so causes that sensation which we call colour: and that this latter may be looked upon as the more proper, though not the usual acceptance of the word colour, will be made probable by divers passages in the ensuing part of our discourse. And indeed it is the light it self, which after a certain manner, either mingled with shades, or some other ways troubled, strikes our eyes, that does more immediately produce that motion in the organ, upon whose account men say they see such or such a colour in the object: yet, because there is in the body that is said to be coloured, a certain disposition of the superficial particles, whereby it sends the light reflected, or refracted, to our eyes thus and thus altered, and not otherwise, it may also in some sense be said, that colour depends upon the visible body; and therefore we shall not be against that way of speaking of colours, that is most used among the modern Naturalists, provided we be allowed to have recourse, when occasion shall require, to the premised distinction, and to take the more immediate cause of colour to be the modified light it self, as it affects the sensory; though the disposition also of the coloured body, as that modifies the light, may be called by that name metonymically (to borrow a school-term) or efficiently, that is, in regard of its turning the light, that rebounds from it, or passes thorough it, into this or that particular colour.

4. I KNOW not whether I may not on this occasion add, that colour is so far from being an inherent quality of the object in the sense that is wont to be declared by the schools, or even in the sense of some modern Atomists, that, if we consider the matter more attentively, we shall see cause to suspect, if not to conclude, that though light do more immediately affect the organ of sight, than do the bodies that send it thither, yet light it self produces the sensation of a colour, but as it produces such a determinate kind of local motion in some part of the brain; which, though it happen most commonly from the motion whereinto the slender string of the retina are put, by the appulse of light; yet if the like motion happen to be produced by any other cause, wherein the light concurs not at all, a man shall think he sees the same colour. For proof of this, I might put you in mind, that it is usual for dreaming men to think they see the images that appear to them in their sleep, adorned some with this, and some with that lively colour, whilst yet, both the curtains of their bed, and those of their eyes, are close drawn. And I might add the confidence with which distracted persons do oftentimes, when they are awake, think they see black fiends in

places, where there is no black object in sight without them. But I will rather observe, that not only when a man receives a great stroke upon his eye, or a very great one upon some other part of his head, he is wont to see, as it were, flashes of lightning, and little vivid, but vanishing flames, though perhaps his eyes be shut: but the like apparitions may happen, when the motion proceeds not from something without, but from something within the body, provided the unwonted fumes that wander up and down in the head, or the propagated concussion of any internal part in the body, do cause, about the inward extremities of the optick nerve, such a motion as is wont to be there produced, when the stroke of the light upon the retina makes us conclude, that we see either light or such and such a colour. This the most ingenious *Des Cartes* hath very well observed; but because he seems not to have exemplified it by any unobvious or peculiar observation, I shall endeavour to illustrate this doctrine by a few instances.

5. AND first, I remember, that having, through God's goodness, been free for several years from troublesome coughs, being afterwards, by an accident, suddenly cast into a violent one, I did often when I was awaked in the night by my distempers, observe, that upon coughing strongly, it would seem to me, that I saw very vivid, but immediately disappearing flames; which I took particular notice of, because of the conjecture I am now mentioning.

6. AN excellent and very discreet person, very near allied both to you and me, was relating to me, that some time since, whilst she was talking with some other ladies, upon a sudden, all the objects she looked upon appeared to her dyed with unusual colours, some of one kind, and some of another, but all so bright and vivid, that she should have been as much delighted, as surprized with them; but that finding the apparition to continue, she feared it portended some very great alteration as to her health: and indeed, the day after she was assaulted with such violence by hysterical and hypocondrical distempers, as both made her rave for some days, and gave her, during that time, a bastard palsy.

7. BEING a while since in a town, where the plague had made great havock, and inquiring of an ingenious man, that was so bold, as without much scruple to visit those that were sick of it, about the odd symptoms of a disease that had swept away so many there; he told me, among other things, that he was able to tell divers patients, to whom he was called, before they took their beds, or had any evident symptoms of the plague, that they were indeed infected, upon peculiar observations, that being asked, they would tell him that the neighbouring objects, and particularly his clothes, appeared to them beautified with most glorious colours, like those of the rainbow, oftentimes succeeding one another: and this he affirmed to be one of the most usual, as well as the most early symptoms, by which this odd pestilence disclosed it self. And when

I asked how long the patients were wont to be thus affected, he answered, that it was most commonly for about a day; and when I further inquired whether or no vomits, which in that pestilence were usually given, did not remove this symptom, (for some used the taking of a vomit, when they came ashore, to cure themselves of the obstinate and troublesome giddiness caused by the motion of the ship) he replied, that generally, upon the evacuation made by the vomit, that strange apparition of colours ceased, though the other symptoms were not so soon abated; yet he added (to take notice of that upon the by, because the observation may perchance do good) that an excellent physician, in whose company he was wont to visit the sick, did give to almost all those to whom he was called, in the beginning, before nature was much weakened, a pretty odd vomit, consisting of eight or ten drams of infusion of *Crocus Metallorum*, and about half a dram, or much more, of white vitriol, with such success, that scarce one of ten to whom it was seasonably administered, miscarried.

8. BUT to return to the consideration of colours: As an apparition of them may be produced by motions from within, without the assistance of an outward object; so I have observed, that it is sometimes possible that the colour that would otherwise be produced by an outward object, may be changed by some motion, or new texture already produced in the sensory, as long as that unusual motion, or new disposition lasts; for I have divers times tried, that after I have through a telescope looked upon the sun, though thorough a thick, red, or blue glass, to make its splendor supportable to the eye, the impression upon the retina would be not only so vivid, but so permanent, that if afterwards I turned my eye towards a flame, it would appear to me of a colour very differing from its usual one. And if I did divers times successively shut and open the same eye, I should see the adventitious colour (if I may so call it) changed or impaired by degrees, till at length (for this unusual motion of the eye would not presently cease) the flame would appear to me of the same hue that it did to other beholders. A not unlike effect I found by looking upon the moon, when she was near full, thorough an excellent telescope, without coloured glass to screen my eye with: but that which I desire may be taken notice of, because we may elsewhere have occasion to reflect upon it, and because it seems not agreeable to what Anatomists and optical writers deliver, touching the relation of the two eyes to each other, is this circumstance, that though my right eye, with which I looked thorough the telescope, were thus affected by the over-strong impression of the light, yet when the flame of a candle, or some other bright object appeared to me of a very unusual colour, whilst looked upon with the decomposed eye, or (though not so notably) with both eyes at once; yet if I shut that eye, and looked upon the same object with the other, it would appear with no other than its usual colour, though if I again opened, and

made use of the dazzled eye, the vivid adventitious colour would again appear. And on this occasion I must not pretermitt an observation which may persuade us, that an over-vehement stroke upon the sensory, especially if it be naturally of a weak constitution, may make a more lasting impression than one would imagine; which impression may in some cases, as it were, mingle with, and vitiate the action of vivid objects for a long time after.

FOR I know a lady of unquestionable veracity, who having lately, by a desperate fall, received several hurts, and particularly a considerable one upon a part of her face near her eye, had her sight so troubled and disordered, that, as she hath more than once related to me, not only when the next morning one of her servants came to her bed-side, to ask how she did, his clothes appeared adorned with such variety of dazzling colours, that she was fain presently to command him to withdraw, but the images in her hangings did, for many days after, appear to her, if the room were not extraordinarily darkened, embellished with several offensively vivid colours, which no body else could see in them. And when I inquired whether or no white objects did not appear to her adorned with more luminous colours than others, and whether she saw not some which she could not well describe to any, whose eyes had never been distempered, she answered me, that sometimes she thought she saw colours so new and glorious, that they were of a peculiar kind, and such as she could not describe by their likeness to any she had beheld either before or since; and that white objects did so much disorder her sight, that if, several days after her fall, she looked upon the inside of a book, she fancied she saw there colours like those of the rainbow: and even when she thought her self pretty well recovered, and made bold to leave her chamber, the coming into a place where the walls and ceiling were whited over, made those objects appear to her clothed with such glorious and dazzling colours, as much offended her sight, and made her repent her venturousness. And she added, that this distemper of her eyes lasted not less than five or six weeks, though since that, she hath been able to read and write much without finding the least inconvenience in doing so. I would gladly have known, whether if she had shut the injured eye, the phenomena would have been the same, when she employed only the other; but I heard not of this accident early enough to satisfy that inquiry.

9. WHEREFORE, I shall now add, that some years before, a person exceedingly eminent for his profound skill in almost all kinds of philosophical learning, coming to advise with me about a distemper in his eyes, told me, among other circumstances of it, that having upon a time looked too fixedly upon the sun, thorough a telescope, without any coloured glass, to take off from the dazzling splendor of the object, the excess of light did so strongly affect his eye, that ever since, when he turns it towards a window, or any white object, he fancies he seeth a globe of light, of about the bigness the sun

sun then appeared of to him, to pass before his eyes: and having inquired of him, how long he had been troubled with this indisposition, he replied, that it was already nine or ten years since the accident, that occasioned it, first befel him.

10. I COULD here subjoin, *Pyrophilus*, some memorable relations that I have met with in the account given us by the experienced *Epiphanius Ferdinandus*, of the symptoms he observed to be incident to those that are bitten with the Tarantula; by which (relations) I could probably shew, that without any change in the object, a change in the instruments of vision may for a great while make some colours appear charming, and make others provoking, and both to a high degree, though neither of them produced any such effects before. These things, I say, I could here subjoin in confirmation of what I have been saying, to shew that the disposition of the organ is of great importance in the dijudications we make of colours, were it not that these strange stories belonging more properly to another discourse, I had rather (contenting my self to have given you an intimation of them here) that you should meet with them fully delivered there.

C H A P. III.

1. **B**UT, *Pyrophilus*, I would not, by all that I have hitherto discoursed, be thought to have forgotten the distinction (of colour) that I mentioned to you about the beginning of the third section of the former chapter; and therefore, after all I have said of colour, as it is modified light, and immediately affects the sensory, I shall now remind you, that I did not deny, but that colour might in some sense be considered as a quality residing in the body that is said to be coloured; and indeed the greatest part of the following experiments refer to colour principally under that notion, for there is in the bodies we call coloured, and chiefly in their superficial parts, a certain disposition, whereby they do so trouble the light that comes from them to our eye, as that it there makes that distinct impression, upon whose account we say, that the seen body is either white or black, or red or yellow, or of any one determinate colour. But because we shall (God permitting) by the experiments that are to follow some pages hence, more fully and particularly shew, that the changes, and consequently in divers places the production and the appearance of colours, depends upon the continuing or altered texture of the object; we shall in this place intimate (and that too but as by the way) two or three things about this matter.

2. **A**ND first, it is not without some reason, that I ascribe colour (in the sense formerly explained) chiefly to the superficial parts of bodies; for not to question how much opacous corpuscles may abound even in those bodies we call diaphanous, it seems plain that of opacous bodies we do indeed see little else than the superficies. For if we found the beams of light

that rebound from the object to the eye, to pierce deep into the coloured body, we should not judge it opacous, but either translucent, or at least semi-diaphanous: and though the schools seem to teach us that colour is a penetrative quality, that reaches to the innermost parts of the object, as if a piece of sealing-wax be broken into never so many pieces, the internal fragments will be as red as the external surface did appear; yet that is but a particular example, that will not overthrow the reason lately offered, especially since I can alledge other examples of a contrary import, and two or three negative instances are sufficient to overthrow the generality of a positive rule, especially if that be built but upon one or a few examples. Not (then) to mention cherries, plums, and I know not how many other bodies, wherein the skin is of one colour, and what it hides of another, I shall name a couple of instances drawn from the colours of durable bodies that are thought far more homogeneous, and have not parts that are either organical, or of a nature approaching thereunto.

3. To give you the first instance, I shall need but to remind you of what I told you a little after the beginning of this essay, touching the blue and red and yellow, that may be produced upon a piece of tempered steel: for these colours, though they be very vivid, yet if you break the steel they adorn, they will appear to be but superficial; not only the innermost parts of the metal, but those that are within a hair's breadth of the superficies, having not any of these colours, but retaining that of the steel it self. Besides that, we may as well confirm this observation, as some other particulars we elsewhere deliver concerning colours, by the following experiment which we purposely made.

4. **W**E took a good quantity of clean lead, and melted it with a strong fire, and then immediately pouring it out into a clean vessel of a convenient shape and matter, (we used one of iron, that the great and sudden heat might not injure it) and then carefully and nimbly taking off the scum that floated on the top, we perceived, as we expected, the smooth and glossy surface of the melted matter to be adorned with a very glorious colour, which being as transitory as delightful, did almost immediately give place to another vivid colour, and that was as quickly succeeded by a third, and this as it were chased away by a fourth; and so these wonderfully vivid colours successively appeared and vanished, (yet the same now and then appearing the second time) till the metal ceasing to be hot enough to afford any longer this pleasing spectacle, the colours that chanced to adorn the surface, when the lead thus began to cool, remained upon it; but were so superficial, that how little soever we scraped off the surface of the lead, we did in such places scrape off all the colour, and discover only that which is natural to the metal it self; which receiving its adventitious colours, only when the heat was very intense, and in that part which was exposed to the com-

paratively very cold air, (which by other experiments seems to abound with subtile saline parts, perhaps not uncapable of working upon lead so disposed :) these things, I say, together with my observing that whatever parts of the so strongly melted lead were exposed a while to the air, turned into a kind of scum or litharge, how bright and clean soever they appeared before, suggested to me some thoughts or ravings, which I have not now time to acquaint you with. One that did not know me, *Pyrophilus*, would perchance think I endeavoured to impose upon you by relating this experiment, which I have several times tried; but the reason why the phenomena mentioned have not been taken notice of, may be, that unless lead be brought to a much higher degree of fusion or fluidity than is usual, or than is indeed requisite to make it melt, the phenomena I mentioned will scarce at all disclose themselves; and we have also observed, that this successive appearing and vanishing of vivid colours was wont to be impaired or determined whilst the metal exposed to the air remained yet hotter than one would readily suspect. And one thing I must further note, of which I leave you to search after the reason, namely, that the same colours did not always and regularly succeed one another, as is usual in steel, but in the diversified order mentioned in this following note, which I was scarce able to write down, the succession of the colours was so very quick: whether that proceeded from the differing degrees of heat in the lead exposed to the cool air, or from some other reason, I leave you to examine.

[Blue, yellow, purple, blue; green, purple, blue, yellow, red; purple, blue, yellow and blue, yellow, blue, purple, green mixt, yellow, red, blue, green, yellow, red, purple, green.]

5. THE Atomists of old, and some learned men of late, have attempted to explicate the variety of colours in opacous bodies from the various figures of their superficial parts; the attempt is ingenious, and the doctrine seems partly true: but I confess I think there are divers other things that must be taken in as concurrent to produce those differing forms of asperity, whereon the colours of opacous bodies seem to depend. To declare this a little, we must assume, that the surfaces of all such bodies, how smooth or polite soever they may appear to our dull sight and touch, are exactly smooth only in a popular, or at most in a physical sense, but not in a strict and rigid sense.

6. THIS, excellent microscopes shew us in many bodies, that seem smooth to our naked eyes; and this not only as to the little hillocks or protuberances that swell above that which may be conceived to be the plane or level of the considered surface; for it is obvious enough to those that are any thing conversant with such glasses: but as to numerous depressions beneath that level, of which sort of cavities, by the help of a microscope, which the greatest artificer that makes them, judges to be the greatest magnifying glass in Europe, except one that equals it, we have on the surface

of a thin piece of cork that appeared smooth to the eye; observed about sixty in a row, within the length of less than a 31 and 32^d part of an inch, (for the glass takes in no longer a space at one view;) and these cavities (which made that little piece of cork almost like an empty honey-comb) were not only very distinct, and figured like one another, but of a considerable bigness, and a scarce credible depth; insomuch that their distinct shadows as well as sides were plainly discerned and easy to be reckoned, and might have been well distinguished, though they had been ten times lesser than they were. Which I thought it not amiss to mention to you, *Pyrophilus*, upon the by, that you may thence make some estimate, what a strange inequality, and what a multitude of little shades there may really be, in a scarce sensible part of the physical superficies, though the naked eye sees no such matter. And as excellent microscopes shew us this ruggedness in many bodies that pass for smooth, so there are divers experiments, though we must not now stay to urge them, which seem to persuade us of the same thing, as to the rest of such bodies as we are now treating of; so, that there is no sensible part of an opacous body, that may not be conceived to be made up of a multitude of singly insensible corpuscles. But in the giving these surfaces that disposition, which makes them alter the light that reflects thence to the eye after the manner requisite to make the object appear green, blue, &c. the figures of these particles have a great, but not the only stroke. It is true indeed, that the protuberant particles may be of very great variety of figures, spherical, elliptical, conical, cylindrical, polyedrical, and some very irregular; and that according to the nature of these, and the situation of the lucid body, the light must be variously affected, after one manner from surfaces (I now speak of physical surfaces) consisting of spherical, and in another from those that are made up of conical or cylindrical corpuscles; some being fitted to reflect more of the incident beams of light, others less, and some towards one part, others towards another. But besides this difference of shape, there may be divers other things that may eminently concur to vary the forms of asperity that colours so much depend on. For, willingly allowing the figure of the particles in the first place, I consider secondly, that the superficial corpuscles, if I may so call them, may be bigger in one body, and less in another, and consequently fitted to allay the light falling on them with greater shades. Next, the protuberant particles may be set more or less close together, that is, there may be a greater or a smaller number of them within the compass of one, than within the compass of another small part of the surface of the same extent; and how much these qualities may serve to produce colour, may be somewhat guessed at, by that which happens in the agitation of water: for if the bubbles that are thereby made be great, and but few, the water will scarce acquire a sensible colour; but if it be reduced to a froth, consisting of bubbles, which being

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being very minute and contiguous to each other, are a multitude of them crowded into a narrow room, the water (turned to froth) does then exhibit a very manifest white colour, to which these last named conditions of the bubbles do, as well as their convex figure, contribute; and that for reasons to be mentioned anon. Besides, it is not necessary that the superficial particles that exhibit one colour should be all of them round, or all conical, or all of any one shape; but corpuscles of differing figures may be mingled on the surface of the opacous body, as when the corpuscles that make a blue colour, and those that make a yellow, come to be accurately and skilfully mix'd, they make up a green; which, though it seem one simple colour, yet, in this case, appears to be made by corpuscles of very differing kinds, duly commix'd. Moreover, the figure and bigness of the little depressions, cavities, furrows, or pores intercepted betwixt these protuberant corpuscles, are as well to be considered as the sizes and shapes of the corpuscles themselves: for we may conceive the physical superficies of a body, where (as we said) its colour does, as it were, reside, to be cut transversely by a mathematical plane, which you know is conceiv'd to be without any depth or thickness at all; and then, as some parts of the physical superficies will be protuberant, or swell above this last plane, so others may be depressed beneath it, as (to explain my self by a gross comparison) in divers places of the surface of the earth, there are not only neighbouring hills, trees, &c. that are rais'd above the horizontal level of the valley, but rivers, wells, pits and other cavities that are depressed beneath it. And that such protuberant and concave parts of a surface may remit the light so differing, as much to vary a colour, some examples, and other things that we shall hereafter have occasion to take notice of in this tract, will sufficiently declare; till when, it may suffice to put you in mind, that of two flat sides of the same piece of, for example, red marble, the one being diligently polished, and the other left to its former roughness, the differing degrees or sorts of asperity, for the side that is smooth to the touch wants not its roughness, will so diversify the light reflected from the several planes to the eye, that a painter would employ two differing colours to represent them.

7. AND I hope, *Pyrophilus*, you will not think it strange or impertinent, that I employ, in divers passages of these papers, examples drawn from bodies and shadows far more gross than those minute protuberances and shady pores on which, in most cases, the colour of a body, as it is an inherent quality or disposition of its surface, seems to depend. For sometimes I employ such examples, rather to declare my meaning, than prove my conjecture; things, whom their smallness makes insensible, being better represented to the imagination by such familiar objects, as being like them enough in other respects, are of a visible bulk. And next, though the beams of light are such subtle bodies, that in respect of them, even surfaces

that are sensibly smooth, are not exactly so, have their own degree of roughness, consisting of little protuberances and depressions; and though consequently such inequalities may suffice to give bodies differing colours, as we see in marble that appears white or black, or red or blue, even when the most carefully polished; yet it is plain, by the late instance of red marble, and many others, that even bigger protuberances and greater shades may likewise so diversify the roughness of a body's superficies, as manifestly to concur to the varying of its colour, whereby such examples appear to be proper enough to be employed in such a subject as we have now in hand. And having hinted thus much on this occasion, I now proceed.

8. THE situation also of the superficial particles is considerable, which I distinguish into the posture of the single corpuscles, in respect of the light, and of the eye, and the order of them in reference also to one another; for a body may otherwise reflect the light, when its superficial particles are more erected upon the plane, that may be conceived to pass along their basis, and when the points or extremes of such particles are obverted to the eye, than when those particles are so inclined, that their sides are in great part discernable; as the colour of plush or velvet will appear varied to you, if you carefully stroak part of it one way, and part of it another; the posture of the particular thrids, in reference to the light, or the eye, becoming thereby different. And you may observe in a field of ripe corn blown upon by the wind, that there will appear as it were waves of a colour (at least gradually) differing from that of the rest of the field; the wind, by depressing some of the ears, and not at the same time others, making the one reflect more from the lateral and strawy parts than do the rest. And so, when dogs are so angry as to erect the hairs upon their necks, and upon some other parts of their bodies, those parts seem to acquire a colour varied from that which the same hairs made, when in their usual posture they did far more stoop. And that the order wherein the superficial corpuscles are rang'd, is not to be neglected; we may guess by turning of water into froth, the beating of glass, and the scraping of horns, in which cases the corpuscles that were before so marshalled as to be perspicuous, do by the troubling of that order become disposed to terminate and reflect more light, and thereby to appear whitish. And there are other ways in which the order of the protuberant parts, in reference to the eye, may much contribute to the appearing of a particular colour; for I have often observed, that when peas are planted, or set in parallel lines, and are shot up about half a foot above the surface of the ground, by looking on the field or plot of ground from that part towards which the parallel lines tended, the greater part of the ground by far, would appear of its own dirty colour; but if I looked upon it transversely, the plot would appear very green, the upper parts of the peas hindering the intercepted parts of the ground, which, as I said, retained their wonted.

wanted colour from being discovered by the Eye. And I know not, *Pyrophilus*, whether I might not add, that even the motion of the small parts of a visible object may in some cases contribute, though it be not so easy to say how, to the producing, or the varying of a colour: for I have several times made a liquor which, when it has well settled in a close phial, is transparent and colourless; but as soon as the glass is unstopped, begins to fly away very plentifully in a white and opacous fume. And there are other bodies, whose fumes, when they fill a receiver, would make one suspect it contains milk; and yet when these fumes settle into a liquor, that liquor is not white, but transparent; and such white fumes I have seen afforded by unstopping a liquor I know, which yet is it self diaphanous and red: nor are these the only instances of this kind, that our trials can supply us with. And if the superficial corpuscles be of the grosser sort, and be so framed, that their differing sides or faces may exhibit differing colours, then the motion or rest of those corpuscles may be considerable, as to the colour of the superficies they compose, upon this account, that sometimes more, sometimes fewer of the sides disposed to exhibit such a colour may by this means become or continue more obverted to the eye than the rest, and compose a physical surface, that will be more or less sensibly interrupted. As, to explain my meaning, by proposing a gross example, I remember, that in some sorts of leafy plants thick set by one another, the two sides of whose leaves were of somewhat differing colours, there would be a notable disparity as to colour; if you looked upon them both, when the leaves, being at rest, had their upper and commonly exposed sides obverted to the eye, and when a breath of wind passing thorough them, made great numbers of the usually hidden sides of the leaves become conspicuous. And though the little bodies we were lately speaking of, may singly and apart seem almost colourless; yet when many of them are placed by one another, so near that the eye does not easily discern an interruption, within a sensible space, they may exhibit a colour: as we see, that though the slenderest thrid of dyed silk does whilst look'd on single, seem almost quite devoid of redness, (for instance) yet when numbers of these thrids are brought together into one skein, their colour becomes notorious.

9. But the same occasion that invited me to say what I have mentioned concerning the leaves of trees, invites me also to give you some account of what happens in changeable taffaties, where we see differing colours, as it were, emerge and vanish upon the ruffling of the same piece of silk; as I have divers times with pleasure observed, by the help of such a microscope, as though it do not very much magnify the object, has in recompence this great conveniency, that you may easily, as fast as you please, remove it from one part to another of a large object, of which the glass taking a great part at once, you may thereby presently survey the whole. Now by the help of such a microscope I could easily (as I began to say)

discern, that in a piece of changeable taffaty (that appeared, for instance, sometimes red, and sometimes green) the stuff was composed of red thrids and green, passing under and over each other, and crossing one another in almost innumerable points: and if I looked through the glass upon any considerable portion of the stuff, that (for example sake) to the naked eye appeared to be red, I could plainly see, that in that position, the red thrids were conspicuous, and reflected a vivid light. And though I could also perceive, that there were green ones, yet by reason of their disadvantageous position in the physical surface of the taffaty, they were in part hid by the more protuberant thrids of the other colour: and for the same cause, the reflection from as much of the green as was discovered, was comparatively but dim and faint. And if, on the contrary, I looked through the microscope upon any part that appeared green, I could plainly see that the red thrids were less fully exposed to the eye, and obscured by the green ones, which therefore made up the predominant colour. And by observing the texture of the silken stuff, I could easily so expose the thrids either of the one colour or of the other, to my eye, as at pleasure to exhibit an apparition of red or green, or make those colours succeed one another: so that, when I observed their succession by the help of the glass, I could mark how the predominant colour did as it were start out, when the thrids that exhibited it came to be advantageously placed; and by making little folds in the stuff after a certain manner, the sides that met and terminated in those folds, would appear to the naked eye, one of them red, and the other green. When thrids of more than two differing colours chance to be interwoven, the resulting changeableness of the taffaty may be also somewhat different. But I chuse to give an instance in the stuff I have been speaking of, because the mixture being more simple, the way whereby the changeableness is produced, may be the more easily apprehended: and though reason alone might readily enough lead a considering man to guess at the explication, in case he knew how changeable taffaties are made; yet I thought it not impertinent to mention it, because both scholars and gentlemen are wont to look upon the inquiry into manufactures, as a mechanick employment, and consequently below them; and because also with such a microscope as I have been mentioning, the discovery is as well pleasant as satisfactory, and may afford hints of the solution of other phaenomena of colours. And it were not amiss, that some diligent inquiry were made, whether the microscope would give us an account of the variableness of colour, that is so conspicuous and so delightful in mother of pearl, in opals, and some other resembling bodies. For though I remember I did formerly attempt something of that kind (fruitlessly enough) upon mother of pearl, yet not having then the advantage of my best microscope, nor some conveniencies that might have been wished, I leave it to you, who have better eyes,

to try what you can do further; since it will be some discovery to find, that in this case the best eyes and microscopes themselves can make none.

10. I CONFESS, *Pyrophilus*, that a great part of what I have delivered, (or proposed rather) concerning the differing forms of asperity in bodies, by which differences, the incident light either comes to be reflected with more or less of shade, and with that shade more or less interrupted, or else happens to be also otherwise modified or troubled, is but conjectural. But I am not sure, that if it were not for the dulness of our senses, either these or some other notions of kin to them, might be better countenanced; for I am apt to suspect, that if we were sharp-sighted enough, or had such perfect microscopes, as I fear are more to be wished than hoped for, our promoted sense might discern in the physical surfaces of bodies, both a great many latent ruggednesses, and the particular sizes, shapes, and situations of the extremely little bodies that cause them, and perhaps might perceive among other varieties that we now can but imagine, how those little protuberances and cavities do interrupt and dilate the light, by mingling with it a multitude of little and singly undiscernable shades, though some of them more, and some of them less minute, some less, and some more numerous, according to the nature and degree of the particular colour we attribute to the visible object. As we see, that in the moon we can with excellent telescopes discern many hills and valleys, and as it were pits and other parts, whereof some are more, and some less vividly illustrated, and others have a fainter, others a deeper shade, though the naked eye can discern no such matter in that planet. And with an excellent microscope, where the naked eye did see but a green powder, the assisted eye, as we noted above, could discern particular granules, some of them of a blue, and some of them of a yellow colour, which corpuscles we had beforehand caused to be exquisitely mixed to compound the green.

11. AND, *Pyrophilus*, that you may not think me altogether extravagant in what I have said of the possibility (for I speak of no more) of discerning the differing forms of asperity in the surfaces of bodies of several colours, I'll here set down a memorable particular that chanced to come to my knowledge, since I writ a good part of this essay; and it is this. Meeting casually the other day with the deservedly famous * Dr. J. Finch, extraordinary anatomist to that great patron of the Virtuosi, the now Great Duke of *Tuscany*, and inquiring of this ingenious person, what might be the chief rarity he had seen in his late return out of *Italy* into *England*, he told me, it was a man at *Maeftricht* in the *Low-Countries*, who at certain times can discern and distinguish colours by the touch with his fingers. You will easily conclude, that this is far more strange than what I proposed but as not impossible; since the sense of the retina seeming to be much more tender and quick than that of those grosser filaments, nerves or membranes of our fingers,

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wherewith we use to handle gross and hard bodies, it seems scarce credible, that any accustomedness, or diet, or peculiarity of constitution, should enable a man to distinguish, with such gross and unfuitable organs, such nice and subtle differences of those of the forms of asperity, that belong to differing colours, to receive whose languid and delicate impressions by the intervention of light; nature seems to have appointed and contexted into the retina the tender and delicate pith of the optick nerve. Wherefore I confess, I proposed divers scruples; and particularly whether the doctor had taken care to bind a napkin or handkerchief over his eyes so carefully, as to be sure he could make no use of his sight, though he had but counterfeited the want of it; to which I added divers other questions, to satisfy my self; whether there were any likelihood of collusion or other tricks. But I found that the judicious doctor having gone far out of his way, purposely to satisfy himself and his learned prince about this wonder, had been very watchful and circumspect to keep himself from being imposed upon. And that he might not through any mistake in point of memory misinform me, he did me the favour, at my request, to look out the notes he had written for his own and his prince's information, the sum of which memorials, as far as we shall mention them here, was this, that the doctor having been informed at *Utrecht*, that there lived one at some miles distance from *Maeftricht*, who could distinguish colours by the touch; when he came to the last named town, he sent a messenger for him, and having examined him, was told upon inquiry these particulars.

THAT the man's name was *John Vermaafen*, at that time about 33 years of age; that when he was but two years old, he had the smallpox, which rendered him absolutely blind; that at this present he is an organist, and serves that office in a publick choir.

THAT the doctor discoursing with him over night, the blind man affirmed, that he could distinguish colours by the touch, but that he could not do it, unless he were fasting; any quantity of drink taking from him that exquisiteness of touch, which is requisite to so nice a sensation.

THAT hereupon the doctor provided against the next morning seven pieces of ribbon, of these seven colours, black, white, red, blue, green, yellow, and grey; but as for mingled colours, this *Vermaafen* would not undertake to discern them, though if offered, he would tell that they were mixed.

THAT to discern the colour of the ribbon; he places it betwixt the thumb and the forefinger, but his most exquisite perception was in his thumb, and much better in the right thumb than in the left.

THAT after the blind man had four or five times told the doctor the several colours; (though blinded with a napkin for fear he might have some sight) the doctor found he was twice mistaken, for he called the white black, and the red blue; but still, he, before his error, would

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would

* Since, for his eminent qualities and loyalty, graced by his Majesty with the honour of knighthood.

would say them by in pairs, saying, that though he could easily distinguish them from all others, yet those two pairs were not easily distinguished amongst themselves. Whereupon the doctor desired to be told by him what kind of discrimination he had of colours by his touch, to which he gave a reply, for whose sake chiefly I insert all this narrative in this place; namely, that all the difference was more or less asperity, for says he, (I give you the doctor's own words) black feels as if you were feeling needles points, or some harsh sand, and red feels very smooth.

THAT the doctor having desired him to tell in order the difference of colours to his touch, he did as follows.

BLACK and white are the most asperous or unequal of all colours, and so like, that 'tis very hard to distinguish them; but black is the most rough of the two: green is next in asperity, grey next to green in asperity, yellow is the fifth in degree of asperity; red and blue are so like, that they are as hard to distinguish as black and white; but red is somewhat more asperous than blue, so that red has the sixth place, and blue the seventh in asperity.

12. To these informations the obliging doctor was pleas'd to add the welcome present of three of those very pieces of ribbon, whose colours in his presence the blind man had distinguished, pronouncing the one grey, the other red, and the third green; which I keep by me as rarities, and the rather, because he fear'd the rest were miscarried.

13. BEFORE I saw the notes that afforded me the precedent narrative, I confess I suspected this man might have thus discriminated colours rather by the smell than by the touch; for some of the ingredients employ'd by dyers to colour things, have scents, that are not so languid, nor so near of kin: but that I thought it not impossible that a very critical nose might distinguish them, and this I the rather suspected, because he required, that the ribbons, whose colours he was to name, should be offer'd him fasting in the morning; for I have observ'd in setting dogs, that the feeding of them (especially with some sorts of aliments) does very much impair the exquisite scent of their noses. And though some of the foregoing particulars would have prevented that conjecture, yet I confess to you (*Pyrophilus*) that I would gladly have had the opportunity of examining this man myself, and of questioning him about divers particulars which I do not find to have been yet thought upon. And though it be not incredible to me, that since the liquors that dyers employ to tinge, are qualified to do so by multitudes of little corpuscles of the pigment or dying stuff, which are dissolved and extract'd by the liquor, and swim to and fro in it, those corpuscles of colour (as the Atomists call them) insinuating themselves into, and filling all the pores of the body to be dyed, may asperate its superficies more or less according to the bigness and texture of the corpuscles of the pigment; yet I can scarce believe, that our blind man could distinguish all the colours he did, merely by

the ribbons having more or less of asperity; so that I cannot but think, notwithstanding this history, that the blind man distinguished colours not only by the degrees of asperity in the bodies offer'd to him, but by forms of it, though this (latter) would perhaps have been very difficult for him to make an intelligible mention of, because those minute disparities having not been taken notice of by men for want of touch as exquisite as our blind man's, are things he could not have intelligibly express'd; which will easily seem probable, if you consider, that under the name of sharp, and sweet, and sour, there are abundance of, as it were, immediate peculiar relishes or tastes in differing sorts of wine, which, though critical and experienced palates can easily discern themselves, cannot make them be understood by others; such minute differences not having hitherto any distinct names assign'd them. And it seems that there was something in the forms of asperity that was requisite to the distinction of colours, besides the degree of it, since he found it so difficult to distinguish black and white from one another, though not from other colours. For I might urge, that he seems not consonant to himself about the red, which, as you have seen in one place, he represents as somewhat more asperous than the blue; and in another, very smooth: but because he speaks of this smoothness in that place, where he mentions the roughness of black, we may favourably presume that he might mean but a comparative smoothness; and therefore I shall not insist on this, but rather countenance my conjecture by this, that he found it so difficult, not only to discriminate red and blue, (though the first of our promiscuous experiments will inform you, that the red reflects by great odds more light than the other) but also to distinguish black and white from one another, though not from other colours. And indeed, though in the ribbons that were offer'd him, they might be almost equally rough, yet in such slender corpuscles, as those of colour, there may easily enough be conceived, not only a greater closeness of parts, or else paucity of protuberant corpuscles, and the little extant particles may be otherwise figur'd, and ranged in the white than in the black, but the cavities may be much deeper in the one than the other.

14. AND perhaps, (*Pyrophilus*) it may prove some illustration of what I mean, and help you to conceive how this may be, if I represent, that where the particles are so exceeding slender, we may allow the parts expos'd to the sight and touch to be a little convex in comparison of the erected particles of black bodies, as if there were wires I know not how many times slenderer than a hair: whether you suppose them to be figur'd like needles, or cylindrically, like the hairs of a brush, with hemispherical (or at least convex) tops, they will be so very slender, and consequently the points both of the one sort and the other so very sharp, that even an exquisite touch will be able to distinguish no greater difference between them, than that which our blind

blind man allowed, when comparing black and white bodies, he said, that the latter was the less rough of the two. Nor is every kind of roughness, though sensible enough, inconsistent with whiteness, there being cases, wherein the physical superficies of a body is made by the same operation both rough and white; as when the level surface of clear water being by agitation asperated with a multitude of unequal bubbles, does thereby acquire a whiteness; and as a smooth piece of glass, by being scratched with a diamond, does in the asperated part of its surface disclose the same colour. But more (perchance) of this elsewhere.

15. AND therefore, we shall here pass by the question, whether any thing might be considered about the opacity of the corpuscles of black pigments, and the comparative diaphaneity of those of many white bodies, applied to our present case; and proceed to represent, that the newly mentioned exiguity and shape of the extant particles being supposed, it will then be considerable what we lately but hinted, (and therefore must now somewhat explain) that the depth of the little cavities, intercepted between the extant particles, without being so much greater in black bodies than in white ones, as to be perceptibly so to the gross organs of touch, may be very much greater in reference to their disposition of reflecting the imaginary subtle beams of light. For in black bodies, those little intercepted cavities, and other depressions, may be so figured, so narrow and so deep, that the incident beams of light, which the more extant parts of the physical superficies are disposed to reflect inwards, may be detained there, and prove unable to emerge; whilst, in a white body, the slender particles may not only by their figure be fitted to reflect the light copiously outwards, but the intercepted cavities being not deep, nor perhaps very narrow, the bottoms of them may be so constituted, as to be fit to reflect outwards much of the light that falls even upon them; as you may possibly better apprehend, when we shall come to treat of whiteness and blackness. In the mean time, it may suffice, that you take notice with me, that the blind man's relations import no necessity of concluding, that though, because, according to the judgment of his touch, black was the roughest, as it is the darkest of colours, therefore white, which (according to us) is the lightest, should be also the smoothest: since I observe, that he makes yellow to be two degrees more asperous than blue, and as much less asperous than green; whereas, indeed, yellow does not only appear to the eye a lighter colour than blue, but (by our first experiment hereafter to be mentioned) it will appear, that yellow reflected much more light than blue, and manifestly more than green; which we need not much wonder at, since in this colour, and the two others (blue and yellow) it is not only the reflected light that is to be considered, since to produce both these, refraction seems to intervene, which by its varieties may much alter the case:

which both seems to strengthen the conjecture I was formerly proposing, that there was something else in the kinds of asperity, as well as in the degrees of it, which enabled our blind man to discriminate colours, and does at least show, that we cannot, in all cases, from the bare difference in the degrees of asperity betwixt colours, safely conclude, that the rougher of any two always reflects the least light.

16. BUT this notwithstanding, (*Pyrophilus*) and whatever curiosity I may have had to move some questions to our sagacious blind man; yet thus much I think you will admit us to have gained by his testimony, that since many colours may be felt with the circumstances above related, the surfaces of such coloured bodies must certainly have differing degrees, and in all probability have differing forms or kinds of asperity belonging to them, which is all the use that my present attempt obliges me to make of the history above delivered; that being sufficient to prove, that colour does much depend upon the disposition of the superficial parts of bodies, and to shew in general, wherein it is probable that such a disposition does (principally at least) consist.

17. BUT to return to what I was saying, before I began to make mention of our blind organist; what we have delivered touching the causes of the several forms of asperity that may diversify the surfaces of coloured bodies, may perchance somewhat assist us to make some conjectures in the general, at several of the ways whereby it is possible for the experiments, hereafter to be mentioned, to produce the sudden changes of colours that are wont to be consequent upon them: for most of these phenomena being produced by the intervention of liquors, and these for the most part abounding with very minute, active, and variously figured saline corpuscles, liquors so qualified may well enough very nimbly alter the texture of the body they are employed to work upon, and so may change the form of asperity, and thereby make them remit to the eye the light that falls on them after another manner than they did before, and by that means vary the colour, so far forth as it depends upon the texture or disposition of the seen parts of the object; which I say, *Pyrophilus*, that you may not think I would absolutely exclude all other ways of modifying the beams of light between their parting from the lucid body, and their reception into the common sensory.

18. Now there seem to me divers ways, by which we may conceive that liquors may nimbly alter the colour of one another, and of other bodies, upon which they act; but my present haste will allow me to mention but some of them, without insisting so much as upon those I shall name.

19. AND first, the minute corpuscles that compose a liquor may easily insinuate themselves into those pores of bodies, whereto their size and figure makes them congruous; and these pores they may either exactly fill, or but inadequately: and in this latter case they will for the most part alter the number and figure, and always the bigness of the former pores.

And

And in what capacity soever these corpuscles of a liquor come to be lodged or harboured in the pores that admit them, the surface of the body will for the most part have its asperity altered, and the incident light that meets with a grosser liquor in the little cavities that before contained nothing but air, or some yet subtler fluid, will have its beams either refracted, or imbibed, or else reflected more or less interruptedly than they would be, if the body had been unmoistened: as we see, that even fair water falling on white paper, or linen, and divers other bodies apt to soak it in, will for some such reasons as those newly mentioned, immediately alter the colour of them, and for the most part make it sadder than that of the unwetted parts of the same bodies. And so you may see, that when in the summer the highways are dry and dusty, if there falls store of rain, they will quickly appear of a much darker colour than they did before; and if a drop of oil be let fall upon a sheet of white paper, that part of it, which by the imbibition of the liquor acquires a greater continuity, and some transparency, will appear much darker than the rest, many of the incident beams of light being now transmitted, that otherwise would be reflected towards the beholder's eyes.

20. **SECONDLY**, A liquor may alter the colour of a body, by freeing it from those things that hindered it from appearing in its genuine colour; and though this may be said to be rather a restoration of a body to its own colour, or a refection of its native colour, than a change, yet still there intervenes in it a change of the colour which the body appeared to be of before this operation. And such a change a liquor may work, either by dissolving, or corroding, or by some such way of carrying off that matter, which either veiled or disguised the colour that afterwards appears. Thus we restore old pieces of dirty gold to a clean and nitid yellow, by putting them into the fire, and into aqua-fortis, which take off the adventitious filth that made that pure metal look of a dirty colour: and there is also an easy way to restore silver coins to their due lustre, by fetching off that which discoloured them. And I know a chymical liquor, which I employed to restore pieces of cloth spotted with grease to their proper colour, by imbibing the spotted part with this liquor, which incorporating with the grease, and yet being of a very volatile nature, does easily carry it away with it self. And I have sometimes tried, that by rubbing upon a good touch-stone a certain metalline mixture so compounded, that the impression it left upon the stone appeared of a very differing colour from that of gold, yet a little of aqua-fortis would in a trice make the golden colour disclose it self, by dissolving the other metalline corpuscles that concealed those of the gold, which you know that menstruum will leave untouched.

21. **THIRDELY**, A liquor may alter the colour of a body by making a comminution of its parts, and that principally two ways; the first by disjoining and dissipating those clusters

of particles, if I may so call them, which stuck more loosely together, being fastened only by some more easily dissoluble cement, which seems to be the case of some of the following experiments, where you will find the colour of many corpuscles brought to cohere by having been precipitated together, destroyed by the affusion of very piercing and incisive liquors. The other of the two ways I was speaking of, is, by dividing the grosser and more solid particles into minute ones, which will be always lesser, and for the most part otherwise shaped than the entire corpuscle so divided, as it will happen in a piece of wood reduced into splinters or chips, or as when a piece of crystal heated red-hot and quenched in cold water is cracked into a multitude of little fragments, which though they fall not asunder, alter the disposition of the body of the crystal, as to its manner of reflecting the light, as we shall have occasion to shew hereafter.

22. **THERE** is a fourth way contrary to the third, whereby a liquor may change the colour of another body, especially of another fluid; and that is, by procuring the coalition of several particles that before lay too scattered and dispersed to exhibit the colour that afterwards appears. Thus sometimes when I have had the solution of gold so dilated, that I doubted whether the liquor had really imbibed any true gold or no, by pouring in a little mercury, I have been quickly able to satisfy my self, that the liquor contained gold; that metal after a little while cloathing the surface of the quicksilver with a thin film of its own livery. And chiefly, though not only by this way of bringing the minute parts of bodies together in such numbers, as to make them become notorious to the eye, many of these colours seem to be generated which are produced by precipitations, especially by such as are wont to be made with fair water; as when resinous gums dissolved in spirit of wine, are let fall again, if the spirit be copiously diluted with that weakening liquor. And so out of the rectified and transparent butter of antimony, by the bare mixture of fair water, there will be plentifully precipitated that milk-white substance, which by having its looser salts well washed off, is turned into that medicine, which vulgar chymists are pleased to call *Mercurius Vita*.

23. **A FIFTH** way, by which a liquor may change the colour of a body, is, by dislocating the parts, and putting them out of their former order into another, and perhaps also altering the posture of the single corpuscles as well as their order or situation in respect of one another. What certain kinds of commotion or dislocation of the parts of a body may do towards the changing its colour, is not only evident in the mutations of colour observable in quicksilver, and some other concretes long kept by chymists in a convenient heat, though in close vessels; but in the obvious degenerations of colour, which every body may take notice of in bruised cherries, and other fruit, by comparing after a while the colour of the injured with

with that of the sound part of the same fruit. And that also such liquors, as we have been speaking of, may greatly discompose the textures of many bodies, and thereby alter the disposition of their superficial parts, the great commotion made in metals, and several other bodies by aqua-fortis, oil of vitriol, and other saline menstruums, may easily persuade us; and what such varied situations of parts may do towards the diversifying of the manner of their reflecting the light, may be guessed in some measure by the beating of transparent glass into a white powder, but far better by the experiments lately pointed at, and hereafter delivered, as the producing and destroying colours by the means of subtle saline liquors, by whose affusion the parts of other liquors are manifestly both agitated, and likewise disposed after another manner than they were before such affusion. And in some chymical oils, as particularly that of lemon peels, by barely shaking the glass that holds it into bubbles, that transposition of the parts which is consequent to the shaking, will shew you on the surfaces of the bubbles exceeding orient and lively colours, which, when the bubbles relapse into the rest of the oil, do immediately vanish.

24. I KNOW not, *Pyrophilus*, whether I should mention as a distinct way, because it is of a somewhat more general nature, that power whereby a liquor may alter the colour of another body, by putting the parts of it into motion; for though possibly the motion so produced does, as such, seldom suddenly change the colour of the body whose parts are agitated, yet this seems to be one of the most general, however not immediate causes of the quick change of colours in bodies. For the parts being put into motion by the adventitious liquor, divers of them that were before united, may become thereby disjoined, and when that motion ceases or decays, others of them may stick together, and that in a new order, by which means the motion may sometimes produce permanent changes of colours, as in the experiment you will meet with hereafter, of presently turning a snowy white body into a yellow, by the bare affusion of fair water, which probably so dissolves the saline corpuscles that remained in the calx, and sets them at liberty to act upon one another, and the metal, far more powerfully than the water without the assistance of such saline corpuscles could do. And though you rub blue vitriol, how venereal and unsophisticated soever it be, upon the whetted blade of a knife, it will not impart to the iron its latent colour; but if you moisten the vitriol with your spittle, or common water, the particles of the liquor disjoining those of the vitriol, and thereby giving them the various agitation requisite to fluid bodies, the metalline corpuscles of the thus dissolved vitriol will lodge themselves in throngs in the small and congruous pores of the iron they are rubbed on, and so give the surface of it the genuine colour of the copper.

25. There remains yet a way, *Pyrophilus*, to be mentioned, by which a liquor may alter

the colour of another body, and this seems the most important of all, because though it be named but as one, yet it may indeed comprehend many; and that is, by associating the saline corpuscles, or any other sort of the more rigid ones of the liquor, with the particles of the body that it is employ'd to work upon. For these adventitious corpuscles associating themselves with the protuberant particles of the surface of a coloured body, must necessarily alter their bigness, and will most commonly alter their shape. And how much the colours of bodies depend upon the bulk and figure of their superficial particles, you may guess by this, that eminent ancient philosophers, and divers moderns, have thought that all colours might, in a general way, be made out by these two; whose being diversified will, in our case, be attended with these two circumstances; the one, that the protuberant particles being increased in bulk, they will oftentimes be varied as to the closeness or laxity of their order, fewer of them being contained within the same sensible (though minute) space than before; or else by approaching to one another, they must straiten the pores, and it may be too they will, by their manner of associating themselves with the protuberant particles, intercept new pores. And this invites me to consider farther, that the adventitious corpuscles I have been speaking of, may likewise produce a great change, as well in the little cavities or pores, as in the protuberances of a coloured body; for, besides what we have just now taken notice of, they may, by lodging themselves in those little cavities, fill them up, and it may well happen, that they may not only fill the pores they insinuate themselves into, but likewise have their upper parts extant above them; and partly by these new protuberances, partly by increasing the bulk of the former, these extraneous corpuscles may much alter the number and bigness of the surface's pores, changing the old and intercepting new ones. And then 'tis odds, but the order of the little extancies, and consequently that of the little depressions in point of situation will be altered likewise: as if you dissolve quicksilver in some kind of aqua-fortis, the saline particles of the menstruum, associating themselves with the mercurial corpuscles, will make a green solution, which afterwards easily enough degenerates. And red lead, or minium, being dissolved in spirit of vinegar, yields not a red, but a clear solution, the redness of the lead being by the liquor destroyed. But a better instance may be taken from copper; for I have tried, that if upon a copper-plate, you let some drops of weak aqua-fortis rest for a while, the corpuscles of the menstruum joining with those of the metal, will produce a very sensible asperity upon the surface of the plate, and will concoagulate that way into very minute grains of a pale blue vitriol; whereas if upon another part of the same plate you suffer a little strong spirit of urine to rest a competent time, you shall find the asperated surface adorned with a deeper and richer blue. And the same aqua-fortis, that will quickly change the redness of red

lead into a darker colour, will, being put upon crude lead, produce a whitish substance, as with copper it did a blueish. And as with iron it will produce a reddish, and on white quills a yellowish, so much may the coalition of the parts of the same liquor, with the differing figured particles of stable bodies, divers ways asperate the differing disposed surfaces, and so diversify the colour of those bodies. And you will easily believe, that in many changes of colour, that happen upon the dissolutions of metals, and precipitations made with oil of tartar, and the like fixed salts, there may intervene a coalition of saline corpuscles with the particles of the body dissolved or precipitated, if you examine how much the vitriol of a metal may be heavier than the metalline part of it alone, upon the score of the saline parts concoagulated therewith; and, that in several precipitations the weight of the calx does for the same reason much exceed that of the metal, when it was first put in to be dissolved.

26. BUT, *Pyrophilus*, to consider these matters more particularly would be to forget that I declared against adventuring, at least for this time, at particular theories of colours, and that accordingly you may justly expect from me rather experiments than speculations: and therefore I shall dismiss this subject of the forms of superficial asperity in coloured bodies, as soon as I shall but have named to you, by way of supplement to what we have hitherto discoursed in this short section, a couple of particulars, (which you will easily grant me;) the one, that there are divers other ways for the speedy production even of true and permanent colours in bodies, besides those practicable by the help of liquors: for proof of which advertisement, though several examples might be alledged, yet I shall need but re-mind you of what I mentioned to you above, touching the change of colours suddenly made on tempered steel, and on lead, by the operation of heat, without the intervention of a liquor. But the other particular I am to observe to you, is of more importance to our present subject; and it is, that though nature and art may in some cases so change the asperity of the superficial parts of a body, as to change its colour by either of the ways I have proposed, single or un-assisted; yet for the most part it is by two or three, or perhaps by more of the fore-mentioned ways associated together, that the effect is produced. And if you consider how variously these several ways and some others allied unto them, which I have left unmentioned, may be compounded and applied, you will not much wonder that such fruitful, whether principles (or manners of diversification) should be fitted to change or generate no small store of differing colours.

27. HITHERTO, *Pyrophilus*, we have in discoursing of the asperity of bodies considered the little protuberances of other superficial particles which make up that roughness, as if we took it for granted, that they must be perfectly opacous and impenetrable by the beams of light, and so must contribute to the variety of colours, as they terminate more or

less light, and reflect it to the eye mixed with more or less of thus or thus mingled shades. But to deal ingenuously with you, *Pyrophilus*, before I proceed any further, I must not conceal from you, that I have often thought it worth a serious inquiry, whether or no particles of matter, each of them singly insensible, and therefore small enough to be capable of being such minute particles, as the Atomists both of old and of late have (not absurdly) called *Corpuscula Coloris*, may not yet consist each of them of divers yet minuter particles, betwixt which we may conceive little commissures where they adhere to one another, and, however, may not be porous enough to be, at least in some degree, pervious to the unimaginably subtle corpuscles that make up the beams of light, and consequently to be in such a degree diaphanous. For, *Pyrophilus*, that the proposed inquiry may be of moment to him that searches after the nature of colour, you will easily grant, if you consider, that whereas perfectly opacous bodies can but reflect the incident beams of light, those that are diaphanous are qualified to refract them too; and that refraction has such a stroke in the production of colours, as you cannot but have taken notice of, and perhaps admired in the colours generated by the trajection of light through drops of water that exhibit a rainbow, through prismatical glasses, and through divers other transparent bodies. But 'tis like, *Pyrophilus*, you will more easily allow that about this matter it is rather important to have a certainty, than that it is rational to entertain a doubt; wherefore I must mention to you some of the reasons that make me think it may need a further inquiry: for I find that in a darkened room, where the light is permitted to enter but at one hole, the little wandering particles of dust, that are commonly called motes, and, unless in the sun-beams, are not taken notice of by the unassisted sight; I have, I say, often observed that these roving corpuscles being looked on by an eye placed on the one side of the beams that entered the little hole, and by the darkness having its pupil much enlarged, I could discern that these motes, as soon as they came within the compass of the luminous, whether cylinder or inverted cone, if I may so call it, that was made up by the unclouded beams of the sun, did in certain positions appear adorned with very vivid colours, like those of the rainbow, or rather like those of very minute, but sparkling fragments of diamonds: and as soon as the continuance of their motion had brought them to an inconvenient position in reference to the light and the eye, they were only visible without darting any lively colours as before. Which seems to argue, that these little motes, or minute fragments of several sorts of bodies reputed opacous, and only crumbled as to their exterior and looser parts into dust, did not barely reflect the beams that fell upon them, but remit them to the eye refracted too. We may also observe, that several bodies, (as well some of a vegetable, as others of an animal nature) which are wont to pass for opacous, appear in great part transparent,

rent, when they are reduced into thin parts, and held against a powerful light. This I have not only taken notice of in pieces of ivory reduced into thick leaves, as also in divers considerable thick shells of fishes, and in shaving of wood; but I have also found that a piece of deal, far thicker than one would easily imagine, being purposely interposed betwixt my eye placed in a room, and the clear day-light, was not only somewhat transparent, but (perhaps by reason of its gummous nature) appeared quite through of a lovely red. And in the darkened room above mentioned, bodies held against the hole at which the light entered, appeared far less opacous than they would elsewhere have done; inso-much that I could easily and plainly see, through the whole thickness of my hand, the motions of a body placed (at a very near distance indeed, but yet) beyond it. And even in minerals, the opacity is not always so great as many think, if the body be made thin: for white marble, though of a pretty thickness, being within a due distance placed betwixt the eye and a convenient light, will suffer the motions of one's finger to be well discerned through it, and so will pieces, thick enough, of many common flints. But above all, that instance is remarkable, that is afforded us by *Muscovy* glass, (which some call *Selenites*, others *Lapis Specularis*;) for though plates of this mineral, though but of a moderate thickness, do often appear opacous, yet if one of these be dexterously split into the thinnest leaves it is made up of, it will yield such a number of them, as scarce any thing but experience could have persuaded me; and these leaves will afford the most transparent sort of consistent bodies, that, for aught I have observed, are yet unknown; and a single leaf or plate will be so far from being opacous, that it will scarce be so much as visible. And multitudes of bodies there are, whose fragments seem opacous to the naked eye, which yet, when I have included them in good microscopes, appeared transparent; but, *Pyrophilus*, on the other side I am not yet sure that there are no bodies, whose minute particles even in such a microscope as that of mine, which I was lately mentioning, will not appear diaphanous. For having considered mercury precipitated *per se*, the little granules that made up the powder, looked like little fragments of coral beheld by the naked eye at a distance, (for very near at hand coral will sometimes, especially if it be good, shew some transparency.) Filings likewise of steel and copper, though in an excellent microscope, and a fair day, they showed like pretty big fragments of those metals, and had considerable brightness on some of their surfaces, yet I was not satisfied, that I perceived any reflection from the inner parts of any of the filings. Nay, having looked in my best microscope upon the red calx of lead, (commonly called *Minium*) neither I, nor any I shewed it to, could discern it to be other than opacous, though the day were clear, and the object strongly enlightened. And the deeply red colour of vitriol appeared in the same mi-

croscope (notwithstanding the great comminution effected by the fire) but like grossly beaten brick. So that, *Pyrophilus*, I shall willingly resign you the care of making some further inquiries into the subject we have now been considering; for I confess, as I told you before, that I think that the matter may need a further scrutiny, nor would I be forward to determine how far or in what cases the transparency or semi-diaphaneity of the superficial corpuscles of bigger bodies may have an interest in the production of their colours; especially because that even in divers white bodies, as beaten glass, snow and froth, where it seems manifest that the superficial parts are singly diaphanous, (being either water, or air, or glass) we see not that such variety of colours are produced as usually are by the refraction of light even in those bodies, when by their bigness, shape, &c. they are conveniently qualified to exhibit such various and lively colours as those of the rainbow, and of prismatical glasses.

28. By what has been hitherto discoursed, *Pyrophilus*, we may be assisted to judge of that famous controversy which was of old disputed betwixt the Epicureans and other Atomists on one side, and most other philosophers on the other side; the former denying bodies to be coloured in the dark, and the latter making colour to be an inherent quality, as well as figure, hardness, weight, or the like. For though this controversy be revived, and hotly agitated among the moderns, yet I doubt whether it be not in great part a nominal dispute; and therefore let us, according to the doctrine formerly delivered, distinguish the acceptations of the word colour, and say, that if it be taken in the stricter sense, the Epicureans seem to be in the right; for if colour be indeed, though not according to them, but light modified, how can we conceive that it can subsist in the dark, that is, where it must be supposed there is no light: but, on the other side, if colour be considered as a certain constant disposition of the superficial parts of the object to trouble the light they reflect after such and such a determinate manner, this constant, and if I may so speak, modifying disposition persevering in the object, whether it be shined upon or no, there seems no just reason to deny, but that in this sense, bodies retain their colour as well in the night as day; or, to speak a little otherwise, it may be said, that bodies are potentially coloured in the dark, and actually in the light. But of this matter discoursing more fully elsewhere, as it is a difficulty that concerns qualities in general, I shall forbear to insist on it here.

C H A P. IV.

1. **O**F greater moment in the investigation of the nature of colours is the controversy, whether those of the rainbow, and those that are often seen in clouds, before the rising, or after the setting of the sun; and in a word, whether those other colours, that are wont to be called emphatical, ought or ought not to be

be accounted true colours. I need not tell you that the negative is the common opinion, especially in the schools, as may appear by that vulgar distinction of colours, whereby these under consideration are termed apparent, by way of opposition to those that in the other member of the distinction are called true or genuine. This question I say seems to me of importance, upon this account, that it being commonly granted, (or however, easy enough to be proved) that emphatical colours are light it self modified by refractions chiefly, with a concurrence sometimes of reflections, and perhaps some other accidents depending on these two; if these emphatical colours be resolved to be genuine, it will seem consequent, that colours, or at least divers of them, are but diversified light, and not such real and inherent qualities as they are commonly thought to be.

2. Now since we are wont to esteem the echoes and other sounds of bodies, to be true sounds, all their odours to be true odours, and (to be short) since we judge other sensible qualities to be true ones, because they are the proper objects of some or other of our senses; I see not why emphatical colours, being the proper and peculiar objects of the organ of sight, and capable to affect it as truly and as powerfully as other colours, should be reputed but imaginary ones.

AND if we have (which perchance you will allow) formerly evinced colour, (when the word is taken in its more proper sense) to be but modified light, there will be small reason to deny these to be true colours, which more manifestly than others disclose themselves to be produced by diversifications of the light.

3. THERE is indeed taken notice of, a difference betwixt these apparent colours, and those that are wont to be esteemed genuine, as to the duration, which has induced some learned men to call the former rather evanid than fantastical. But as the ingenious *Gassendus* does somewhere judiciously observe, if this way of arguing were good, the greenness of a leaf ought to pass for apparent, because, soon fading into a yellow, it scarce lasts at all, in comparison of the greenness of an emerald. I shall add, that if the sun-beams be in a convenient manner trajected through a glass prism, and thrown upon some well shaded object within a room, the rainbow thereby painted on the surface of the body that terminates the beams, may oftentimes last longer than some colours I have produced in certain bodies, which would justly, and without scruple be accounted genuine colours, and yet suddenly degenerate, and lose their nature.

4. A GREATER disparity betwixt emphatical colours, and others, may perhaps be taken from this, that genuine colours seem to be produced in opacous bodies by reflection, but apparent ones in diaphanous bodies, and principally by refraction; I say principally, rather than solely, because in some cases reflection also may concur: but still this seems not to conclude these latter colours not to be true ones. Nor must what has been newly said of the differences of true and apparent colours, be

interpreted in too unlimited a sense, and therefore it may perhaps somewhat assist you, both to reflect upon the two foregoing objections, and to judge of some other passages which you will meet with in this tract, if I take this occasion to observe to you, that if water be agitated into froth, it exhibits, you know, a white colour, which soon after it loses upon the resolution of the bubbles into air and water. Now in this case either the whiteness of the froth is a true colour, or not; if it be, then true colours, supposing the water pure and free from mixtures of any thing tenacious, may be as short-lived as those of the rainbow; also the matter, wherein the whiteness did reside, may in a few moments perfectly lose all footsteps or remains of it. And besides, even diaphanous bodies may be capable of exhibiting true colours by reflection; for that whiteness is so produced, we shall anon make it probable. But if on the other side it be said, that the whiteness of froth is an emphatical colour, then it must no longer be said, that fantastical colours require a certain position of the luminary and the eye, and must be varied or destroyed by the change thereof, since froth appears white, whether the sun be rising or setting, or in the meridian, or any where between it and the horizon, and from what (neighbouring) place soever the beholder's eye looks upon it. And since by making a liquor tenacious enough, yet without destroying its transparency, or staining it with any colour, you may give the little films, whereof the bubbles consist, such a texture as may make the froth last very many hours, if not some days, or even weeks, it will render it somewhat improper to assign duration for the distinguishing character to discriminate genuine from fantastical colours. For such froth may much outlast the undoubtedly true colours of some of nature's productions, as in that gaudy plant, not undeservedly called the *Marvel of Peru*, the flowers do so often fade the same day they are blown; and I have often seen a Virginian flower, which usually withers within the compass of a day; and I am credibly informed, that not far from hence, a curious herborist has a plant, whose flowers perish in about an hour. But, if the whiteness of water turned into froth must therefore be reputed emphatical, because it appears not that the nature of the body is alter'd, but only that the disposition of its parts, in reference to the incident light, is chang'd, why may not the whiteness be accounted emphatical too; which I shall shew anon to be producible, barely by such another change in black horn: and yet this so easily acquired whiteness seems to be as truly its colour as the blackness was before, and at least is more permanent than the greenness of leaves, the redness of roses, and in short, than the genuine colours of the most part of nature's productions. It may indeed be further objected, that according as the sun or other luminous body changes place, these emphatical colours alter or vanish. But not to repeat what I have just now said, I shall add, that if a piece of cloth in a draper's shop (in such the light

light being seldom primary) be variously folded, it will appear of differing colours, as the parts happen to be more illuminated, or more shaded; and if you stretch it flat, it will commonly exhibit some one uniform colour: and yet these are not wont to be reputed emphatical, so that the difference seems to be chiefly this, that in the case of the rain-bow, and the like, the position of the luminary varies the colour, and in the cloth I have been mentioning, the position of the object does it. Nor am I forward to allow, that in all cases, the apparition of emphatical colours requires a determinate position of the eye; for if men will have the whiteness of froth emphatical, you know what we have already inferred from thence. Besides, the sun-beams trajected through a triangular glass, after the manner lately mentioned, will, upon the body that terminates them, paint a rain-bow, that may be seen, whether the eye be placed on the right hand of it, or the left, or above, or beneath it, or before or behind it: and though there may appear some little variation in the colours of the rain-bow beheld from differing parts of the room, yet such a diversity may be also observed by an attentive eye in real colours, looked upon under the like circumstances. Nor will it follow, that because there remain no footsteps of the colour upon the object, when the prism is removed, that therefore the colour was not real, since the light was truly modified by the refraction and reflection it suffered in its trajection through the prism; and the object in our case serv'd for a specular body, to reflect that colour to the eye. And that you may not be startled, *Pyrophilus*, that I should venture to say, that a rough and coloured object may serve for a speculum to reflect the artificial rain-bow I have been mentioning, consider what usually happens in darkened rooms, where a wall, or other body conveniently situated within, may so reflect the colours of bodies without the room, that they may very clearly be discerned and distinguished; and yet it is taken for granted, that the colours seen in a darkened room, though they leave no traces of themselves upon the wall or body that receives them, are the true colours of the external objects, together with which the colours of the images are moved, or do rest. And the error is not in the eye, whose office is only to perceive the appearances of things, and which does truly so; but in the judging or estimative faculty, which mistakingly concludes that colour to belong to the wall, which does indeed belong to the object, because the wall is that from whence the beams of light, that carry the visible species, do come in strait lines directly to the eye: as for the same reason we are wont, at a certain distance from concave spherical glasses, to persuade ourselves, that we see the image come forth to meet us, and hang in the air betwixt the glass and us, because the reflected beams, that compose the image cross in that place where the image seems to be, and thence, and not from the glass, do in direct lines take their course to the eye. And upon the like cause it is, that divers deceptions in

found and other sensible objects do depend, as we elsewhere declare.

5. I Know not whether I need add, that I have purposely tried, (as you will find some pages hence, and will perhaps think somewhat strange) that colours, that are called emphatical, because not inherent in the bodies in which they appear, may be compounded with one another, as those that are confessedly genuine may. But when all this is said, *Pyrophilus*, I must advertise you, that it is but problematically spoken; and that though I think the opinion I have endeavoured to fortify probable, yet a great part of our discourse concerning colours may be true, whether that opinion be so or not.

C H A P. V.

1. **T**HERE are, you know, *Pyrophilus*, besides those obsolete opinions about colours, which have been long since rejected, very various theories, that have each of them, even at this day, eminent men for their abettors: for the Peripatetick schools, though they dispute amongst themselves divers particulars concerning colours, yet in this they seem unanimously enough to agree, that colours are inherent and real qualities, which the light doth but disclose, and not concur to produce. Besides, there are moderns, who with a slight variation adopt the opinion of *Plato*; and as he would have colour to be nothing but a kind of flame consisting of minute corpuscles, as it were darted by the object against the eye, to whose pores their littleness and figure made them congruous; so these would have colour to be an internal light of the more lucid parts of the object, darkened, and consequently altered by the various mixtures of the less luminous parts. There are also others, who, in imitation of some of the ancient Atomists, make colour not to be lucid steam, but yet a corporeal effluvia issuing out of the coloured body; but the knowingest of these have of late reformed their hypothesis, by acknowledging and adding, that some external light is necessary to excite, and, as they speak, solicit these corpuscles of colour, as they call them, and bring them to the eye. Another and more principal opinion of the modern philosophers, to which this last named may by a favourable explication be reconciled, is that, which derives colours from the mixture of light and darkness, or rather light and shadows. And as for the Chymists, it is known, that the generality of them ascribe the origin of colours to the sulphureous principle in bodies; though I find, as I elsewhere largely shew, that some of the chiefest of them derive colours rather from salt than sulphur, and others from the third hypostatical principle, mercury. And as for the Cartesians, I need not tell you, that they, supposing the sensation of light to be produced by the impulse made upon the organs of sight, by certain extremely minute and solid globules, to which the pores of the air and other diaphanous bodies are pervious; endeavour to derive the varieties of colours from the various proportion

portion of the direct progress or motion of these globules to their circumvolution, or motion about their own centre, by which varying proportion they are by this hypothesis supposed qualified to strike the optick nerve after several distinct manners, so to produce the perception of differing colours.

2. BESIDES these six principal hypotheses, *Pyrophilus*, there may be some others, which though less known, may perhaps as well as these deserve to be taken into consideration by you; but that I should copiously debate any of them at present, I presume you will not expect, if you consider the scope of these papers, and the brevity I have designed in them; and therefore I shall at this time only take notice to you in the general of two or three things, that do more peculiarly concern the treatise you have now in your hands.

3. AND first, though the embracers of the several hypotheses I have been naming to you, by undertaking each sect of them to explicate colours indefinitely by the particular hypotheses they maintain, seem to hold it forth as the only needful theory about that subject; yet for my part I doubt, whether any one of all these hypotheses have a right to be admitted exclusively to all others: for I think it probable, that whiteness and blackness may be explicated by reflection alone without refraction, as you will find endeavoured in the discourse you will meet with ere long, of the origin of whiteness and blackness; and on the other side, since I have not found, that by any mixture of white and true black, (for there is a blueish black, which many mistake for a genuine) there can be a blue, a yellow, or a red, to name no other colours, produced; and since we do find, that these colours may be produced in the glass prism and other transparent bodies, by the help of refractions, it seems, that refraction is to be taken in, into the explication of some colours, to whose generation they seem to concur, either by making a further or other commixture of shades with the refracted light, or by some other way not now to be discoursed. And as it seems not improbable, that in case the pores of the air, and other diaphanous bodies be every where almost filled with such globuli, as the Cartesians suppose, the various kind of motion of these globuli may in many cases have no small stroke in varying our perception of colour; so without the supposition of these globuli, which it is not so easy to evince, I think we may probably enough conceive in general, that the eye may be variously affected, not only by the entire beams of light that fall upon it, as they are such; but by the order, and by the degree of swiftness, and in a word, by the manner, according to which the particles that compose each particular beam arrive at the sensory: so that whatever be the figure of the little corpuscles, of which the beams of light consist, not only the celerity or slowness of their revolution or rotation, in reference to their progressive motion, by their more absolute celerity, their direct or undulating motion, and other accidents, which

may attend their appulse to the eye, may fit them to make differing impressions on it.

4. SECONDLY, For these and the like considerations, *Pyrophilus*, I must desire, that you would look upon this little treatise, not as a discourse written principally to maintain any of the fore-mentioned theories, exclusively to all others, or substitute a new one of my own; but as the beginning of a history of colours, upon which, when you and your ingenious friends shall have enriched it, a solid theory may be safely built. But yet because this history is not meant barely for a register of the things recorded in it, but for an apparatus to a sound and comprehensive hypothesis, I thought fit so to temper the whole discourse, as to make it as conducive as conveniently I can to that end: and therefore I have not scrupled to let you see, that I was willing, as to save you the labour of cultivating some theories, that I thought would never enable you to reach the ends you aim at, so to contract your enquiries into a narrow compass. For both which purposes I thought it requisite to do these two things; the one, to set down some experiments, which by the help of the reflections and insinuations that attend them, may assist you to discover the infirmness and insufficiency both of the common Peripatetick doctrine, and of the now more applauded theory of the chymists about colour; because these two doctrines having possessed themselves, the one of the most part of the schools, and the other of the esteem of the generality of physicians and other learned men, whose professions and ways of study do not exact, that they should scrupulously examine the very first and simplest principles of nature: I feared it would be to little purpose, without doing something to discover the insufficiency of these hypotheses, that I should, (which was the other thing I thought requisite for me to do) set down among my other experiments those in the greatest number, that may let you see, that, till I shall be better informed, I incline to take colour to be a modification of light; and would invite you chiefly to cultivate that hypothesis, and improve it to the making out of the generation of particular colours, as I have endeavoured to apply it to the explication of whiteness and blackness.

5. THIRDLY, But *Pyrophilus*, though this be at present the hypothesis I prefer, yet I propose it but in a general sense, teaching only, that the beams of light, modified by the bodies whence they are sent (reflected or refracted) to the eye, produce there that kind of sensation, men commonly call colour. But whether I think this modification of the light to be performed by mixing it with shades, or by varying the proportion of the progress and rotation of the Cartesian *Globuli Caelestes*, or by some other way, which I am not now to mention, I pretend not here to declare; much less do I pretend to determine, or scarce so much as to hope to know all that were requisite to be known, to give you, or even my self, a perfect account of the theory of vision and colours. For in order to such an undertaking, I would

would first know what light is, and if it be a body (as a body or the motion of a body it seems to be) what kind of corpuscles for size and shape it consists of, with what swiftness they move forwards, and whirl about their own centres. Then I would know the nature of refraction, which I take to be one of the abstrusest things (not to explicate plausibly, but to explicate satisfactorily) that I have met with in physics. I would further know, what kind and what degree of commixture of darkness or shades is made by refractions, or reflections, or both, in the superficial particles of those bodies, that being shined upon, constantly exhibit the one, for instance, a blue, the other a yellow, the third a red colour. I would further know, why this contemperation of light and shade, that is made, for example, by the skin of a ripe cherry, should exhibit a red, and not a green, and the leaf of the same tree should exhibit a green rather than a red. And indeed, lastly, why since the light that is modified into these colours consists but of corpuscles moved against the retina or pith of the optick nerve, it should

there not barely give a stroke, but produce a colour; whereas a needle wounding likewise the eye would not produce colour, but pain. These, and perhaps other things I should think requisite to be known, before I should judge my self to have fully comprehended the true and whole nature of colours: and therefore, though by making the experiments and reflections delivered in this paper, I have endeavoured somewhat to lessen my ignorance in this matter, and think it far more desirable to discover a little, than to discover nothing; yet I pretend but to make it probable by the experiments I mention, that some colours may be plausibly enough explicated in the general by the doctrine here proposed. For whensoever I would descend to the minute and accurate explication of particulars, I find my self very sensible of the great obscurity of things, without excepting those, which we never see but when they are enlightned, and confess with *Scaliger*, *Latet natura hæc*, (says he, speaking of that of colour) *Et sicut aliarum rerum species in profundissima caligine inscitie humanæ.*

Exercitat. 325. Paragraph. 4.

The Experimental History of COLOURS.

PART II.

Of the Nature of Whiteness and Blackness.

CHAP. I.

I. **T**HOUGH after what I have acknowledged, *Pyrophilus*, of the abstruse nature of colours in particular, you will easily believe, that I pretend not to give you a satisfactory account of whiteness and blackness; yet not wholly to frustrate your expectation of my offering something by way of specimen towards the explication of some colours in particular, I shall make choice of these as the most simple ones, (and by reason of their mutual opposition the least hardly explicable) about which to present you my thoughts, upon condition you will take them at most to be my conjectures, not my opinions.

2. **W**HEN I applied my self to consider, how the cause of whiteness might be explained by intelligible and mechanical principles, I remembred not to have met with any thing among the ancient Corpuscularian philosophers, touching the quality we call whiteness, save that *Democritus* is by *Aristotle* said to have ascribed the whiteness of bodies to their smoothness, and on the contrary their blackness to their asperity. But though about the latter of those qualities his opinion be allowable, as we shall see anon; yet that he needs a favourable interpretation in what is delivered concerning the first, (at least if his doctrine be not misrepresented in this point, as it has been in many others,) we shall quickly have occasion to manifest. But amongst the moderns, the most learned *Gassendus* in his ingenious epistle

published in the year 1642, *De apparente magnitudine solis humilis Et sublimis*, reviving the atomical philosophy, has, though but incidentally, delivered something towards the explication of whiteness upon mechanical principles. And because no man, that I know of, has done so before him, I shall, to be sure to do him right, give you his sense in his own words: *Cogites velim* (says he) *lucem quidem in diaphano nullius coloris videri, sed in opaco tamen terminante candicare, ac tanto magis, quanto densior seu collectior fuerit. Deinde aquam non esse quidem coloris ex se candidi, Et radium tamen ex eâ reflexum versus oculum candicare. Rursus cum plana aquæ superficies non nisi ex una parte eam reflexionem faciat: si contigerit tamen illam in aliquot bullas intumescere, bullam unamquamque reflexionem facere, Et candoris speciem creare certa superficiæ parte. Ad hæc spumam ex aqua pura non alia ratione videri candescere Et albescere, quam quod sit congeries confertissima minutissimarum bullarum, quarum unaquæque suum radium reflectit, unde continens candor alborve apparet. Denique nivem nihil aliud videri quam speciem purissimæ spumæ ex bullulis quam minutissimis Et confertissimis coherentis. Sed ridiculum me exhibeam, si tales meas nugas uberius proponem.*

Epist. 2. pag. 45.

3. **B**UT though in this passage, that very ingenious person has anticipated part of what I should say; yet I presume you will for all that expect, that I should give you a fuller account

Album quippe Et nigrum, hoc quidem asperum esse dicit, hoc verò læve. De sensu 3. Et sensu 3.

count of that notion of whiteness, which I have the least exceptions to, and of the particulars whence I deduce it; which to do, I must mention to you the following experiments and observations.

WHITENESS then considered as a quality in the object seems chiefly to depend upon this, that the superficies of the body, that is called white, is asperated by almost innumerable small surfaces; which being of an almost specular nature, are also so placed, that some looking this way, and some that way, they yet reflect the rays of light that fall on them, not towards one another, but outwards towards the spectator's eye. In this rude and general account of whiteness, it seems, that besides those qualities, which are common to bodies of other colours, as for instance the minuteness and number of the superficial parts, the two chief things attributed to bodies as white are made to be, first, that little protuberances and superficial parts be of somewhat a specular nature, that they may, as little looking-glasses, each of them reflect the beams it receives, (or the little picture of the sun made on it) without otherwise considerably altering them; whereas in most other colours, they are wont to be much changed, by being also refracted, or by being returned to the eye, mixt with shades or otherwise. And next, that its superficial parts be so situated, that they retain not the incident rays of light by reflecting them inwards, but send them almost all back; so that the outermost corpuscles of a white body, having their various little surfaces of a specular nature, a man can from no place behold the body, but that there will be among those innumerable *superficiecula*, that look some one way, and some another, enough of them obverted to his eye, to afford, like a broken looking-glass a confused idea, or representation of light, and make such an impression on the organ, as that for which men are wont to call a body white. But this notion will perhaps be best explained by the same experiments and observations, on which it is built, and therefore I shall now advance to them.

4. AND in the first place I consider, that the sun, and other powerfully lucid bodies, are not only wont to offend, which we call to dazzle our eyes; but that if any colour be to be ascribed to them as they are lucid, it seems it should be whiteness. For the sun at noon-day, and in clear weather, and when his face is less troubled, and as it were stained by the steams of sublunary bodies, and when his beams have much less of the atmosphere to traject in their passage to our eyes, appears of a colour more approaching to white, than when nearer the horizon: the interposition of certain sorts of fumes and vapours make him oftentimes appear either red, or at least more yellow. And when the sun shines upon that natural looking-glass, a smooth water, that part of it, which appears to this or that particular beholder the most shined on, does to his eye seem far whiter than the rest. And here I shall add, that I have sometimes had the opportunity to observe a thing, that may make to my present purpose; namely, that when the sun was veiled

over as it were, with a thin white cloud, and yet was too bright to be looked upon directly without dazzling, by casting my eyes upon a smooth water, as we sometimes do to observe eclipses without prejudice to our eyes, the sun then not far from the meridian appeared to me not red, but so white, that it was not without some wonder, that I made the observation. Besides, though we in *English* are wont to say, a thing is red-hot, as an expression of its being superlatively ignited, (if I may so speak for want of a proper *English* word) yet in the forges of smiths, and the furnaces of other artificers, by that which they call a white heat, they mean a further degree of ignition, than by that which both they and we call a red heat.

5. SECONDLY, I consider, that common experience informs us, that as much light over-powers the eye, so when the ground is covered with snow, (a body extremely white) those that have weak eyes are wont to complain of too much light: and even those, that have not, are generally sensible of an extraordinary measure of light in the air; and if they are fain to look very long upon snow, find their sight offended by it. On which occasion we may call to mind what *Xenophon* relates, that his *Cyrus* marching his army for divers days through mountains covered with snow, the dazzling splendor of its whiteness prejudiced the sight of very many of his soldiers, and blinded some of them; and other stories of that nature may be met with in writers of good note. And the like has been affirmed to me by credible persons of my own acquaintance, and especially by one, who, though skilled in physick, and not ancient, confessed to me, when I purposely asked him, that not only during his stay in *Muscovy* he found his eyes much impaired, by being reduced frequently to travel in the snow; but that the weakness of his eyes did not leave him when he left that country, but has followed him into these parts, and yet continues to trouble him. And to this doth agree what I as well as others have observed, namely, that when I travelled by night, when the ground was all covered with snow, though the night otherwise would not have been lightsome, yet I could very well see to chuse my way. But much more remarkable to my present purpose is that, which I have met with in *Olaus Magnus*, concerning the way of travelling in winter in the Northern regions, where the days of that season are so very short: for after other things not needful to be here transcribed; *Iter*, says he, *diurnum duo scilicet montana miliaria (quæ 12 Italica sunt) conficiunt. Nocte verò sub splendidissima luna, duplatum iter consumunt aut triplatum. Neque id incommodè fit, cum nivium reverberatione lunaris splendor sublimes & declives campos illustrat, ac etiam montium præcipitia ac noxias feras à longè prospiciant evitandas.* Which testimony I the less scruple to alledge, because that it agrees very well with what has been affirmed to me by a physician of *Moscow*, whom the notion I have been treating of concerning whiteness invited me to ask, whether he could not see much farther, when he travelled by night in *Russia*

Gent. Septent. Histor. lib. 4. cap. 13.

Russia than he could do in *England*, or elsewhere, when there was no snow upon the ground; for this ingenious person informed me, that he could see things at a far greater distance, and with more clearness, when he travelled by night on the *Russian* snow, though without the assistance of moon-shine, than we in these parts would easily be persuaded. Though it seems not unlikely to me, that the intenseness of the cold may contribute something to the considerableness of the effect, by much clearing the air of darkish steams, which in these more temperate climates are wont to thicken it in snowy weather: for having purposely enquired of this doctor, and consulted that ingenious navigator captain *James's* voyage hereafter to be further mentioned, I find both their relations agree in this, that in dark frosty nights they could discover more stars, and see the rest clearer, than we in *England* are wont to do.

6. I KNOW indeed, that divers learned men think, that snow so strongly affects our eyes, not by a borrowed, but a native light; but I venture to give it as a proof, that white bodies reflect more light than others, because having once purposely placed a parcel of snow in a room carefully darkened, that no celestial light might come to fall upon it, neither I, nor an ingenious person (skilled in opticks) whom I desired for a witness, could find, that it had any other light than what it received. And however, it is usual among those that travel in dark nights, that the guides wear something of white to be discerned by, there being scarce any night so dark, but that in the free air there remains some light, though broken and debilitated perhaps by a thousand reflections from the opacous corpuscles that swim in the air, and send it to one another before it comes to arrive at the eye.

7. THIRDLY, And the better to shew that white bodies reflect store of light, in comparison of those that are otherwise coloured, I did in the darkened room, formerly mentioned, hold not far from the hole, at which the light was admitted, a sheet only of white paper, from whence casting the sun-beams upon a white wall, whereunto it was obverted, it manifestly appeared both to me, and to the person I took for a witness of the experiment, that it reflected a far greater light, than any of the other colours formerly mentioned; the light so thrown upon the wall notably enlightening it, and by it a good part of the room. And yet further to shew you, that white bodies reflect the beams from them, and not towards themselves, let me add, that ordinary burning glasses, such as are wont to be employed to light tobacco, will not in a great while burn, or so much as discolour a sheet of white paper. Inasmuch that even when I was a boy, and loved to make trials with burning-glasses, I could not but wonder at this odd phenomenon, which set me very early upon guessing at the nature of whiteness; especially because I took notice, that the image of the sun upon a white paper was not so well defined (the light seeming too diffused) as upon black,

and because I tried, that blacking over the paper with ink, not only the ink would be quickly dried up, but the paper, that I could not burn before, would be quickly set on fire. I have also tried, that by exposing my hand with a thin black glove over it to the warm sun, it was thereby very quickly and considerably more heated, than if I took off the glove, and held my hand naked, or put on it another glove of thin but white leather. And having thus shewn you, *Pyrophilus*, that white bodies reflect the most light of any, let us now proceed to consider, what is further to be taken notice of in them, in order to our present enquiry.

8. AND fourthly, whereas among the dispositions we attributed to white bodies, we also intimated this, that such bodies are apt, like speculums, though but imperfect ones, to reflect the light that falls on them untroubled or unstained we shall, besides other particulars to be met with in these papers, offer you this in favour of the conjecture; that in the darkened room several times mentioned in this treatise, we tried, that the sun-beams being cast from a coloured body upon a neighbouring white wall, the determinate colour of the body was from the wall reflected to the eye; whereas we could in divers cases manifestly alter the colour arriving at the eye, by substituting at a convenient distance, a (conveniently) coloured (and glossy) body, instead of the white wall: as by throwing the beams from a yellow body upon a blue, there would be exhibited a kind of green, as in the experiments about colours is more fully declared.

9. I KNOW not whether I should on this occasion take notice, that when, as when looking upon the calm and smooth surface of a river betwixt my eye and the sun, it appeared to be a natural speculum, wherein that part, which reflected to my eye the entire and defined image of the sun, and the beams less remote from those which exhibited that image, appeared indeed of a great and whitish brightness, but the rest comparatively dark enough; if afterwards the superficies chanced to be a little, but not much troubled by a gentle breath of wind, and thereby reduced into a multitude of small and smooth speculums, the surface of the river would, suitably to the doctrine lately delivered, at a distance appear very much of kin to white, though it would lose that brightness or whiteness upon the return of the surface to calmness and an uniform level. And I have sometimes, for trial sake, brought by a lenticular glass the image of a river, shined upon by the sun, into an upper room darkened, and distant about a quarter of a mile from the river; by which means the numerous declining surfaces of the water appeared so contracted, that upon the body, that received the images, the whole river appeared a very white object at two or three paces distance. But if we drew near it, this whiteness appeared to proceed from an innumerable company of lucid reflections, from the several gently waved superficies of the water, which looked near at hand like a multitude of very little, but

shining scales of fish, of which many did every moment disappear, and as many were by the sun, wind and river generated anew. But though this observation seemed sufficiently to discover, how the appearing whiteness in that case was produced, yet in some other cases water may have the same, though not so vivid a colour upon other accounts; for oftentimes it happens, that the smooth surface of the water does appear bright or whitish, by reason of the reflection not immediately of the images of the sun, but of the brightness of the sky; and in such cases a convenient wind may where it passes along make the surface look black, by causing many such furrows and cavities, as may make the inflected superficies of the water reflect the brightness of the sky rather inward than outward. And again, if the wind increase into a storm, the water may appear white, especially near the shore and the ship; namely because the rude agitation breaks it into foam or froth. So much do whiteness and blackness depend upon the disposition of the superficial parts of a body, to reflect the beams of light inward or outward. But that as white bodies reflect the most light of any, so their superficial particles are, in the sense newly delivered, of a specular nature; I shall now further endeavour to shew, both by the making of specular bodies white, and the making of a white body specular.

10. IN the fifth place then, I will inform you, that (not to repeat what *Gassendus* observes concerning water) I have for curiosity sake distilled quicksilver in a cucurbit, fitted with a capacious glass-head, and observed, that when the operation was performed by the degrees of fire requisite for my purpose, there would stick to the inside of the alembick a multitude of little round drops of mercury: and as you know, that mercury is a specular body, so each of these little drops was a small round looking-glass; and a multitude of them lying thick and near one another, they did both in my judgment, and that of those invited to see it, make the glass they were fastened to, appear manifestly a white body. And yet, as I said, this whiteness depended upon the minuteness and nearness of the little mercurial globuli, the convexity of whose surfaces fitted them to represent in a narrow compass a multitude of little lucid images to differinglly situated beholders. And here let me observe a thing, that seems much to countenance the notion I have been recommending; namely, that whereas divers parts of the sky, and especially the milky way, do to the naked eye appear white, (as the name it self imports) yet the galaxy looked upon through the telescope does not shew white, but appears to be made up of a vast multitude of little stars; so that a multitude of lucid bodies, if they be so small, that they cannot singly or apart be discerned by the eye, and if they be sufficiently thick set by one another, may by their confused beams appear to the eye one white body. And why is it not possible, that the like may be done, when a multitude of bright and little corpuscles being crowded together, are made to send together vivid beams

to the eye, though they shine but, as the planets, by a borrowed light?

11. BUT to return to our experiments. We may take notice, that the white of an egg, though in part transparent, yet by its power of reflecting some incident rays of light, is in some measure a natural speculum, being long agitated with a whisk or spoon, loses its transparency, and becomes very white, by being turned into froth, that is, into an aggregate of numerous small bubbles, whose convex superficies fits them to reflect the light every way outwards. And it is worth noting, that when water, for instance, is agitated into froth, if the bubbles be great and few, the whiteness will be but faint, because the number of specula within a narrow compass is but small, and they are not thick set enough to reflect so many little images or beams of the lucid body, as are requisite to produce a vigorous sensation of whiteness. And partly, lest it should be said, that the whiteness of such globulous particles proceeds from the air included in the froth, (which to make good, it should be proved that the air it self is white;) and partly, to illustrate the better the notion we have proposed of whiteness, I shall add, that I purposely made this experiment: I took a quantity of fair water, and put to it, in a clear glass phial, a convenient quantity of oil or spirit of turpentine, because that liquor will not incorporate with water, and yet is almost as clear and colourless as it. These being gently shaken together, the agitation breaks the oil (which, as I said, is indisposed to mix like wine or milk *per minima* with the water) into a multitude of little globes, which each of them reflecting outwards a lucid image, make the imperfect mixture of the two liquors appear whitish; but if by vehemently shaking the glass, for a competent time, you make a further comminution of the oil into far more numerous and smaller globuli, and thereby confound it also better with the water, the mixture will appear of a much greater whiteness, and almost like milk: whereas if the glass be a while let alone, the colour will by degrees impair, as the oily globes grow fewer and bigger, and at length will quite vanish, leaving both the liquors distinct and diaphanous as before. And such a trial hath not ill succeeded, when instead of the colourless oil of turpentine, I took a yellow mixture made of a good proportion of crude turpentine dissolved in that liquor; and (if I mis-remember not) it also succeeded better than one would expect, when I employed an oil brought by filings of copper, infused in it, to a deep green. And this (by the way) may be the reason, why oftentimes when the oils of some spices and of aniseeds, &c. are distilled in a limbeck with water, the water (as I have several times observed) comes over whitish, and will perhaps continue so for a good while; because if the fire be made too strong, the subtil chymical oil is thereby much agitated and broken, and blended with the water in such numerous and minute globules, as cannot easily in a short time emerge to the top of the water, and whilst they remain in it, make

make it, for the reason newly intimated, look whitish. And perhaps upon the same ground a cause may be rendred, why hot water is observed to be usually more opacous and whitish, than the same water cold; the agitation turning the more spirituous or otherwise conveniently disposed particles of the water into vapours, thereby producing in the body of the liquor a multitude of small bubbles, which interrupt the free passage, that the beams of light would else have every way, and from the innermost parts of the water reflect many of them outwards. These and the like examples, *Pyrophilus*, have induced me to suspect, that the superficial particles of white bodies may for the most part be as well convex as smooth: I content my self to say, *suspect*, and *for the most part*, because it seems not easy to prove, that when diaphanous bodies, as we shall see by and by, are reduced into white powders, each corpúcle must needs be of a convex superficies, since perhaps it may suffice that specular surfaces look several ways. For (as we have seen) when a diaphanous body comes to be reduced to very minute parts, it thereby acquires a multitude of little surfaces within a narrow compass. And though each of these should not be of a figure convenient to reflect a round image of the sun, yet even from such an inconveniently figured body there may be reflected some (either streight or crooked) physical line of light; which line I call physical, because it has some breadth in it, and in which line in many cases some refraction of the light falling upon the body it depends on may contribute to the brightness: As if a slender wire, or solid cylinder of glass, be exposed to the light, you shall see in some part of it a vivid line of light; and if we were able to draw out and lay together a multitude of these little wires or thrids of glass, so slender, that the eye could not discern a distance betwixt the luminous lines, there is little doubt (as far as I can guess by a trial purposely made with very slender, but far less slender thrids of glass, whose aggregate was looked upon one way white) but the whole physical superficies composed of them would to the eye appear white; and if so, it will not be always necessary that the figure of those corpúcles, that make a body appear white, should be globulous. And as for snow it self, though the learned *Gassendus* (as we have seen above) makes it to seem nothing else but a pure frozen froth, consisting of exceedingly minute and thick-set bubbles; yet I see no necessity of admitting that, since not only by the variously and curiously figured snow, that I have divers times had the opportunity with pleasure to observe, but also by the common snow, it rather doth appear both to the naked eye, and in a microscope, often, if not most commonly, to consist principally of little slender icicles of several shaps, which afford such numerous lines of light, as we have been newly speaking of.

12. SIXTHLY, If you take a diaphanous body, as for instance a piece of glass, and reduce it to powder, the same body, which, when it was entire, freely transmitted the beams of

light, acquiring by contusion a multitude of minute surfaces, each of which is as it were a little, but imperfect speculum, is qualified to reflect, in a confused manner, so many either beams; or little and singly unobservable images of the lucid body, that from a diaphanous it degenerates into a white body. And I remember, I have for trial's sake taken lumps of rock crystal, and heating them red-hot in a crucible, I found, according to my expectation, that being quenched in fair water, even those, that remained in seemingly entire lumps, exchanged their translucency for whiteness, the ignition and extinction having as it were cracked each lump into a multitude of minute bodies, and thereby given it a great multitude of new surfaces. And even with diaphanous bodies, that are coloured, there may be this way a greater degree of whiteness produced, than one would lightly think; as I remember, I have by contusion obtained whitish powders of granates, glass of antimony, and emeralds finely beaten; and you may more easily make the experiment, by taking good venereal vitriol of a deep blue, and comparing with some of the entire crystals purposely reserved some of the subtile powder of the same salt, which will comparatively exhibit a very considerable degree of whitishness.

13. SEVENTHLY, And as by a change of position in the parts, a body that is not white may be made white; so by a slight change of the texture of its surface, a white body may be deprived of its whiteness. For if (as I have tried in gold-smiths shops) you take a piece of silver, that has been freshly boiled, as the artificers call it, (which is done by first brushing, and then decocting it with salt and tartar, and perhaps some other ingredients) you shall find it to be of a lovely white. But if you take a piece of smooth steel, and therewith burnish a part of it, which may be presently done, you shall find, that part will lose its whiteness, and turn a speculum, looking almost every where dark, as other looking-glasses do; which may not a little confirm our doctrine. For by this we may guess, what it is chiefly, that made the body white before, by considering that all, that was done to deprive it of that whiteness, was only to depress the little protuberances, that were before on the surface of the silver, into one continued superficies, and thereby effect this, that now the image of the lucid body, and consequently a kind of whiteness shall appear to your eye; but in some place of the greater silver looking-glass (whence the beams reflected at an angle equal to that wherewith they fall on it, may reach your eye) whilst the asperity remained undestroyed, the light falling on innumerable little specula obverted some one way, and some another, did from all sensibly distinguishable parts of the superficies reflect confused beams or representations of light to the beholder's eye, from whence soever he chance to look upon it. And among the experiments annexed to this discourse, you will find one, wherein, by the change of texture in bodies, whiteness is in a trice both generated and destroyed.

C H A P. II.

1. **W**HAT we have discoursed of whiteness, may somewhat assist us to form a notion of blackness, those two qualities being contrary enough to illustrate each other. Yet among the ancient philosophers I find less assistance to form a notion of blackness than of whiteness; only *Democritus* in the passage above recited out of *Aristotle* has given a general hint of the cause of this colour, by referring the blackness of bodies to their asperity. But this I call but a general hint, because those bodies that are green, and purple, and blue, seem to be so, as well as black ones, upon the account of their superficial asperity. But among the moderns, the formerly mentioned *Gassendus*, perhaps invited by this hint of *Democritus*, has incidentally in another epistle given us, though a very short, yet a somewhat clearer account of the nature of blackness in these words; *Existimare par est corpora suapte naturâ nigra constare ex particulis, quarum superficiem scabrae sint, nec facillè lucem extrorsum reflectant.* I wish this ingenious man had enlarged himself upon this subject; for indeed it seems, that as that, which makes a body white, is chiefly such a disposition of its parts, that it reflects (I mean without much interruption) more of the light that falls on it, than bodies of any other colour do; so that, which makes a body black, is principally a peculiar kind of texture, chiefly of its superficial particles, whereby it does as it were dead the light that falls on it, so that very little is reflected outwards to the eye.

2. **AND** this texture may be explicated two, and perhaps more than two several ways; whereof the first is by supposing in the superficies of the black body a particular kind of asperity, whereby the superficial particles reflect but few of the incident beams outwards, and the rest inwards towards the body it self. As if, for instance, we should conceive the surface of a black body to be asperated by an almost numberless throng of little cylinders, pyramids, cones, and other such corpuscles, which, by their being thick set and erected, reflect the beams of light from one to another inwards, and send them to and fro so often, that at length they are lost, before they can come to rebound out again to the eye. And this is the first of the two mentioned ways of explicating blackness. The other way is by supposing the texture of black bodies to be such, that either by their yielding to the beams of light, or upon some other account, they do as it were dead the beams of light, and keep them from being reflected in any plenty, or with any considerable vigour or motion, outwards. According to this notion it may be said, that the corpuscles, that make up the beams of light, whether they be solar effluvia, or minute particles of some ætherial substance, thrusting on one another from the lucid body, do, falling on black bodies, meet with such a texture, that such bodies receive into themselves, and retain almost all the motion communicated to them by the corpuscles that make up the beams of light, and consequently reflect but few of them,

or those but languidly, towards the eye; it happening here almost in like manner as to a ball, which thrown against a stone or floor would rebound a great way upwards, but rebounds very little or not at all, when it is thrown against water, or mud, or a loose net, because the parts yield, and receive into themselves the motion, on whose account the ball should be reflected outwards. But this last way of explicating blackness I shall content myself to have proposed, without either adopting it, or absolutely rejecting it. For the hardness of touch-stones, black marble, and other bodies, that being black are solid, seem to make it somewhat improbable, that such bodies should be of so yielding a texture, unless we should say, that some bodies may be more disposed to yield to the impulses of the corpuscles of light by reason of a peculiar texture, than other bodies, that in other trials appear to be softer than they. But though the former of these two explications of blackness be that, by which we shall endeavour to give an account of it; yet, as we said, we shall not absolutely reject this latter, partly because they both agree in this, that black bodies reflect but little of the light that falls on them, and partly because it is not impossible, that in some cases both the disposition of the superficial particles, as to figure and position, and the yielding of the body, or some of its parts, may jointly, though not in an equal measure concur to the rendering of a body black. The considerations, that induced me to propose this notion of blackness, as I explained it, are principally these:

3. **FIRST**, That as I lately said, whiteness and blackness being generally reputed to be contrary qualities, whiteness depending, as I said, upon the disposition of the parts of a body to reflect much light, it seems likely, that blackness may depend upon a contrary disposition of the black bodies surface; but upon this I shall not insist.

4. **NEXT** then we see, that if a body of one and the same colour be placed, part in the sun-beams, and part in the shade, that part which is not shined on will appear more of kin to blackness than the other, from which more light rebounds to the eye; and dark colours seem the blacker, the less light they are looked upon in; and we think all things black in the dark, when they send no beams to make impressions on our organs of sight: so that shadows and darkness are near of kin, and shadow, we know, is but a privation of light: and accordingly blackness seems to proceed from the paucity of beams reflected from the black body to the eye; I say, the paucity of beams, because those bodies, that we call black, as marble, jett, &c. are short of being perfectly so, else we should not see them at all. But though the beams, that fall on the sides of those erected particles, that we have been mentioning, do few of them return outwards, yet those, that fall upon the points of those cylinders, cones, or pyramids, may thence rebound to the eye, though they make there but a faint impression, because they arrive not there, but mingled with a great proportion of little shades.

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This may be confirmed by my having procured a large piece of black marble well polished, and brought to the form of a large spherical and concave speculum; for on the inside this marble being well polished, was a kind of dark looking-glass, wherein I could plainly see a little image of the sun, when that shined upon it. But this image was very far from offending and dazzling my eyes, as it would have done from another speculum; nor, though the speculum were large, could I in a long time, or in a hot sun, set a piece of wood on fire, though a far less speculum of the same form, and of a more reflecting matter, would have made it flame in a trice.

5. AND on this occasion we may as well in reference to something formerly delivered concerning whiteness, as in reference to what has been newly said, subjoin what we further observed touching the differing reflections of light from white and black marble; namely, that having taken a pretty large mortar of white marble, new, and polished in the inside, and exposed it to the sun, we found, that it reflected a great deal of glaring light, but so dispersed, that we could not make the reflected beams concur in any such conspicuous focus, as that newly taken notice of in the black marble; though perhaps there may enough of them be made to meet near the bottom, to make some kind of focus, especially since by holding in the night-time a candle at a convenient distance, we were able to procure a concourse of some, though not many of the reflected beams, at about two inches distant from the bottom of the mortar: but we found the heat even of the sun-beams so dispersedly reflected to be very languid, even in comparison of the black marble's focus. And the little picture of the sun, that appeared upon the white marble as a speculum, was but very faint and exceeding ill defined. Secondly, that taking two pieces of plain and polished surfaces, and casting on them successively the beams of the same candle, in such manner, as that the neighbouring superficies being shaded by an opacous and perforated body, the incident beams were permitted to pass but through a round hole of about half an inch diameter, the circle of light, that appeared on the white marble, was in comparison very bright, but very ill defined; whereas that on the black marble was far less luminous, but much more precisely defined.

6. THIRDLY, when you look upon a piece of linen, that has small holes in it, those holes appear very black, and men are often deceived in taking holes for spots of ink; and painters, to represent holes, make use of black; the reason of which seems to be, that the beams, that fall on those holes, fall into them so deep, that none of them is reflected back to the eye. And in narrow wells part of the mouth seems black, because the incident beams are reflected downwards from one side to another, till they can no more rebound to the eye.

WE may consider too, that if differing parts of the same piece of black velvet be stroaked opposite ways, the piece of velvet

will appear of two distinct kinds of blackness, the one far darker than the other; of which disparity the reason seems to be, that in the less obscure part of the velvet, the little filken piles, whereof it is made up, being inclined, there is a greater part of each of them obverted to the eye; whereas in the other part the piles of silk being more erected, there are far fewer beams reflected outwards from the lateral parts of each pile; so that most of those, that rebound to the eye, come from the tops of the piles, which make but a small part of the whole superficies, that may be covered by the piece of velvet. Which explication I propose, not that I think the blackness of the velvet proceeds from the cause assigned, since each single pile of silk is black by reason of its texture, in what position soever you look upon it; but that the greater blackness of one of these tufts seems to proceed from the greater paucity of beams reflected from it, and that from the fewness of those parts of a surface, that reflect beams, and the multitude of those shaded parts, that reflect none. And I remember, that I have oftentimes observed, that the position of particular bodies far greater than piles of silk in reference to the eye, may, notwithstanding their having each of them a colour of its own, make one part of their aggregate appear far darker than the other; for I have near great towns often taken notice, that a cart-load of carrots packed up appeared of a much darker colour when looked upon, where the points of the carrots were obverted to the eye, than where the sides of them were so.

7. FOURTHLY, In a darkened room, I purposely observed, that if the sun-beams, which came in at the hole, were received upon white or any other colour, and directed to a convenient place of the room, they would manifestly, though not all equally, increase the light of that part; whereas if we substituted, either a piece of black cloth or black velvet, it would so dead the incident beams, that the place (newly mentioned) whereto I obverted the black body, would be less enlightened than it was before, when it received its light but from the weak and oblique reflections of the floor and walls of a pretty large room, through which the beams, that came in at the hole, were confusedly and brokenly dispersed.

8. FIFTHLY, And to shew, that the beams, that fall on black bodies, as they do not rebound outwards to the eye, so they are reflected towards the body it self, as the nature of those erected particles, to which we have imputed blackness, requires, we will add an experiment, that will also confirm our doctrine touching whiteness; namely, that we took a broad and large tile, and having whitened over one half of the superficies of it, and blacked the other, we exposed it to the summer's sun; and having let it lie there a convenient time (for the difference is more apparent, if it have not lain there too long) we found, as we expected, that whilst the whited part of the tile remained cool enough, the blacked part of the same tile was grown not only sensible, but very hot, (sometimes to a strong degree.)

And to satisfy some of our friends the more, we have sometimes left upon the surface of the tile, besides the white and black parts thereof, a part, that retained the native red of the tile it self; and exposing them to the sun, we observed this last mentioned to have contracted a heat in comparison of the white, but a heat inferior to that of the black; of which the reason seems to be, that the superficial particles of black bodies, being, as we said, more erected, than those of white or red ones, the corpuscles of light falling on their sides, being for the most part reflected inward from one particle to another, and thereby engaged as it were, and kept from rebounding upwards, they communicate their brisk motion, wherewith they were impelled against the black body, (upon whose account, had they fallen upon a white body, they would have been reflected outwards) to the small parts of the black body, and thereby produce in those small parts such an agitation, as (when we feel it) we are wont to call heat. I have been lately informed, that an observation near of kin to ours has been made by some learned men in *France* and *Italy*, by long exposing to a very hot sun two pieces of marble, the one white and the other black. But though the observation be worthy of them; and may confirm the same truth with our experiment, yet besides that our trial needs not the summer, nor any great heat to succeed, it seems to have this advantage above the other, that whereas bodies more solid, and of a closer texture, though they use to be more slowly heated, are wont to receive a greater degree of heat from the sun or fire, than (*ceteris paribus*) bodies of a slighter texture; I have found by the information of stone-cutters, and by other ways of enquiry, that black marble is much solidier and harder than white; so that possibly the difference betwixt the degrees of heat, they receive from the sun-beams, will by many be ascribed to the difference of their texture, rather than to that of their colour; though I think our experiment will make it probable enough, that the greater part of that difference may well be ascribed to that disposition of parts, which makes the one reflect the sun-beams inward, and the other outwards. And with this doctrine accords very well, that rooms hung with black are not only darker than else they would be, but are wont to be warmer too; insomuch that I have known a great lady, whose constitution was somewhat tender, complain, that she was wont to catch cold, when she went out into the air, after having made any long visits to persons, whose rooms were hung with black. And this is not the only lady I have heard complain of the warmth of such rooms; which though perhaps it may be partly imputed to the effluvia of those materials, wherewith the hangings were dyed, yet probably the warmth of such rooms depends chiefly upon the same cause, that the darkness does; as (not to repeat what I formerly noted touching my gloves) to satisfy some curious persons of that sex, I have convinced them, by trial, that of two pieces of

filken stuff given to me by themselves, and exposed in their presence to the same window, shined on by the sun, the white was considerably heated, when the black was not so much as sensibly so.

9- SIXTHLY, I remember, that acquainting one day a Virtuoso of unsuspected credit, that had visited hot countries, with part of what I have here delivered concerning blackness, he related to me, by way of confirmation of it, a very notable experiment, which he had both seen others make, and made himself in a warm climate; namely, that having carefully blacked over eggs, and exposed them to the hot sun, they were thereby in no very long time well roasted; to which effect I conceive the heat of the climate must have concurred with the disposition of the black surface to reflect the sun-beams inward: for I remember, that having made that among other trials in *England*, though in summer-time, the eggs I exposed acquired indeed a considerable degree of heat, but yet not so intense a one, as proved sufficient to roast them.

10. SEVENTHLY, and lastly, our conjectures at the nature of blackness may be somewhat confirmed by the (formerly mentioned) observation of the blind *Dutchman*, that discerns colours with his fingers; for he says, that he feels a greater roughness upon the surfaces of black bodies, than upon those of red, or yellow, or green. And I remember, that the diligent *Bartolinus* says, that a blind Earl of *Mansfield* could distinguish white from black only by the touch; which would sufficiently argue a great disparity in the asperities, or other superficial textures of bodies of those two colours, if the learned relater had affirmed the matter upon his own knowledge.

11. THESE, *Pyrophilus*, are the chief things, that occur to me at present, about the nature of whiteness and blackness; which if they have rendered it so much as probable, that in most, or at least many cases, the causes of these qualities may be such as I have adventured to deliver, it is as much as I pretend to. For till I have opportunity to examine the matter by some further trials, I am not sure, but that in some white and black bodies, there may concur to the colour some peculiar texture or disposition of the body, whereby the motion of the small corpuscles, that make up the incident beams of light, may be differingly modified, before they reach the eye; especially in this, that white bodies do not only copiously reflect on those incident corpuscles outwards, but reflect them briskly, and do not otherwise alter them in the manner of their motion. Nor shall I now stay to inquire, whether some of those other ways (as a disposition to alter the velocity, the rotation, or the order and manner of appulse to the eye of the reflected corpuscles, that composed the incident beams of light) which we mentioned, when we considered the production of colours in general, may not in some cases be applicable to those of white and black bodies: for I am yet so much a seeker in this matter, and so little wedded to the

opinions

opinions I have proposed, that what I am to add, shall be but the beginning of a collection of experiments and observations towards the history of whiteness and blackness, without at

present interposing my explications of them; that so I may assist your enquiries, without much forestalling or byassing your judgment.

EXPERIMENT in CONSORT,

Touching WHITENESS and BLACKNESS.

EXPERIMENT I.

HAVING promised in the 27th page of the foregoing discourse of whiteness and blackness, to shew, that those two colours may, by a change of texture in bodies, each of them apart diaphanous and colourless, be at pleasure and in a trice as well generated as destroyed, we shall begin with experiments, that may acquit us of that promise.

TAKE then what quantity you please of fair water, and having heated it, put into it as much good common sublimate, as it is able to dissolve, and (to be sure of having it well glutted) continue putting in the sublimate, till some of it lie untouched in the bottom of the liquor. Filter this solution through cap-paper, to have it clear and limpid, and into a spoonful or two thereof (put into a clean glass-vessel) shake about four or five drops (according as you took more or less of this solution) of good limpid spirits of urine, and immediately the whole mixture will appear white like milk; to which mixture if you presently add a convenient proportion of rectified aqua-fortis (for the number of drops is hard to determine, because of the differing strength of the liquor, but easily found by trial) the whiteness will presently disappear, and the whole mixture become transparent; which you may, if you please, again reduce to a good degree of whiteness (though inferior to the first) only by a more copious affusion of fresh spirit of urine. *N. B.* First, that is is not so necessary to employ either aqua-fortis or spirit of urine about this experiment, but that we have made it with other liquors instead of these; of which perhaps more elsewhere. Secondly, that this experiment, though not made with the same menstruums, not producing the same colour, is yet much of kin to that other to be mentioned in this tract, among our other experiments of colours, about turning a solution of precipitate into an orange colour; and the chymical reason being much alike in both, the annexing it to one of them may suffice for both.

EXPERIMENT II.

MAKE a strong infusion of broken galls in fair water; and having filtered it into a clean phial, add more of the same liquor to it, till you have made it somewhat transparent, and sufficiently diluted the colour, for the credit of the experiment, lest otherwise the darkness of the liquor might make it be objected,

that it was already almost ink. Into this infusion shake a convenient quantity of a clear, but very strong solution of vitriol; and you shall immediately see the mixture turn black almost like ink, and such a way of producing blackness is vulgar enough; but if presently after you do upon this mixture drop a small quantity of good oil of vitriol, and, by shaking the phial, disperse it nimbly through the two other liquors, you shall (if you perform your part well, and have employed oil of vitriol clear and strong enough) see the darkness of the liquor presently begin to be discussed, and grow pretty clear and transparent, losing its inky blackness, which you may again restore to it by the affusion of a small quantity of a very strong solution of salt of tartar. And though neither of these atramentous liquors will seem other than very pale ink, if you write with a clean pen dipt in them; yet that is common to them with some sorts of ink, that prove very good when dry; as I have also found, that when I made these carefully, what I wrote with either of them, especially with the former, would, when thoroughly dry, grow black enough not to appear bad ink. This experiment of taking away, and restoring blackness from and to the liquors, we have likewise tried in common ink; but there it succeeds not so well, and but very slowly, by reason that the gum wont to be employed in the making it does by its tenacity oppose the operations of the above mentioned saline liquors. But to consider gum no more, what some kind of precipitation may have to do in the producing and destroying of inks without it, I have elsewhere given you some occasion and assistance to inquire: but I must not now stay to do so my self, only I shall take notice to you, that though it be taken for granted, that bodies will not be precipitated by alcalizate salts, that have not first been dissolved in some acid menstruums; yet I have found upon trials, which my conjectures led me to make on purpose, that divers vegetables, barely infused, or, but slightly decocted in common water, would, upon the affusion of a strong and clear lixivium of pot-ashes, and much more of some other precipitating liquors that I sometimes employ, afford good store of a curdled matter, such as I have had in the precipitations of vegetable substances, by the intervention of acid things; and that this matter was easily separable from the rest of the liquor, being left behind it in the filtre. And in making the first ink mentioned in this experiment, I found, that I could by filtration separate pretty store of

a black pulverable substance, that remained in the filtre; and when the ink was made clear again by the oil of vitriol, the affusion of dissolved *sal tartari* seemed but to precipitate, and thereby to unite and render conspicuous the particles of the black mixture, that had before been dispersed into very minute and singly invisible particles by the incisive and resolving power of the highly corrosive oil of vitriol.

AND to manifest, *Pyrophilus*, that galls are not so requisite as many suppose to the making atramentous liquors, we have sometimes the following experiment: we took dried rose-leaves, and decocted them for a while in fair water; into two or three spoonfuls of this decoction we shook a few drops of a strong and well filtrated solution of vitriol (which perhaps, had it been green, would have done as well) and immediately the mixture did turn black, and when into this mixture, presently after it was made, we shook a just proportion of aquafortis, we turned it from a black-ink to a deep red one, which by the affusion of a little spirit of urine may be reduced immediately to an opacous and blackish colour. And in regard, *Pyrophilus*, that in the former experiments, both the infusion of galls, and the decoction of roses, and the solution of copperas, employed about them, are endowed each of them with its own colour, there may be a more noble experiment of the sudden production of blackness made by the way mentioned in the second section of the second part of our essays; for though upon the confusion of the liquors there mentioned, there do immediately emerge a very black mixture; yet both the infusion of orpiment and the solution of minium were, before their being joined together, limpid and colourless.

EXPERIMENT III.

IF pieces of white hartshorn be with a competent degree of fire distilled in a glass-retort, they will, after the avolation of the phlegm, spirit, volatile salt, and the looser and the lighter parts of the oleaginous substance, remain behind of a coal-black colour. And even ivory it self being skilfully burnt (how I am wont to do it, I have elsewhere set down) affords painters one of the best and deepest blacks they have. And yet in the instance of distilled hartshorn, the operation being made in glass-vessels carefully closed, it appears there is no extraneous black substance, that insinuates it self into white hartshorn, and thereby makes it turn black; but that the whiteness is destroyed, and the blackness generated, only by a change of texture, made in the burnt body, by the recess of some parts, and the transposition of others. And though I remember not, that in many distillations of hartshorn I ever found the *Cap. mort.* to pass from black to a true whiteness, whilst it continued in closed vessels; yet having taken out the coal-black fragments, and calcined them in open vessels, I could in few hours quite destroy that blackness, and without sensibly changing their bulk or figure,

reduce them to great whiteness. So much do these two colours depend upon the disposition of the little parts, that the bodies, wherein they are to be met with, do consist of. And we find, that if white-wine tartar, or even the white crystals of such tartar be burnt without being truly calcined, the *Cap. mortuum* (as the chymists call the more fixt part) will be black. But if you further continue the calcination, till you have perfectly incinerated the tartar, and kept it long enough in a strong fire, the remaining calx will be white. And so we see, that not only other vegetable substances, but even white woods, as the hazel, will yield a black charcoal, and afterwards whitish ashes; and so animal substances naturally white, as bones and egg-shells, will grow black upon the being burnt, and white again, when they are perfectly calcined.

EXPERIMENT IV.

BUT yet I much question, whether that rule delivered by divers, as well as philosphers as chymists, *adusta nigra, sed perusta alba*, will hold as universally as is presumed, since I have several examples to alledge against it. For I have found, that by burning alabaster, so as both to make it appear to boil almost like milk, and to reduce it to a very fine powder, it would not at all grow black, but retain its pure and native whiteness; and though by keeping it longer than is usual in the fire, I produced but a faint yellow, even in that part of the powder, that lay nearest the top of the crucible; yet having purposely inquired of an experienced stone-cutter, who is curious enough in trying conclusions in his own trade, he told me he had found, that if alabaster or plaister of *Paris* be very long kept in a strong fire, the whole heap of burnt powder would exchange its whiteness for a much deeper colour than the yellow I observed. Lead being calcined with a strong fire turns (after having perhaps run through divers other colours) into minium, whose colour we know is a deep red; and if you urge this minium, as I have purposely done with a strong fire, you may much easier find a glassy and brittle body darker than minium, than any white calx or glass. It is known among chymists, that the white calx of antimony, by the further and more vehement operation of the fire, may be melted into glass, which we have obtained of a red colour, which is far deeper than that of the calx of burnt antimony. And though common glass of antimony being usually adulterated with borax, have its colour thereby diluted, oftentimes to a very pale yellow; yet not only ours made more sincerely was, as we said, of a colour less remote from black, than was the calx; but we observed, that by melting it once or twice more, and so exposing it to the further operation of the fire, we had, as we expected, the colour heightened. To which we shall add but this one instance, (which is worth the taking notice of, in reference to colours,) that, if you take blue, but unsophisticated, vitriol, and burn it very slowly, and with

with a gentle degree of heat, you may observe, that when it is burnt but a little, and yet so far as that you may rub it to powder betwixt your fingers, it will be of a white or whitish colour; but if you prosecute the calcination, this body, which by a light aduſtion was made white, will paſs through other colours, as gray, yellowiſh, and red; and if you further burn it with a long and vehement fire, by that time it comes to be *peruſtum*, it will be of a dark purple, nearer to black, not only than the firſt calx, but than the vitriol before it at all felt the fire. I might add, that *Crocus Martis* (*per ſe*, as they call it) made by the laſting violence of the reverberated flames is not ſo near a-kin to white, as the iron or ſteel that afforded it was before its calcinations; but that I ſuppoſe, theſe inſtances may ſuffice to ſatiſfy you, that minerals are to be excepted out of the forementioned rule, which perhaps, though it ſeldom fail in ſubſtances belonging to the vegetable or animal kingdom, may yet be queſtioned even in ſome of theſe, if that be true, which the judicious traveller *Bellonius* affirms, that charcoals made out of the wood of oxycedar are white: and I could not find, that though in retorts hart's-horn and other white bodies will be denigrated by heat, yet camphire would not at all loſe its whiteness, though I have purpoſely kept it in ſuch a heat, as made it melt and boil.

EXPERIMENT V.

AND now I ſpeak of camphire, it puts me in mind of adding this experiment, that though, as I ſaid, in cloſed glaſſes I could not denigrate it by heat, but it would ſublime to the ſides and top of the glaſs, as it was before; yet not only it will, being ſet on fire in the free air, ſend forth a copious ſmoke, but having purpoſely upon ſome of it that was flaming, clapt a large glaſs, almoſt in the form of a hive, (but more ſlender only) with a hole at the top, (which I cauſed to be made to try experiments of fire and flame in) it continued ſo long burning, that it lined all the inſide of the glaſs with a foot as black as ink, and ſo copious, that, the cloſeneſs of the veſſel conſidered, almoſt all that part of the white camphire, that did take fire, ſeemed to have been changed into that deep black ſubſtance.

EXPERIMENT VI.

AND this alſo brings into my mind another experiment, that I made about the production of blackneſs, whereof, for reaſons too long to be here deduced, I expected and found a good ſucceſs; and it was this: I took rectified oil of vitriol (that I might have the liquor clean as well as ſtrong) and by degrees mixt with it a convenient proportion of the eſſential oil, as chymiſts call it, of wormwood, drawn over with ſtore of water in a limbeck; and warily diſtilling the mixture in a retort, there remained a ſcarce credible quantity of dry matter, black as a coal. And becauſe the oil of wormwood, though a chymical oil drawn

by a Virtuoso, ſeemed to have ſomewhat in it of the colour of the plant, I ſubſtituted in its room the pure and ſubtile eſſential oil of winter-favory, and mixing little by little this liquor with (if I miſ-remember not) an equal weight of the formerly mentioned rectified oil of vitriol, and diſtilling them as before in a retort, beſides what there paſſed over into the receiver, even theſe two clear liquors left me a conſiderable proportion, (though not ſo great as the two former) of a ſubſtance black as pitch, which I yet keep by me as a rarity.

EXPERIMENT VII.

A WAY of whiting wax cheaply and in great quantity may be a thing of good oeconomicall uſe; and we have elſewhere ſet down the practice of tradſemen that blanch it; but here treating of whiteness only, in order to the philoſophy of colours, I ſhall not examine, which of the ſlow ways may be beſt employed, to free wax from the yellow melleous parts, but ſhall rather ſet down a quick way of making it white, though but in very ſmall quantities. Take then a little yellow wax, ſcraped or thinly ſliced, and putting it into a bolt's-head or ſome other convenient glaſs, pour to it a pretty deal of ſpirit of wine, and placing the veſſel in warm ſand, increaſe the heat by degrees, till the ſpirit of wine begin to ſimmer or to boil a little; and continuing that degree of fire, if you have put liquor enough, you will quickly have the wax diſſolved: then taking it off the fire, you may either ſuffer it to cool aſtaſtily as with ſafety to the glaſs you can, or pour it, whiſt it is yet hot, into a filtre of paper; and either in the glaſs where it cools, or in the filtre; you will ſoon find the wax and menſtrum together reduced into a white ſubſtance, almoſt like butter, which by letting the ſpirit exhale will ſhrink into a much leſſer bulk, but ſtill retaining its whiteness. And that, which is pretty in the working of this magiſtery of wax, is, that the yellowneſs vaniſhes, neither appearing in the ſpirit of wine, that paſſes limpid through the filtre, nor in the butter of wax, if I may ſo call it, that, as I ſaid, is white.

EXPERIMENT VIII.

THERE is an experiment, *Pyrophilus*, which though I do not ſo exactly remember; and though it be ſomewhat nice to make, yet I am willing to acquaint you with, becauſe the thing produced, though it be but a curioſity, is wont not a little to pleaſe the beholders; and it is a way of turning, by the help of a dry ſubſtance, an almoſt golden-coloured concrete into a white one. The ſeveral trials are not at preſent ſo freſh in my memory to enable me to tell you certainly, whether an equal only or a double weight of common ſublimite muſt be taken in reference to the tin-glaſs; but, if I miſtake not, there was in the experiment, that ſucceeded beſt, two parts of the former taken to one of the latter. Theſe ingredients being finely powdered and exactly mixed,

mixed, we sublimed together by degrees of fire (the due gradation of which is in this experiment a thing of main importance;) there ascended a matter of a very peculiar texture; for it was for the most part made up of very thin, smooth, soft and slippery plates, almost like the finest sort of scales of fishes, but of so lovely a white inclining to pearl-colour, and of so curious a colour and shining a gloss, that they appeared in some respect little inferior to orient pearls, and in other regards, they seemed to surpass them, and were applauded for a sort of the prettiest trifles, that we had ever prepared to amuse the eye. I will not undertake, that though you will hardly miss changing the colour of your shining tin-glass, yet you will upon the first or perhaps the second time hit right upon the way of making the glistering sublimate I have been mentioning.

EXPERIMENT IX.

WHEN we dissolve in aqua fortis a mixture of gold and silver melted into one lump, it usually happens, that the powder of gold, that falls to the bottom, as not being dissoluble by that menstruum, will not have its own yellow, but appear of a black colour, though neither the gold, nor the silver, nor the aqua fortis did before manifest any blackness. And divers alchymists, when they make solutions of minerals they would examine, are very glad, if they see a black powder precipitated to the bottom, taking it for a hopeful sign, that those particles are of a golden nature, which appear in a colour so ordinary to gold parted from other metals by aqua fortis, that it is a trouble to the refiner to reduce the precipitated calx to its native colour. For though (as we have tried) that may be quickly enough done by fire, which will make this gold look very gloriously (as indeed it is at least one of the best ways, that is practised for the refining of gold,) yet it requires both watchfulness and skill, to give it such a degree of fire, as will serve to restore it to its lustre, without giving it such a one, as may bring it to fusion, to which the minuteness of the corpuscles it consists of makes the powder very apt. And this brings into my mind, that having taken a flat and bright piece of gold, that was refined by a curious and skilful person on purpose to try to what height of purity gold could be brought by art, I found that this very piece, as glorious as it looked, being rubbed a little upon a piece of fine clean linnen, did sully it with a kind of black: and the like I have observed in refined silver, which I therefore mention, because I formerly suspected, that the impurity of the metal might have been the only cause of what I have divers times observed in wearing silver-hilted swords, namely, that where they rubbed upon my clothes, if they were of a light-coloured cloth, the affriction would quickly black them; and congruously hereunto I have found pens blacked almost all over, when I had a while carried them about me in a silver ink-case. To which I shall only add, that whereas in these several instances

of denigration, the metals are worn off, or otherwise reduced into very minute parts, that circumstance may prove not unworthy your notice.

EXPERIMENT X.

THAT a solution of silver does dye hair of a black colour, is a known experiment, which some persons, more curious than dextrous, have so unluckily made upon themselves, as to make their friends very merry. And I remember, that the other day I made my self some sport by an improvement of this observation; for having dissolved some pure silver in aqua fortis, and evaporated the *menstruum ad siccitatem*, as they speak, I caused a quantity of fair water to be poured upon the calx two or three several times, and to be at each evaporated, till the calx was very dry, and all the greenish blueness, that is wont to appear in common crystals of silver, was quite carried away. Then I made those I meant to deceive, moisten some part of their skin with their own spittle, and slightly rub the moistened parts with a little of this prepared silver; whereupon they admired to see, that a snow-white body laid upon the white skin should presently produce a deep blackness, as if the stans had been made with ink; especially considering, that this blackness could not, like that produced by ordinary ink, be readily washed off, but required many hours, and part of it some days to its obliteration. And with the same white calx and a little fair water we likewise stained the white hafts of knives, with a lasting black in those parts, where the calx was plentifully enough laid on; for where it was laid on but very thinly, the stain was not quite of so deep a colour.

EXPERIMENT XI.

THE cause of the blackness of those many nations, which by one common name we are wont to call Negroes, has been long since disputed of by learned men, who possibly had not done amiss, if they had also taken into consideration, why some whole races of other animals besides men, as foxes and hares, are distinguished by a blackness not familiar to the generality of animals of the same species. The general opinion (to be mentioned a little lower) has been rejected even by some of the ancient geographers, and among the moderns *Ortelius* and divers other learned men have questioned it. But this is no place to mention what thoughts I have had to and fro about these matters: only as I shall freely acknowledge, that to me the inquiry seems more abstruse than it does to many others, and that because consulting with authors, and with books of voyages, and with travellers, to satisfy my self in matters of fact, I have met with some things among them, which seem not to agree very well with the notions of the most classick authors concerning these things; for it being my present work to deliver rather matters historical than theories, I shall annex some few

of my collections, instead of a solemn disputation. It is commonly presumed, that the heat of the climates, wherein they live, is the reason, why so many inhabitants of the scorching regions of *Africa* are black; and there is this familiar observation to countenance this conjecture, that we plainly see that mowers, reapers, and other country-people, who spend the most part of the hot summer days exposed to the sun, have the skin of their hands and faces, which are the parts immediately exposed to the sun and air, made of a darker colour than before, and consequently tending to blackness: and contrariwise we observe, that the Danes and some other people that inhabit cold climates, and even the English who feel not so rigorous a cold, have usually whiter faces than the Spaniards, Portugals and other European inhabitants of hotter climates. But this argument I take to be far more specious than convincing; for though the heat of the sun may darken the colour of the skin by that operation, which we in English call sun-burning; yet experience doth not evince, that I remember, that that heat alone can produce a discolouring, that shall amount to a true blackness, like that of Negroes; and we shall see by and by, that even the children of the Negroes not yet ten days old (perhaps not so much by three quarters of that time) will notwithstanding their infancy be of the same hue with their parents. Besides, there is a strong argument to be alledged against the vulgar opinion, that in divers places in *Asia* under the same parallel, or even of the same degree of latitude with the African regions inhabited by the Blacks, the people are at most but tawny; and in *Africa* it self divers nations in the empire of *Ethiopia* are not Negroes, though situated in the torrid zone, and as near the equinoctial, as other nations that are so, (as the black inhabitants of *Zeylan* and *Malabar* are not in our globes placed so near the line as *Amara* the famous place in *Ethiopia*.) Moreover, (that which is of no small moment in our present disquisition) I find not by the best navigators and travellers to the *West-Indies*, whose books or themselves I have consulted on this subject, that excepting perhaps one place or two of small extent, there are any Blacks originally natives of any part of *America* (for the Blacks now there have been long by the Europeans long transplanted thither) though the new world contain in it so great a variety of climates, and particularly reach quite cross the torrid zone from one tropick to another. And though it be true, that the Danes be a whiter people than the Spaniards, yet that may proceed rather from other causes (not here to be enquired into) than from the coldness of the climate, since not only the Swedes and other inhabitants of those cold countries, are not usually so white as the Danes, nor whiter than other nations in proportion to their vicinity to the pole. [And since the writing of the former part of this essay, having an opportunity on a solemn occasion to take notice of the numerous train of some extraordinary ambassadors sent from the Russian emperor to a great

monarch, I observed, that (though it were then winter) the colour of their hair and skin was far less whitish than the Danes who inhabit a milder region is wont to be, but rather from the most part of a darkish brown; and the physician to the ambassador, with whom those Russians came, being asked by me, whether in *Muscovy* it self the generality of the people were more inclined to have dark-coloured hair than flaxen, he answered affirmatively; but seemed to suspect, that the true and ancient Russians, a sept of whom he told me he had met with in one of the provinces of that vast empire, were rather white like the Danes than any thing near so brown as the present Muscovites, whom he guesses to be descended of the Tartars, and to have inherited their colour from them.] But to prosecute our former discourse, I shall add for further proof the conjecture I was countenancing, that good authors inform us, that there are Negroes in *Africa* not far from the *Cape of Good Hope*, and consequently beyond the southern tropick, and without the torrid zone, much about the same northern latitude (or very little more) wherein there are divers American nations, that are not Negroes, and wherein the inhabitants of *Candia*, some parts of *Sicily*, and even of *Spain*, are not so much as Tawny-moors. But (which is a fresh and strong argument against the common opinion) I find by our recent relations of *Greenland*, (our accounts whereof we owe to the curiosity of that royal Virtuoso the present King of *Denmark*;) that the inhabitants are olive-coloured, or rather of a darker hue. But if the case were the same with men, and those other kinds of animals I formerly named, I should offer something as a considerable proof, that cold may do much towards the making men white or black; and however I shall set down the observation as I have met with it, as worthy to come into the history of whiteness and blackness; and it is, that in some parts of *Russia* and of *Livonia* it is affirmed by *Olaus Magnus* and others, that hares and foxes (some add partridges) which before were black, or red, or grey, do in the depth of winter become white by reason of the great cold; (for that it should be, as some conceive, by looking upon the snow, seems improbable upon divers accounts:) And I remember, that having purposely inquired of a Virtuoso, who lately travelled through *Livonia* to *Mosco*, concerning the truth of this tradition, he both told me, he believed it, and added, that he saw divers of those lately named animals either in *Russia* or *Livonia*, (for I do not very well remember whether of the two) which, though white when he saw them in winter, they assured him had been black, or other colours, before the winter began, and would be so again when it was over. But for further satisfaction, I also consulted one, that had for some years been an eminent physician in *Russia*, who though he rejected some other traditions, that are generally enough believed concerning that country, told me nevertheless, that he saw no cause to doubt of this tradition of *Olaus Magnus*, as to foxes and hares; not only because it is common

mon and uncontroled assertion of the natives ; but also because he himself in the winter could never, that he remembered, see foxes and hares of any other colour than white. And I my self having seen a small white fox, brought out of *Russia* into *England*, towards the latter end of winter, foretold those, that shewed him me, that he would change colour in summer ; and accordingly coming to look upon him again in *July*, I found, that the back and sides, together with the upper part of the head and tail, were already grown of a dark colour, the lower part of the head and belly containing as yet a whiteness. Let me add, that were it not for some scruple I have, I should think more than what *Olaus* relates confirmed by the judicious *Olearius*, who was twice employed into those parts as a publick minister, who in his account of *Muscovy* has this passage : *The hares there are grey ; but in some provinces they grow white in the winter.* And within some few lines after ; *It is not very difficult to find the cause of this change, which certainly proceeds only from the outward cold, since I know, that even in summer hares will change colour, if they be kept a competent time in a cellar.* I say, were it not for some scruple, because I take notice, that in the same page the author affirms, that the like change of colour, that happens to hares in some provinces of *Muscovy*, happens to them also in *Livonia* ; and yet immediately subjoins, that in *Courland* the hares vary not their colour in winter ; though these two last named countries be contiguous, that is, sever'd only by the river of *Dugna*. For it is scarce conceivable how cold alone should have, in countries so near, so strangely differing an operation, though no less strange a thing is confessed by many, that ascribe the complexion of Negroes to the heat of the sun, when they would have the river of *Cenega* so to bound the *Moors*, that though on the north-side they are but tawny, on the other side they are black.

THERE is another opinion concerning the complexion of Negroes, that is not only embraced by many of the more vulgar writers, but likewise by that ingenious traveller Mr. *Sandys*, and by a late most learned critick, besides other men of note ; and these would have the blackness of Negroes an effect of *Noah's* curse ratified by God's, upon *Cham*. But though I think, that even a Naturalist may without disparagement believe all the miracles attested by the holy scriptures, yet in this case, to fly to a supernatural cause, will, I fear, look like shifting off the difficulty, instead of resolving it ; for we inquire not the first and universal, but the proper, immediate, and physical cause of the jetty colour of Negroes ; and not only we do not find expressed in the scripture, that the curse meant by *Noah* to *Cham* was the blackness of his posterity, but we do find plainly enough there, that the curse was quite another thing, namely, that he should be a servant of servants, that is, by an Hebraism, a very abject servant to his brethren : which accordingly did in part come to pass, when the Israelites of the posterity of *Sem* subdued the Canaanites, that descended from *Cham*, and kept them in

great subjection. Nor is it evident, that blackness is a curse ; for navigators tell us of black nations, who think so much otherwise of their own condition, that they paint the devil white. Nor is blackness inconsistent with beauty, which even to our European eyes consists not so much in colour, as an advantageous stature, a comely symmetry of the parts of the body, and good features in the face. So that I see not, why blackness should be thought such a curse to the Negroes, unless perhaps it be, that being wont to go naked in those hot climates, the colour of their skin does probably, according to the doctrine above delivered, make the sun-beams more scorching to them, than they would prove to a people of a white complexion.

GREATER probability there is, that the principal cause (for I would not exclude all concurrent ones) of the blackness of Negroes is some peculiar and seminal impresson : for not only we see, that Blackmoor boys, brought over into these colder climates, lose not their colour ; but good authors inform us, that the offspring of Negroes transplanted out of *Africa*, above a hundred years ago, retain still the complexion of their progenitors, though possibly in tract of time it will decay ; as, on the other side, the white people removing into very hot climates, have their skins by the heat of the sun scorched into dark colours ; yet neither they, nor their children have been observed, even in the countries of Negroes, to descend to a colour amounting to that of the natives. Whereas I remember I have read in *Piso's* excellent account of *Brasil*, that betwixt the Americans and Negroes are generated a distinct sort of men, which they call *Cabocles* ; and betwixt Portugals and *Æthiopian* women, he tells us, he has sometimes seen twins, whereof one had a white skin, the other a black : not to mention here some other instances he gives, that the productions of the mixtures of differing people, that is (indeed) the effects of seminal impressons, which they consequently argue to have been their causes. And we shall not much scruple at this, if we consider, that even organical parts may receive great differences from such peculiar impressons, upon what account soever they came to be settled in the first individual persons, from whom they are propagated to posterity, as we see in the blobber-lips and flat-noses of most nations of Negroes. And if we may credit what learned men deliver concerning the little feet of the Chineses, the *Macrocephali* taken notice of by *Hippocrates* will not be the only instance we might apply to our present purpose. And on this occasion it will not perchance be impertinent to add something of what I have observed in other animals, as there are a sort of hens, that want rumps ; and that (not to mention, that in several places there is a sort of crows or daws, that are not coal-black as ours, but partly of a whitish colour) in sight of *Pophry's* examples of inseparable accidents, I have seen a perfectly white raven, as to bill as well as feathers, which I attentively considered, for fear of being imposed upon. And this recalls into my memory, what

Piso Nat. & Med. Hist. Brasil. lib. 1. in fine.

what a very ingenious physician has divers times related to me of a young lady, to whom being called, he found, that though she much complained of want of health, yet there appeared so little cause either in her body, or her condition, to guess, that she did any more than fancy herself sick, that scrupling to give her physick, he persuaded her friends rather to divert her mind by little journeys of pleasure; in one of which going to visit St. Winifred's well, this lady, who was a catholick, and devout in her religion, and a pretty while in the water to perform some devotions, and had occasion to fix her eyes very attentively upon the red pebble-stones, which in a scattered order made up a good part of those that appeared through the water, and a while after growing big, she was delivered of a child, whose white skin was copiously speckled with spots of the colour and bigness of those stones; and though now this child have already lived several years, yet she still retains them. I have but two things to add concerning the blackness of Negroes; the one is, that the seat of that colour seems to be but the thin epidermis, or outward skin; for I knew a young Negro, who having been lightly sick of the small-pox or measles, (for it was doubted, which of the two was his disease) I found by inquiry of a person, that was concerned for him, that in those places the little tumours had broke their passage through the skin, when they were gone, they left whitish specks behind them; and the lately commended *Piso* assures us, that having the opportunity in *Brasil* to dissect many Negroes, he clearly found, that their blackness went no deeper than the very outward skin, which cuticula or epidermis being removed, the undermost skin or cutis appeared just as white as that of European bodies. And the like has been affirmed to me by a physician of our own, whom hearing he had dissected a Negro here in *England*, I consulted about this particular. The other thing to be here taken notice of concerning Negroes is, that having inquired of an intelligent acquaintance of mine (who keeps in the *Indies* about three hundred of them, as well women as men, to work in his plantations,) whether their children come black into the world; he answered, that they did not, but were brought forth of almost the like reddish colour with our European children: and having further inquired, how long it was before these infants appeared black, he replied, that it was not wont to be many days. And agreeable to this account I find that given us in a freshly published French book, written by a Jesuit, that had good opportunity of knowing the truth of what he delivers; for being one of the missionaries of his order into the Southern *America* upon the laudable design of converting infidels to Christianity, he baptized several infants, which when newly born were much of the same colour with European babes, but within about a week began to appear of the hue of their parents. But more pregnant is the testimony of our countryman *Andrew Battel*, who being sent prisoner by the Portugals to *Angola*, lived there, and in the

adjoining regions, partly as a prisoner, partly as a pilot, and partly as a soldier, near eighteen years; and he mentioning the African kingdom of *Longo*, peopled with Blacks, has this passage: *The children in this country are born white, and change their colour in two days to a perfect black.* As for example, *The Portugals, which dwell in the kingdom of Longo, have sometimes children by the Negro-women; and many times the fathers are deceived, thinking, when the child is born, that it is theirs, and within two days it proves the son or daughter of a Negro, which the Portugals greatly grieve at.* And the same person has elsewhere a relation, which, if he have made no use at all of the liberty of a traveller, is very well worth our notice; since this, together with that we have formerly mentioned of seminal impressions, shews a possibility, that a race of Negroes might be begun, though none of the sons of *Adam* for many precedent generations were of that complexion. For I see not, why it should not be at least as possible, that white parents may sometimes have black children, as that African Negroes should sometimes have lastingly white ones; especially since concurrent causes may easily more befriend the productions of the former kind, than under the scorching heat of *Africa* those of the latter. And I remember on the occasion of what he delivers, that of the white raven formerly mentioned, the possessor affirmed to me, that in the nest, out of which he was taken white, they found with him but one other young one, and that he was of as jetty a black as any common raven. But let us hear our author himself: *Here are* (says he, speaking of the formerly mentioned regions) *born in this country white children, which is very rare among them, for their parents are Negroes; and when any of them are born, they are presented to the king, and are called Dondos; these are as white as any white men. These are the king's witches, and are brought up in witchcraft, and always wait on the king: there is no man, that dares meddle with these Dondos; if they go to the market, they may take what they list, for all men stand in awe of them. The king of Longo bath four of them.* And yet this country in our globes is placed almost in the midst of the torrid zone, (four or five degrees southward of the line.) And our author elsewhere tells us of the inhabitants, that they are so fond of their blackness, that they will not suffer any, that is not of that colour (as the Portugals that come to trade thither) to be so much as buried in their land; of which he annexes a particular example, that may be seen in his voyage preserved by our industrious countryman Mr. *Purchas*. But it is high time for me to dismiss observations, and go on with experiments.

EXPERIMENT XII.

THE way, *Pyrophilus*, of producing whiteness by chymical precipitations is very well worth our observing; for thereby bodies, of very differing colours as well as natures, though dissolved in several liquors, are all brought

brought into calces or powders that are white. Thus we find, that not only crabs-eyes, that are of themselves white, and pearls that are almost so, but coral and minium that are red, being dissolved in spirit of vinegar, may be uniformly precipitated by oil of tartar into white powders. Thus silver and tin separately dissolved in aqua fortis will the one precipitate it self, and the other be precipitated by common salt-water into a white calx, and so will crude lead and quicksilver first dissolved likewise in aqua fortis. The like calx will be afforded, as I have tried, by a solution of that shining mineral tin-glass dissolved in aqua fortis, and precipitated out of it; and divers of these calces may be made at least as fair and white, if not better coloured, if instead of oil of tartar they were precipitated with oil of vitriol, or with another liquor I could name. Nay, that black mineral antimony it self, being reduced by and with the salts, that concur to the composition of common sublimate, into that clear though unctuous liquor, that chymists commonly call rectified butter of antimony, will, by the bare affusion of store of fair water, be struck down into that snow-white powder, which when the adhering saltiness is well washed off, chymists are pleased to call *Mercurius Vitæ*; though the like powder may be made of antimony, without the addition of any mercury at all. And this lactescence, if I may so call it, does also commonly ensue, when spirit of wine, being impregnated with those parts of gums or other vegetable concretions, that are supposed to abound with sulphureous corpuscles, fair water is suddenly poured upon the tincture or solution. And I remember, that very lately I did, for trial sake, on a tincture of Benjamin drawn with spirit of wine, and brought to be as red as blood, pour some fair water; which presently mingling with the liquor, immediately turned the whole mixture white. But if such seeming milks be suffered to stand unstirred for a convenient while, they are wont to let fall to the bottom a resinous substance, which the spirit of wine diluted and weakened by the water poured into it is unable to support any longer. And something of kin to this change of colour in vegetables is that, which chymists are wont to observe upon the pouring of acid spirits upon the red solution of sulphur, dissolved in an infusion of pot-ashes, or in some other sharp lixivium; the precipitated sulphur, before it subsides, immediately turning the red liquor into a white one. And other examples might be added of this way of producing whiteness in bodies by precipitating them out of the liquors, wherein they have been dissolved. But I think it may be more useful to admonish you, *Pyrophilus*, that this observation admits of restrictions, and is not so universal, as by this time perhaps you have begun to think it: for though most precipitated bodies are white, yet I know some that are not; for gold dissolved in aqua regis, whether you precipitate it with oil of tartar, or with spirit of sal armoniack, will not afford a white, but a yellow calx. Mercury also, though reduced into sublimate, and precipitated with

liquors abounding with volatile salts, as the spirits drawn from urine, hartshorn, and other animal substances, yet will afford, as we noted in our first experiment about whiteness and blackness, a white precipitate; yet with the solution of pot-ashes and other lixiviate salts, it will let fall an orange-tawny powder. And so will crude antimony, if being dissolved in a strong lye, you pour (as far as I remember) any acid liquor upon the solution newly filtrated, whilst it is yet warm. And if upon the filtrated solution of vitriol, you pour a solution of one of these fixed salts, there will subside a copious substance, very far from having any whiteness, which the chymists are pleased to call (how properly I have elsewhere examined,) the sulphur of vitriol. So that most dissolved bodies being by precipitation brought to white powders, and yet some affording precipitates of other colours, the reason of both the phenomena may deserve to be inquired into.

EXPERIMENT XIII.

SOME learned modern writers are of opinion, that the account, upon which whiteness and blackness ought to be called, as they commonly are, the two extreme colours, is, that blackness (by which I presume is meant the bodies endowed with it) receives no other colours; but whiteness very easily receives them all: whence some of them compare whiteness to the *Aristotelian Materia prima*, that being capable of any sort of forms, as they suppose white bodies to be of every kind of colour. But not to dispute about names or expressions, the thing itself, that is affirmed as matter of fact, seems to be true enough in most cases, not in all, or so as to hold universally. For though it be a common observation among dyers, that cloaths, which have once been thoroughly imbued with black, cannot so well afterwards be dyed into lighter colours, the pre-existent dark colour infecting the ingredients, that carry the lighter colour to be introduced, and making it degenerate into some more sad one; yet the experiments lately mentioned may shew us, that where the change of colour in black bodies is attempted, not by mingling bodies of lighter colours with them, but by addition of such things as are proper to alter the texture of those corpuscles that contain the black colour, it is no such difficult matter, as the lately mentioned learned men imagine, to alter the colour of black bodies. For we saw, that inks of several kinds might in a trice be deprived of all their blackness; and those made with logwood and red-roses might also be changed, the one into a red, the other into a reddish liquor; and with oil of vitriol I have sometimes turned black pieces of silk into a kind of yellow; and though the taffaty were thereby made rotten, yet the spoiling of that does no way prejudice the experiment, the change of black silk into yellow being never the less true, because the yellow silk is the less good. And as for whiteness, I think the general affirmation of its being so easily destroyed, or transmuted by any other colour,

See Scalliger Exercit. 325. Sect. 9.

ought not to be received without some cautions and restrictions. For whereas, according to what I formerly noted, lead is by calcination turned into that red powder we call minium, and tin by calcination reduced to a white calx; the common putty, that is sold and used so much in shops, instead of being, as it is pretended and ought to be, only the calx of tin, is, by the artificers that make it, to save the charge of tin, made (as some of themselves have confessed, and as I long suspected by the cheap rate it may be bought for) but of half tin and half lead, if not far more lead than tin; and yet the putty, in spite of so much lead, is a very white powder, without disclosing any mixture of minium. And so if you take two parts of copper, which is a high coloured metal, to but one of tin, you may by fusion bring them into one mass, wherein the whiteness of the tin is much more conspicuous and predominant than the reddishness of the copper. And on this occasion it may not be impertinent to mention an experiment, which I relate upon the credit of a very honest man, whom I purposely inquired of about it, being my self not very fond of making trials with arsenick: the experiment is this; that if you colligate arsenick and copper in a due proportion, the arsenick will blanch the copper both within and without, which is an experiment well enough known. But when I inquired, whether or no this white mixture being skilfully kept a while upon the cupel would not let go its arsenick, which made whiteness its predominant colour, and return to the reddishness of copper, I was assured of the affirmative. So that among mineral bodies, some of those that are white, may be far more capable, than those I am reasoning with seem to have known, of eclipsing others, and of making their colour predominant in mixtures. In further confirmation of which may be added, that I remember, that I also took a lump of silver and gold melted together, wherein, by the estimate of a very experienced refiner, there might be about a fourth or third part of gold; and yet the yellow colour of the gold was so hid by the white of the silver, that the whole mass appeared to be but silver; and when it was rubbed upon the touch-stone, an ordinary beholder could scarce have distinguished it from the touch of common silver; though if I put a little aqua fortis upon any part of the white surface it had given the touch-stone, the silver in the moistened part being immediately taken up and concealed by the liquor; the golden particles would presently disclose that native yellow, and look rather as if gold, than if the above mentioned mixture had been rubbed upon the stone.

EXPERIMENT XIV.

I TOOK a piece of black horn, (polished as being part of a comb;) this with a piece of broken glass I scraped into many thin and curdled flakes, some shorter and some longer; and having laid a pretty quantity of these scrapings together, I found, as I looked for, that

the heap they composed was white; and though, if I laid it upon a clean piece of white-paper, its colour seemed somewhat eclipsed by the greater whiteness of the body it was compared with, looking somewhat like linen, that had been sullied by a little wearing; yet if I laid it upon a very black body, as upon a beaver hat, it then appeared to be of a good white. Which experiment, that you may in a trice make when you please, seems very much to disavour both their doctrine, that would have colours to flow from the substantial forms of bodies; and that of the chymists also, who ascribe them to one or other of their three hypostatical principles: for though in our case there was so great a change made, that the same body, without being substantially either increased or lessened, passes immediately from one extreme colour to another (and that too from black to white) yet this so great and sudden change is effected by a slight mechanical transposition of parts, there being no salt or sulphur or mercury, that can be pretended to be added or taken away, nor yet any substantial form, that can reasonably be supposed to be generated and destroyed, the effect proceeding only from a local motion of the parts, which so varied their position, as to multiply their distinct surfaces, and to qualify them to reflect far more light to the eye, than they could before they were scraped off from the entire piece of black horn.

EXPERIMENT XV.

AND now, *Pyrophilus*, it will not be improper for us to take some notice of an opinion touching the cause of blackness, which I judged it not so seasonable to question, till I had set down some of the experiments, that might justify my dissent from it. You know, that of late divers learned men, having adopted the three hypostatical principles, besides other notions of the chymists, are very inclinable to reduce all qualities of bodies to one or other of those three principles; and particularly assign for the cause of blackness the sooty steam of adust or torrifed sulphur. But I hope, that what we have delivered above to countenance the opinion we have proposed about the cause of blackness, will so easily supply you with several particulars, that may be made use of against this opinion, that I shall now represent to you but two things concerning it.

AND first, it seems, that the favourers of the chymical theories might have pitcht upon some more proper term, to express the efficient of blackness than sulphur adust; for we know, that common sulphur, not only when melted, but even when sublimed, does not grow black by suffering the action of the fire, but continues and ascends yellow, and rather more than less white, than it was before its being exposed to the fire. And if it be set on fire, as when we make that acid liquor, that chymists call *Oleum Sulphuris per campanam*, it affords very little soot; and indeed the flame yields so little, that it will scarce in any degree black a sheet of white

white paper, held a pretty while over the flame and smoke of it, which is observed rather to whiten than infect linen, and which does plainly make red roses grow very pale, but not at all black, as far as the smoke is permitted to reach the leaves. And I can shew you a sort of fixt sulphur made by an industrious laborant of your acquaintance, who assured me, that he was wont to keep it for divers weeks together night and day in a naked and violent fire, almost like that of the glass-house; and when, to satisfy my curiosity, I made him take out a lump of it, though it were glowing hot (and yet not melted) it did not, when I had suffered it to cool, appear black, the true colour of it being a true red. I know it may be said, that chymists in the opinion above recited mean the principle of sulphur, and not common sulphur, which receives its name, not from its being all perfectly of a sulphureous nature, but for that plenty and predominancy of the sulphureous principle in it. But allowing this, it is easy to reply, that according to this very reason, torrifed sulphur should afford more blackness than most other concretes, wherein that principle is confessed to be far less copious. Also when I have exposed camphire to the fire in close vessels, as inflammable, and consequently (according to the chymists) as sulphureous a body as it is, I could not by such a degree of heat as brought it to fusion, and made it boil in the glass, impress any thing of blackness, or of any other colour, than its own pure white, upon this vegetable concrete. But what shall we say to spirit of wine, which being made by a chymical analysis of the liquor that affords it, and being totally inflammable, seems to have a full right to the title they give it of *Sulphur Vegetabile*? and yet this fluid sulphur not only contracts not any degree of blackness by being often so heated, as to be made to boil, but when it burns away with an actual flame, I have not found, that it would discolour a piece of white paper held over it, with any discernable soot. Tin also, that wants not, according to the chymists, a *Sulphur Joviale*, when thoroughly burned by the fire into a calx, is not black, but eminently white. And I lately noted to you out of *Bechmius*, that the charcoals of Oxy-cedar are not of the former of these two colours, but of the latter. And the smoke of our *Tinby* coals here in *England* has been usually observed rather to blanch linen than to black it. To all which other particulars of the like nature might be added; but I rather chuse to put you in mind of the third experiment, about making black liquors, or ink, of bodies, that were none of them black before. For how can it be said, that when those liquors are put together actually cold, and continue so after their mixture, there intervenes any new aduption of sulphur to produce the emergent blackness? (and the same question will be applicable to the blackness produced upon the blade of a knife, that has cut lemons and some kind of sour apples, if the juice, though both actually and potentially cold, be not quickly wiped off.) And when by the in-

stilling either of a few drops of oil of vitriol, as in the second experiment, or of a little of the liquor mentioned in the passage pointed at in the fourth experiment, (where I teach at once to destroy one black ink, and make another) the blackness produced by those experiments is presently destroyed; if the colour proceeded only from the plenty of sulphurous parts, torrifed in the black bodies, I demand what becomes of them, when the colour so suddenly disappears? For it cannot reasonably be said, that all those, that sufficed to make so great a quantity of black matter, should resort to so very small a proportion of the clarifying liquor, (if I may so call it) as to be diluted by it, without at all denigrating it. And if it be said, that the instilled liquor dispersed those black corpuscles, I demand, how that dispersion comes to destroy their blackness, but by making such a local motion of their parts, as destroys their former texture? Which may be a matter of such moment in cases like ours, that I remember, that I have in few hours, without addition, from soot it self, attained pretty store of crystalline salt, and good store of transparent liquor; and (which I have on another occasion noted as remarkable) this so black substance had its colour so altered, by the change of texture it received from the fire, wherewith it was distilled, that it did for a great while afford such plenty of very white exhalations, that the receiver, though large, seemed to be almost filled with milk.

SECONDLY, But were it granted, as it is in some cases not improbable, that divers bodies may receive a blackness from a sooty exhalation, occasioned by the aduption of their sulphur, which (for the reasons lately mentioned) I should rather call their oily parts; yet still this account is applicable but to some particular bodies, and will afford us no general theory of blackness. For if, for example, white hartshorn being, in vessels well luted to each other, exposed to the fire, be said to turn black by the infection of its own smoke, I think I may justly demand, what it is that makes the smoke or soot it self black, since no such colour, but its contrary, appeared before in the hartshorn? And with the same reason, when we are told, that torrifed sulphur makes bodies black, I desire to be told also, why torrefaction makes sulphur it self black? Nor will there be any satisfactory reason assigned of these queries, without taking in those fertile as well as intelligible mechanical principles of the position and texture of the minute parts of the body in reference to the light and the eye; and these applicable principles may serve the turn in many cases, where the aduption of sulphur cannot be pretended; as in the appearing blackness of an open window lookt upon at a somewhat remote distance from the house; as also in the blackness men think they see in the holes, that happen to be in white linen, or paper of the like colour; and in the increasing blackness immediately produced barely by so rubbing velvet, whose piles were inclined before, as to reduce them

them to a more erected posture; in which and in many other cases formerly alledged, there appears nothing requisite to the production of the blackness, but the hindering of the incident beams of light from rebounding plentifully enough to the eye. To be short; those I reason with, do concerning blackness what the chymists are wont also to do concerning other qualities; namely, to content themselves to tell us, in what ingredient of a mixt body, the quality inquired after does reside, instead of explicating the nature of it, which (to borrow a comparison from their own laboratories) is much as if in an inquiry after the cause of salivation, they should think it enough to tell us, that the several kinds of precipitates of gold and mercury, as likewise of quicksilver and silver (for

I know the make and use of such precipitates also) do salivate upon the account of the mercury, which though disguised abounds in them; whereas the difficulty is as much to know upon what account mercury it self, rather than other bodies, has that power of working by salivation. Which I say not, as though it were not something (and too often the most we can arrive at) to discover in which of the ingredients of a compounded body the quality, whose nature is sought, resides; but because, though this discovery it self may pass for something, and is oftentimes more than what is taught us about the same subjects in the schools, yet we ought not to think it enough, when more clear and particular accounts are to be had.

The Experimental History of COLOURS begun.

PART III.

Containing promiscuous Experiments about COLOURS.

EXPERIMENT I.

BECAUSE that, according to the conjectures I have above proposed, one of the most general causes of the diversity of colours in opacous bodies, is, that some reflect the light mingled with more, others with less of shade, (either as to quantity, or as to interruption;) I hold it not unfit to mention, in the first place, the experiments, that I thought upon to examine this conjecture. And though coming to transcribe them out of some physiological *Adversaria* I had written in loose papers, I cannot find one of the chief records I had of my trials of this nature, yet the papers, that escaped miscarrying, will, I presume, suffice to manifest the main thing, for which I now alledge them. I find then among my *Adversaria* the following narrative.

October the 11th, About ten in the morning in sun-shiny weather, (but not without fleeting clouds) we took several sorts of paper stained, some of one colour, and some of another; and in a darkened room, whose window looked southward, we cast the beams, that came in at a hole about three inches and a half in a diameter, upon a white wall, that was placed on one side, about five foot distance from them.

THE white gave much the brightest reflection.

THE green, red, and blue being compared together, the red gave much the strongest reflection, and manifestly enough also threw its colour upon the wall: the green and blue were scarce discernable by their colours, and seemed to reflect an almost equal light.

THE yellow, compared with the two last named, reflected somewhat more light.

THE red and purple being compared together,

the former manifestly reflected a good deal more light.

THE blue and purple compared together, the former seemed to reflect a little more light, though the purple colour were more manifestly seen.

A SHEET of very well flecked marbled paper being applied as the others, did not cast any of its distinct colours upon the wall, nor throw its light upon it with an equal diffusion; but threw the beams unstained and bright to this and that part of the wall, as if its polish had given it the nature of a specular body. But comparing it with a sheet of white paper, we found the reflection of the latter to be much stronger, it diffusing almost as much light to a good extent as the marble paper did to one part of the wall.

THE green and purple left us somewhat in suspense, which reflected the most light; only the purple seemed to have some little advantage over the green, which was dark in its kind.

THUS much I find in our above mentioned collections; among which there are also some notes concerning the production of compounded colours, by reflection from bodies differently coloured. And these notes we intended should supply us with what we should mention as our second experiment: but having lost the paper, that contained the particulars, and remembering only in general, that if the objects, which reflected the light, were not strongly coloured and somewhat glossy, the reflected beams would not manifestly make a compounded colour upon the wall, and even then but very faintly; we shall now say no more of that matter, only reserving our selves to mention hereafter the composition of a green, which we still retain in memory.

EXPERIMENT II.

WE may add, *Pyrophilus*, on this occasion, that though a darkened room be generally thought requisite to make the colour of a body appear by reflection from another body, that is not one of those, that are commonly agreed upon to be specular, (as polished metal, quicksilver, glass, water, &c.) yet I have often observed, that when I wore doublets lined with some silken stuff, that was very glossy and vividly coloured, especially red, I could in an enlightened room plainly enough discern the colour upon the pure white linen, that came out at my sleeve, and reached to my cuffs; as if that fine white body were more specular than coloured and unpolished bodies are thought capable of being.

EXPERIMENT III.

WHILST we were making the newly mentioned experiments, we thought fit to try also what composition of colours might be made by altering the light in its passage to the eye, by the interposition not of perfectly diaphanous bodies (that having been already tried by others as well as by us, as we shall soon have occasion to take notice) but of semi-opacous bodies, and those such as looked upon in an ordinary light, and not held betwixt it and the eye, are not wont to be discriminated from the rest of opacous bodies. Of this trial our mentioned *Adversaria* present us the following account:

HOLDING these sheets, sometimes one, sometimes the other of them, before the hole betwixt the sun and the eye, with the coloured sides obverted to the sun; we found them single to be somewhat transparent, and appear of the same colour as before, only a little altered by the great light they were placed in: but laying two of them one over another, and applying them so to the hole, the colours were compounded as follows.

THE blue and yellow scarce exhibited any thing but a darker yellow, which we ascribed to the coarseness of the blue paper, and its darkness in its kind. For applying the blue parts of the marbled paper with the yellow paper after the same manner, they exhibited a good green.

THE yellow and red looked upon together gave us but a dark red, somewhat (and but a little) inclining to an orange colour.

THE purple and red looked on together appeared more scarlet.

THE purple and yellow made an orange.

THE green and red made a dark orange-tawny.

THE green and purple made the purple appear more dirty.

THE blue and purple made the purple more lovely, and far more deep.

THE red parts of the marbled paper, looked upon with the yellow, appeared of a red far more like scarlet than without it.

BUT the fineness or coarseness of the papers,

their being carefully or slightly coloured, and divers other circumstances, may so vary the events of such experiments as these, that if, *Pyrophilus*, you would build much on them, you must carefully repeat them.

EXPERIMENT IV.

THE triangular prismatical glass being the instrument, upon whose effects we may the most commodiously speculate the nature of emphatical colours, (and perhaps that of others too;) we thought it might be useful to observe the several reflections and refractions, which the incident beams of light suffer in rebounding from it, and passing through it. And this we thought might be best done, not (as is usual) in an ordinary enlightened room, where (by reason of the difficulty of doing otherwise) even the curious have left particulars unheeded, which may in a convenient place be easily taken notice of; but in a darkened room, where by placing the glass in a convenient posture, the various reflections and refractions may be distinctly observed; and where it may appear, what beams are untinged, and which they are, that, upon the bodies, that terminate them, do paint either the primary or secondary iris. In pursuance of this we did, in the abovementioned darkened room, make observation of no less than four reflections, and three refractions, that were afforded us by the same prism; and thought, that, notwithstanding what was taught us by the rules of catoptricks and dioptricks, it would not be amiss to find also, by hiding sometimes one part of the prism, and sometimes another, and observing where the light or colour vanished thereupon, by which reflection and by which refraction each of the several places whereon the light rebounding from, or passing through, the prism, appeared either sincere or tinged, was produced. But because it would be tedious, and not so intelligible to deliver this in words, I have thought fit to refer you to the annexed scheme, where the newly mentioned particulars may be at one view taken notice of.

EXPERIMENT V.

I KNOW not whether you will think it inconsiderable to annex to this experiment, that we observed in a room not darkened, that the prismatical iris (if I may so call it) might be reflected without losing any of its several colours (for we now consider not their order) not only from a plain looking-glass and from the calm surface of fair water, but also from a concave looking-glass; and that refraction did as little destroy those colours as reflection. For by the help of a large (double convex) burning-glass, through which we refracted the sunbeams, we found, that one part of the iris might be made to appear either beyond, or on this side of the other parts of the same iris; but yet the same vivid colours would appear in the displaced part (if I may so term it) as in the other. To which I shall add, that having, by hiding the side of the prism, obverted

to the sun with an opacous body, wherein only one small hole was left for the light to pass through, reduced the prismatical iris (cast upon white paper) into a very narrow compass, and looked upon it through a microscope; the colours appeared the same as to kind, that they did to the naked eye.

EXPERIMENT VI.

IT may afford matter of speculation to the inquisitive, such as you, *Pyrophilus*, that as the colours of outward objects brought into a darkened room do so much depend for their visibility upon the dimness of the light they are there beheld by, that the ordinary light of the day being freely let in upon them, they immediately disappear; so our trials have informed us, that as to the prismatical iris painted on the floor by the beams of the sun trajected thorough a triangular glass, though the colours of it appear very vivid even at noon-day, and in sun-shiny weather, yet by a more powerful light they may be made to disappear. For having sometimes, (in prosecution of some conjectures of mine not now to be insisted on) taken a large metalline concave speculum, and with it cast the converging beams of the sun upon a prismatical iris, which I had caused to be projected upon the floor, I found, that the over-powerful light made the colours of the iris disappear. And if I so reflected the light, as that it crossed but the middle of the iris, in that part only the colours vanished or were made invisible; those parts of the iris, that were on the right and left hand of the reflected light (which seemed to divide them, and cut the iris asunder) continuing to exhibit the same colours as before. But upon this we must not now stay to speculate.

EXPERIMENT VII.

IHAVE sometimes thought it worth while to take notice, whether or no the colours of opacous bodies might not appear to the eye somewhat diversified, not only by the disposition of the superficial parts of the bodies themselves, and by the position of the eye in reference to the object and the light, (for these things are notorious enough;) but according also to the nature of the lucid body, that shines, upon them. And I remember, that in prosecution of this curiosity, I observed a manifest difference in some kinds of coloured bodies looked on by day-light, and afterwards by the light of the moon, either directly falling on them, or reflected upon them from a concave looking-glass. But not finding at present, in my collections about colours, any thing set down of this kind, I shall, till I have opportunity to repeat them, content myself to add what I find registered concerning colours looked on by candle-light, in regard that not only the experiment is more easy to be repeated, but the objects being the same sorts of coloured paper lastly mentioned, the collation of the two experiments may help to make the conjectures they will suggest somewhat the less uncertain.

WITHIN a few days of the time above mentioned, divers sheets of coloured paper, that had been looked upon before in the sun-shine, were looked upon at night by the light of a pretty big candle (snuffed;) and the changes that were observed were these:

THE yellow seemed much fainter than in the day, and inclinable to a pale straw-colour.

THE red seemed little changed; but seemed to reflect light more strongly than any other colour, (for white was none of them.)

A FAIR deep green looked upon by itself, seemed to be a dark blue: but being looked upon together with a dark blue, appeared greenish; and beheld together with a yellow, appeared more blue than at first.

THE blue looked more like a deep purple or murray, than it had done in the day-light.

THE purple seemed very little altered.

THE red looked upon with the yellow made the yellow look almost like brown cap-paper.

N. B. THE caution subjoined to the third experiment is also applicable to this.

EXPERIMENT VIII.

BUT here I must not omit to subjoin, that to satisfy our selves, whether or no the light of a candle were not made unsincere, and as it were tinged with a yellow colour, by the admixtion of the corpuscles it assumes from its fuel; we did not content ourselves with what appears to the naked eye, but taking a pretty thick rod or cylinder (for thin pieces would not serve the turn) of deep blue glass, and looking upon the candle's flame at a convenient distance through it, we perceived, as we expected, the flame to look green: which, as we often note, is the colour wont to emerge from the composition of opacous bodies, which were apart one of them blue, and the other yellow. And this perchance may be the main reason of that, which some observe, that a sheet of very white paper being looked upon by candle-light, it is not easy at first to discern it from a light yellow or lemon colour; white bodies (as we have elsewhere observed) having more than those, that are otherwise coloured, of a specular nature; in regard that though they exhibit not (unless they be polished) the shape of the luminary, that shines on them, yet they reflect its light more sincere and untroubled, by either shades or refractions, than bodies of other colours, (as blue, or green, or yellow, or the like.)

EXPERIMENT IX.

WE took a leaf of such foliated gold, as apothecaries are wont to gild their pills with; and with the edge of a knife, (lightly moistened by drawing it over the surface of the tongue, and afterwards) laid upon the edge of the gold leaf, we so fastened it to the knife, that being held against the light, it continued extended like a little flag. This leaf being held

very

very near the eye, and obverted to the light, appeared so full of pores, that it seemed to have such a kind of transparency, as that of a sieve, or a piece of cypress, or a love-hood; but the light that passed by these pores was in its passages so tempered with shadow, and modified, that the eye discerned no more a golden colour, but a greenish blue. And for others satisfaction, we did in the night look upon a candle through such a leaf of gold; and by trying the effect of several proportions of distance betwixt the leaf, the eye and the light, we quickly hit upon such a position for the leaf of gold, as that the flame, looked on through it, appeared of a greenish blue, as we have seen in the day-time. The like experiment tried with a leaf of silver succeeded not well.

EXPERIMENT X.

WE have sometimes found in the shops of our druggists a certain wood, which is there called *Lignum Nepbriticum*, because the inhabitants of the country, where it grows, are wont to use the infusion of it made in fair water against the stone of the kidneys. And indeed an eminent physician of our acquaintance, who has very particularly inquired into that disease, assures me, that he has found such an infusion one of the most effectual remedies, which he has ever tried against that formidable disease. The ancientest account I have met with of this simple, is given us by the experienced *Monardes* in these words: *Nobis, says he, Nova Hispania mittit quoddam ligni genus crassum & enode, cujus usus jam diu receptus fuit in his regionibus ad renum vitia, & urine difficultates ac arenulas pellendas. Fit autem hac ratione; lignum assulatim & minutim concisum in limpidissima aqua fontana maceratur, inque ea relinquitur, donec aqua à bibentibus absumpta sit; dimidia hora post injectum lignum aqua cæruleum colorem contrahit, qui sensim intenditur pro temporis diuturnitate, tametsi lignum candidum sit.* This wood, *Pyrophilus*, may afford us an experiment, which, besides the singularity of it, may give no small assistance to an attentive considerer towards the detection of the nature of colours. The experiment, as we made it, is this: Take *Lignum Nepbriticum*, and with a knife cut it into thin slices; put about a handful of these slices into two, three or four pound of the purest spring-water; let them infuse there a night; but if you be in haste, a much shorter time may suffice. Decant this impregnated water into a clear glass phial; and if you hold it directly between the light and your eye, you shall see it wholly tinted, (excepting the very top of the liquor, wherein you will sometimes discern a sky-coloured circle) with an almost golden colour, unless your infusion have been made too strong of the wood; for in that case it will against the light appear somewhat dark and reddish, and requires to be diluted by the addition of a convenient quantity of water. But if you hold this phial from the light, so that your eye be placed betwixt the win-

dow and the phial, the liquor will appear of a deep and lovely ceruleous colour, of which also the drops, if any be lying on the outside of the glass, will seem to be very perfectly. And thus far we have tried the experiment, and found it to succeed even by the light of candles of the larger size. If you so hold the phial over against your eyes, that it may have a window on one side of it, and a dark part of the room both before it and on the other side, you shall see the liquor partly of a blueish and partly of a golden colour. If turning your back to the window, you pour out some of the liquor towards the light and towards your eyes, it will seem at the coming out of the glass to be perfectly ceruleous; but when it is fallen down a little way, the drops may seem particoloured, according as the beams of light do more or less fully penetrate and illustrate them. If you take a basin about half full of water, and having placed it so in the sun-beams shining into a room, that one part of the water may be freely illustrated by the beams of light, and the other part of it darkened by the shadow of the brim of the basin; if then, I say, you drop of our tincture, made somewhat strong, both into the shaded and illuminated parts of the water, you may by looking upon it from several places, and by a little agitation of the water, observe divers pleasing phænomena, which were tedious to particularize. If you pour a little of this tincture upon a sheet of white paper, so as the liquor may remain of some depth upon it, you may perceive the neighbouring drops to be partly of one colour, and partly of the other, according to the position of your eye in reference to the light when it looks upon them; but if you pour off the liquor, the paper will seem dyed of an almost yellow colour. And if a sheet of paper with some of this liquor in it be placed in a window where the sun-beams may shine freely on it, then if you turn your back to the sun and take a pen or some such slender body, and hold it over-thwart betwixt the sun and the liquor, you may perceive, that the shadow projected by the pen upon the liquor will not all of it be a vulgar and dark, but in part a curiously coloured shadow; that edge of it, which is next the body that makes it, being almost of a lively golden colour, and the remoter verge of a ceruleous one.

THESE and other phænomena, which I have observed in this delightful experiment, divers of my friends have looked upon not without some wonder; and I remember an excellent oculist, finding by accident in a friend's chamber a fine phial full of this liquor, which I had given that friend, and having never heard any thing of the experiment, nor having any body near him, that could tell him what this strange liquor might be, was a great while apprehensive, as he presently after told me, that some strange new distemper was invading his eyes. And I confess, that the unusualness of the phænomena made me very solicitous to find out the cause of this experiment; and though I am far from pretending to have found it, yet my inquiries have, I suppose, enabled me to give

Nicolaus
Monardes
lib. simplic.
ex India
allator.
cap. 27.

give such hints, as may lead your greater sagacity to the discovery of the cause of this wonder. And first finding that this tincture, if it were too copious in the water, kept the colours from being so lively, and their change from being so discernable, and finding also that the impregnating virtue of this wood did by its being frequently infused in new water by degrees decay; I conjectured that the tincture afforded by the wood must proceed from some subtiler parts of it drawn forth by the water, which swimming to and fro in it, did so modify the light, as to exhibit such and such colours: and because these subtiler parts were so easily soluble even in cold water, I concluded that they must abound with salts, and perhaps contain much of the essential salt, as the chymists call it, of the wood. And to try whether these subtiler parts were volatile enough to be distilled, without the dissolution of their texture, I carefully distilled some of the tinted liquor in very low vessels, and the gentle heat of a lamp furnace; but found all that came over to be as limpid and colourless as rock-water, and the liquor remaining in the vessel to be so deeply ceruleous, that it required to be opposed to a very strong light to appear of any other colour. I took likewise a phial with spirit of wine, and a little salt of hartshorn, and found that there was a certain proportion to be met with betwixt the liquor and the salt, which made the mixture fit to exhibit some little variety of colours not observable in ordinary liquors, as it was variously directed in reference to the light and the eye; but this change of colour was very far short from that which we had admired in our tincture. But however, I suspected that the tinging particles did abound with such salts, whose texture, and the colour springing from it, would probably be altered by piercing acid salts, which would in likelihood either make some dissipation of their parts, or associate themselves to the like bodies, and either way alter the colour exhibited by them; whereupon pouring into a small phial, full of impregnated water, a very little spirit of vinegar, I found that, according to my expectation, the ceruleous colour immediately vanished, but was deceived in the expectation I had, that the golden colour would do so too; for, which way soever I turned the phial, either to or from the light, I found the liquor to appear always of a yellowish colour and no other. Upon this I imagined that the acid salts of the vinegar having been able to deprive the liquor of its ceruleous colour, a sulphureous salt being of a contrary nature, would be able to mortify the saline particles of vinegar, and destroy their effects; and accordingly having placed my self betwixt the window, and the phial, and into the same liquor dropt a few drops of oil of tartar *per deliquium*, (as chymists call it) I observed with pleasure, that immediately upon the diffusion of this liquor, the impregnated water was restored to its former ceruleous colour; and this liquor of tartar being very ponderous, and falling at first to the bottom of the phial, it was easy to observe that for a little

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while the lower part of the liquor appeared deeply ceruleous, whilst all the upper part retained its former yellowness, which it immediately lost as soon as either agitation or time had made a competent diffusion of the liquor of tartar through the body of the former tincture; and this restored liquor did, as it was looked upon against or from the light, exhibit the same phenomena as the tinted water did, before either of the adventitious liquors was poured into it.

HAVING made, *Pyrophilus*, divers trials upon this nephritick wood, we found mention made of it by the industrious Jesuit *Kircherus*, who having received a cup turned of it from the Mexican procurator of his society, has probably received also from him the information he gives us concerning that exotick plant; and therefore partly for that reason, and partly because what he writes concerning it, does not perfectly agree with what we have delivered, we shall not scruple to acquaint you in his own words, with as much of what he writes concerning our wood, as is requisite to our present purpose. *Hoc loco (says he) neuiquam omit-tendum duximus quoddam ligni candidi Mexicani genus, quod indigenæ Coalle & Tlapazatl vocant, quod etsi experientia hucusque non nisi ceruleo a-quam colore tingere docuerit, nos tamen continua experientia invenimus id aquam in omne colorum genus transformare, quod merito cuiuspiam paradoxum videri posset; ligni frutex grandis, ut aiunt, non raro in molem arboris excrescit, truncus illius est crassus, enodis, instar piri arboris, folia ciceris foliis, aut rutæ haud absimilia, flores exigui, oblongi, lutei & spicatum digesti, est frigida & humida planta, licet parum recedat à medio temperamento. Hujus itaque descriptæ arboris lignum in poculum efformatum, aquam eidem infusam primo in aquam intense ceruleam, colore floris buglossæ, tingit, & quo diutius in eo steterit, tanto intensiorem colorem acquirit. Hanc igitur aquam si vitriæ spheræ infuderis, lucique exposueris, ne ullum quidem cerulei coloris vestigium apparebit, sed instar aquæ puræ putæ fontanæ limpidam claramque aspicientibus se præbebit. Porro si hanc phialam vitream versus locum magis umbrosam direxeris, totus humor gratissimum virorem referet; si adhuc umbrosioribus locis, subrubrum, & sic pro rerum objectarum conditione, mirum dictu, colorem mutabit; in tenebris verò vel in vase opaco posita, ceruleum colorem suum resumet.*

In this passage we may take notice of the following particulars. And first, he calls it a white Mexican wood, whereas (not to mention that *Monardes* informs us that it is brought out of *Nova Hispania*) the wood that we have met with in several places, and employed as *Lignum Nephriticum*, was not white, but for the most part of a much darker colour, not unlike that of the sadder coloured wood of juniper. It is true, that *Monardes* himself also says, that the wood is white; and it is affirmed, that the wood which is of a sadder colour is adulterated by being imbued with the tincture of a vegetable, in whose decoction it is steeped. But having purposely inquired of the eminentest of our English druggists, he per-

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emptorily

emptorily denied it. And indeed, having considered some of the fairest round pieces of this wood that I could meet with in these parts, I had opportunity to take notice that in one or two of them it was the external part of the wood that was white, and the more inward part that was of the other colour; the contrary of which would probably have appeared, if the wood had been adulterated after the aforementioned manner. And I have at present by me a piece of such wood, which for about an inch next the bark is white, and then, as it were, abruptly passes to the abovementioned colour; and yet this wood, by the tincture it afforded us in water, appears to have its coloured part genuine enough: for as for the white part, it appears, upon trial of both at once, much less enriched with the tingent property.

NEXT, whereas our author tells us, that the infusion of this wood exposed in a phial to the light, looks like spring-water, in which, he afterwards adds, that there is no tincture to be seen in it; our observation and his agree not: for the liquor which opposed to the darker part of a room exhibits a sky-colour, did constantly, when held against the light, appear yellowish or reddish, according as its tincture was more dilute or deep; and then, whereas it has been already said, that the ceruleous colour was by acid salts abolished, this yellowish one survived without any considerable alteration, so that unless our author's words be taken in a very limited sense, we must conclude, that either his memory misinformed him, or that his white nephritick wood, and the fadder coloured one which we employed, were not altogether of the same nature. What he mentions of the cup made of *Lignum Nephriticum*, we have not had opportunity to try, not having been able to procure pieces of that wood great enough, and otherwise fit to be turned into cups; but as for what he says in the title of his experiment, that this wood tinges the water with all sorts of colours, that is much more than any of those pieces of nephritick wood that we have hitherto employed, was able to make good; the change of colours discernable in a phial full of water, impregnated by any of them, as it is directed towards a place more lightsome or obscure, being far from affording a variety answerable to so promising a title. And as for what he tells us, that in the dark the infusion of our wood will resume a ceruleous colour, I wish he had informed us how he tried it.

BUT this brings into my mind, that having sometimes, for curiosity sake, brought a round phial with a long neck filled with the tincture of *Lignum Nephriticum* into the darkened room already often mentioned, and holding it sometimes in, sometimes near the sun-beams that entered at the hole, and sometimes partly in them, and partly out of them, the glass being held in several postures, and looked upon from several neighbouring parts of the room, disclosed a much greater variety of colours than in ordinary enlightened rooms it is wont to do; exhibiting, besides the usual colours, a red in some parts, and a green in others, besides

intermediate colours produced by the differing degrees, and odd mixtures of light and shade.

By all this you may see, *Pyrophilus*, the reasonableness of what we elsewhere had occasion to mention, when we have divers times told you, that it is useful to have new experiments tried over again, though they were, at first, made by knowing and candid men; such reiterations of experiments commonly exhibiting some new phenomena, detecting some mistake or hinting some truth, in reference to them, that was not formerly taken notice of. And some of our friends have been pleased to think, that we have made no unuseful addition to this experiment, by shewing a way, how in a moment our liquor may be deprived of its blueness, and restored to it again by the affusion of a few drops of liquors, which have neither of them any colour at all of their own. And that which deserves some particular wonder, is, that the ceruleous tincture of our wood is subject by the former method to be destroyed or restored, the yellowish or reddish tincture continuing what it was. And that you may see, that salts are of a considerable use in the striking of colours, let me add to the many experiments which may be afforded us to this purpose by the dyers trade, this observation; that as far as we have hitherto tried, those liquors in general that are strong of acid salts have the power of destroying the blueness of the infusion of our wood, and those liquors indiscriminately that abound with sulphureous salts (under which I comprehend the urinous and volatile salts of animal substances, and the alcalizate or fixed salts that are made by incineration) have the virtue of restoring it.

A Corollary of the TENTH EXPERIMENT.

THAT this experiment, *Pyrophilus*, may be as well useful as delightful to you, I must mind you, *Pyrophilus*, that in the newly mentioned observation, I have hinted to you a new and easy way of discovering in many liquors (for I dare not say in all) whether it be an acid or sulphureous salt, that is predominant; and that such a discovery is oftentimes of great difficulty, and may frequently be of great use, he that is not a stranger to the various properties and effects of salts, and of how great moment it is to be able to distinguish their tribes, may readily conceive. But to proceed to the way of trying other liquors by an infusion of our wood, take it briefly thus. Suppose I have a mind to try whether I conjecture aright, when I imagine that allom, though it be plainly a mixt body, does abound rather with acid than sulphureous salt: To satisfy my self herein, I turn my back to the light, and holding a small phial full of the tincture of *Lignum Nephriticum*, which, looked upon in that position, appears ceruleous, I drop into it a little of a strong solution of allom made in fair water; and finding upon the affusion and shaking of this new liquor, that the blueness formerly conspicuous on our tincture does presently vanish, I am thereby incited to suppose, that the salt predominant in allom

allom belongs to the family of four salts. But if on the other side I have a mind to examine whether or no I rightly conceive that salt of urine, or of hartshorn is rather of a saline sulphureous (if I may so speak) than of an acid nature, I drop a little of the saline spirit of either into the nephritick tincture, and finding that the ceruleous colour is rather thereby deepned than destroyed, I collect that the salts, which constitute these spirits, are rather sulphureous than acid. And to satisfy my self yet farther in this particular, I take a small phial of fresh tincture, and placing both it and my self in reference to the light as formerly, I drop into the infusion just as much distilled vinegar, or other acid liquor as will serve to deprive it of its blueness, (which a few drops, if the four liquor be strong, and phial small, will suffice to do;) then without changing my posture, I drop and shake into the same phial a small proportion of spirit of hartshorn or urine, and finding that upon this affusion the tincture immediately recovers its ceruleous colour, I am thereby confirmed in my former opinion, of the sulphureous nature of these salts. And so, whereas it is much doubted by some modern chymists to what sort of salt, that which is predominant in quicklime belongs, we have been persuaded to refer it rather to lixivate than acid salts; by having observed, that though an evaporated infusion of it will scarce yield such a salt, as ashes and other alcalizate bodies are wont to do, yet if we deprive our nephritick tincture of its blueness by just so much distilled vinegar as is requisite to make that colour vanish, the lixivium of quicklime will immediately upon its affusion recall the banished colour, but not so powerfully as either of the sulphureous liquors formerly mentioned. And therefore I allow my self to guess at the strength of the liquors examined by this experiment, by the quantity of them which is sufficient to destroy or restore the ceruleous colour of our tincture. But whether concerning liquors, wherein neither acid nor alcalizate salts are eminently predominant, our tincture will enable us to conjecture any thing more than that such salts are not predominant in them, I take not upon me to determine here, but leave to further trial; for I find not that spirit of wine, spirit of tartar freed from acidity, or chymical oil of turpentine, (although liquors which must be conceived very saline, if chymists have, which is here no place to dispute, rightly ascribed tastes to the saline principle of bodies,) have any remarkable power either to deprive our tincture of its ceruleous colour, or restore it, when upon the affusion of spirit of vinegar it has disappeared.

EXPERIMENT XI.

AND here I must not omit, *Pyrophilus*, to inform you, that we can shew you even in a mineral body something that may seem very near of kin to the changeable quality of the tincture of *Lignum Nephriticum*;

for we have several flat pieces of glass, of the thickness of ordinary panes for windows, one of which being interposed betwixt the eye and a clear light, appears of a golden colour, not much unlike that of the moderate tincture of our wood; but being so looked upon as that the beams of light are not so much trajected through it as reflected from it to the eye, that yellow seems to degenerate into a pale blue, somewhat like that of a turquoise. And that which may also appear strange, is this, that if in a certain posture you hold one of these plates perpendicular to the horizon, so that the sunbeams shine upon half of it, the other half being shaded, you may see that the part shined upon will be of a much diluter yellow than the shaded part, which will appear more richly coloured; and if you alter the posture of the glass, so that it be not held perpendicular, but parallel in reference to the horizon, you may see, (which perhaps you will admire) the shaded part look of a golden colour, but the other that the sun shines freely on, will appear considerably blue, and as you remove any part of the glass thus held horizontally into the sunbeams or shade, it will in the twinkling of an eye seem to pass from one of the above mentioned colours to the other; the sunbeams trajected through it upon a sheet of white-paper held near it, do colour it with yellow, somewhat bordering upon a red, but yet the glass may be so opposed to the sun, that it may upon paper project a mixed colour here and there more inclined to yellow, and here and there more to blue. The other phenomena of this odd glass, I fear it would be scarce worth while to record; and therefore I shall rather advertise you, first, that in the trying of these experiments with it, you must take notice that one of the sides has either alone, or at least principally, its superficial parts disposed to the reflection of the blue colour above named, and that therefore you must have a care to keep that side nearest to the eye. And next, that we have our selves made glasses not unfit to exhibit an experiment not unlike that I have been speaking of, by laying upon pieces of glass some very finely foliated silver, and giving it by degrees a much stronger fire than is requisite or usual for the tinging of glasses of other colours. And this experiment, not to mention that it was made without a furnace, in which artificers that paint glass are wont to be very curious, is the more considerable, because, that though a skilful painter could not deny to me that it was with silver he coloured his glasses yellow; yet he told me, that when to burn them (as they speak) he lays on the plates of glass, nothing but a calx of silver calcined without corrosive liquors, and tempered with fair water, the plates are tinged of a fine yellow that looks of a golden colour, which part soever of it you turn to or from the light; whereas (whether it be what an artificer would call over-doing, or burning, or else the employing the silver crude that makes the difference) we have found more than once, that some pieces of glass prepared as we have related,

lated, though held against the light they appeared of a transparent yellow, yet looked on with one's back turned to the light, they exhibited an untransparent blue.

EXPERIMENT XII.

IF you will allow me, *Pyrophilus*, for the avoiding of ambiguity, to imploy the word pigments, to signify such prepared materials (as cochineal, vermilion, orpiment,) as painters, dyers, and other artificers make use of to impart or imitate particular colours; I shall be the better understood in divers passages of the following papers, and particularly when I tell you, that the mixing of pigments being no inconsiderable part of the painters art, it may seem an incroachment in me to meddle with it. But I think I may easily be excused (though I do not altogether pass it by) if I restrain myself to the making of a transient mention of some few of their practices about this matter; and that only so far forth, as may warrant me to observe to you, that there are but few simple and primary colours (if I may so call them) from whose various compositions all the rest do as it were result. For though painters can imitate the hues (though not always the splendor) of those almost numberless differing colours that are to be met with in the works of nature, and of art, I have not yet found, that to exhibit this strange variety they need imploy any more than white, and black, and red, and blue, and yellow; these five, variously compounded, and (if I may so speak) decomposed, being sufficient to exhibit a variety and number of colours, such, as those that are altogether strangers to the painters pallets, can hardly imagine.

Thus (for instance) black and white differing mixed, make a vast company of lighter and darker greys.

BLUE and yellow make a huge variety of greens.

RED and yellow make orange tawny.

RED with a little white makes a carnation.

RED with an eye of blue, makes a purple; and by these simple compositions again compounded among themselves, the skilful painter can produce what kind of colour he pleases, and a great many more than we have yet names for. But, as I intimated above, it is not my design to prosecute this subject, though I thought it not unfit to take some notice of it, because we may hereafter have occasion to make use of what has been now delivered; to illustrate the generation of intermediate colours; concerning which we must yet subjoin this caution, that to make the rules about the emergency of colours fit to be relied upon, the corpuscles whereof the pigments consist must be such as do not destroy one another's texture; for in case they do, the produced colour may be very different from that which would result from the mixture of other harmless pigments of the same colours, as I shall have occasion to shew ere long.

EXPERIMENT XIII.

IT may also give much light to an inquirer into the nature of colours, to know that not only in green, but in many (if not all) other colours, the light of the sun passing through diaphanous bodies of differing hues may be tinged of the same compound colour, as if it came from some painters colours of the same denomination, though this later be exhibited by reflection, and be (as the former experiment declares) manifestly compounded of material pigments. Wherefore to try the composition of colours by trajection, we provided several plates of tinged glass, which being laid two at a time, one on the top of another, the object looked upon through them both, appeared of a compounded colour, which agrees well with what we have observed in the second experiment, of looking against the light through differing coloured papers. But we thought the experiment would be more satisfactory, if we procured the sun-beams to be so tinged in their passage through plates of glass, as to exhibit the compounded colour upon a sheet of white paper. And though by reason of the thickness of the glasses, the effect was but faint, even when the sun was high and shined forth clear, yet, we easily remedied that by contracting the beams we cast on them by means of a convex burning-glass, which, where it made the beams much converge, increased the light enough to make the compounded colour very manifest upon the paper. By this means we observed, that the beams trajected through blue and yellow composed a green; that an intense and moderate red did with yellow make differing degrees of saffron, and orange-tawny colours; that green and blue made a colour partaking of both, such as that which some Latin writers call *Pavonaceus*; that red and blue made a purple; to which we might add other colours, that we produced by the combinations of glasses differing tinged, but that I want proper words to express them in our language, and had not, when we made the trials, the opportunity of consulting with a painter, who perchance might have supplied me with some of the terms I wanted.

I KNOW not whether it will be requisite to subjoin on this occasion, what I tried concerning reflections from coloured glasses, and other transparent bodies; namely, that having exposed four or five sorts of them to the sun, and cast the reflected beams upon white paper held near at hand, the light appeared not manifestly tinged, but as if it had been reflected from the impervious parts of a colourless glass; only that reflected from the yellow was here and there stained with the same colour, as if those beams were not all reflected from the superficial, but some from the internal parts of the glass; upon which occasion you may take notice, that a skilful tradesman, who makes such coloured glass, told me, that whereas the red pigment was but superficial, the yellow penetrated to the very midst of the plate. But for further satisfaction, not having the opportunity to

to foliate those plates, and so turn them into looking-glasses, we foliated a plate of *Muscovy* glass, and then laying on it a little transparent varnish of a gold colour, we exposed it to the sun-beams, so as to cast them upon a body fit to receive them; on which the reflected light appearing, as we expected, yellow, manifested that rebounding from the specular part of the selenitis, it was tinged in its return with the colour of the transparent varnish through which it passed.

EXPERIMENT XIV.

AFTER what we have said of the composition of colours, it will now be reasonable to annex some experiments that we made in favour of those colours, that are taught in the schools not to be real, but only apparent and fantastical; for we found by trials, that these colours might be compounded, both with true and stable colours, and with one another, as well as unquestionably genuine and lasting colours, and that the colours resulting from such compositions, would respectively deserve the same denominations.

For first, having by the trajection of the sun-beams through a glass prism thrown an iris on the floor, I found that by placing a blue glass at a convenient distance betwixt the prism and the iris, that part of the iris that was before yellow, might be made to appear green, though not of a grass green, but of one more dilute and yellowish. And it seems not improbable, that the narrow greenish list (if I may so call it) that is wont to be seen between the yellow and blue parts of the iris, is made by the confusion of those two bordering colours.

NEXT, I found, that though the want of a sufficient liveliness in either of the compounding colours, or a light error in the manner of making the following trials, was enough to render some of them unsuccessful, yet, when all necessary circumstances were duly observed, the event was answerable to our expectation and desire.

AND (as I formerly noted) that red and blue compound a purple, so I could produce this last named colour, by casting at some distance from the glass the blue part of the prismatical iris (as I think it may be called for distinction sake) upon a lively red, (or else the experiment succeeds not so well.) And I remember, that sometimes when I tried this upon a piece of red cloth, that part of the iris which would have been blue, (as I tried by covering that part of the cloth with a piece of white paper) and compounded with the red, wherewith the cloth was imbued before, appeared of a fair purple, did, when I came to view it near at hand, look very oddly, as if there were some strange reflection or refraction, or both, made in the hairs of which that cloth was composed.

CASTING likewise the prismatical iris upon a very vivid blue, I found that part of it, which would else have been the yellow, appear green. (Another somewhat differing trial,

and yet fit to confirm this, you will find in the fifteenth experiment.)

BUT it may seem somewhat more strange, that though the prismatical iris being made by the refraction of light through a body that has no colour at all, must, according to the doctrine of the schools, consist of as purely emphatical colours as may be, yet even these may be compounded with one another, as well as real colours in the grossest pigments. For I took at once two triangular glasses, and one of them being kept fixt in the same posture, that the iris it projected on the floor might not waver, I cast on the same floor another iris with the other prism, and moving it to and fro to bring what part of the second iris I pleased, to fall upon what part of the first I thought fit, we did sometimes (for a small error suffices to hinder the success) obtain by this means a green colour in that part of the more stable iris, that before was yellow, or blue; and frequently by casting those beams, that in one of the iris's made the blue upon the red parts of the other iris, we were able to produce a lovely purple, which we can destroy or re-compose at pleasure, by severing and re-approaching the edges of the two iris's.

EXPERIMENT XV.

ON this occasion, *Pyrophilus*, I shall add, that finding the glass prism to be the usefulest instrument men have yet employed about the contemplation of colours, and considering that prisms, hitherto in use, are made of glass transparent and colourless, I thought it would not be amiss to try, what change the superinduction of a colour, without the destruction of the diaphaneity, would produce in the colours exhibited by the prism. But being unable to procure one to be made of coloured glass, and fearing also that if it were not carefully made, the thickness of it would render it too opacous, I endeavoured to substitute one made of clarified rosin, or of turpentine brought (as I elsewhere teach) to the consistence of a transparent gum. But though these endeavours were not wholly lost, yet we found it so difficult to give these materials their true shape, that we chose rather to varnish over an ordinary prism with some of those few pigments that are to be had transparent; as accordingly we did first with yellow, and then with red, or rather crimson, made with lake tempered with a convenient oil; and the event was, that for want of good transparent colours (of which you know there are but very few) both the yellow and the red made the glass so opacous, (though the pigment were laid on but upon two sides of the glass, no more being absolutely necessary) that unless I looked upon an enlightened window, or the flame of a candle, or some other luminous or very vivid object, I could scarce discern any colours at all, especially when the glass was covered with red. But when I did look on such objects, it appeared (as I expected) that the colour of the pigment had vitiated or drowned some of those which the prism would, according to its wont, have exhibited,

bited, and mingling with others, altered them : as I remember, that both to my eyes, and others to whom I shewed it, when the prism was covered with yellow, it made those parts of bright objects, where the blue would else have been conspicuous, appear of a light green. But, *Pyrophilus*, both the nature of the colours, and the degree of transparency, or of darknes in the pigment, besides divers other circumstances, did so vary the phænomena of these trials, that till I can procure small coloured prisms, or hollow ones that may be filled with tinted liquor, or obtain some better pigments than those I was reduced to employ, I shall forbear to build any thing upon what has been delivered, and shall make no other use of it, than to invite you to prosecute the inquiry further.

EXPERIMENT XVI.

AND here, *Pyrophilus*, since we are treating of emphatical colours, we shall add what we think not unworthy your observation, and not unfit to afford some exercise to the speculative. For there are some liquors which, though colourless themselves, when they come to be elevated, and dispersed into exhalations, exhibit a conspicuous colour, which they lose again, when they come to be recombined into a liquor; as good spirit of nitre, or upon its account strong aqua fortis, though devoid of all appearance of redness whilst they continue in the form of a liquor, if a little heat chance to turn the minute parts of them into vapours, the steam will appear of a reddish or deep yellow colour, which will vanish when those exhalations come to resume the form of a liquor.

AND not only if you look upon a glass half full of aqua fortis, or spirit of nitre, and half full of nitrous steams proceeding from it, you will see the upper part of the glass of the colour freshly mentioned, if through it you look upon the light. But which is much more considerable, I have tried, that putting aqua fortis in a long clear glass, and adding a little copper or some such open metal to it, to excite heat and fumes, the light trajected through those fumes, and cast upon a sheet of white paper, did upon that appear of the colour that the fumes did, when directly looked upon, as if the light were as well tinged in its passage through these fumes, as it would have been by passing through some glass or liquor in which the same colour was inherent.

To which I shall further add, that having sometimes had the curiosity to observe whether the beams of the sun near the horizon, trajected through a very red sky, would not (though such rednesses are taken to be but emphatical colours) exhibit the like colour; I found that the beams falling within a room upon a very white object, placed directly opposite to the sun, disclosed a manifest redness, as if they had passed through a coloured medium.

EXPERIMENT XVII.

THE emergency, *Pyrophilus*, of colours upon the coalition of the particles of such bodies as were neither of them of the co-

lour of that mixture whereof they are the ingredients, is very well worth our attentive observation, as being of good use both speculative and practical: for much of the mechanical use of colours among painters and dyers doth depend upon the knowledge of what colours may be produced by the mixtures of pigments so and so coloured. And (as we lately intimated) it is of advantage to the contemplative Naturalist, to know how many and which colours are primitive (if I may so call them) and simple, because it both eases his labour by confining his most sollicitous inquiry to a small number of colours upon which the rest depend, and assists him to judge of the nature of particular compounded colours, by shewing him, from the mixture of what more simple ones, and of what proportions of them to one another, the particular colour to be considered does result. But because, to insist on the proportions, the manner and the effects of such mixtures, would oblige me to consider a greater part of the painter's art and dyer's trade, than I am well acquainted with, I confined my self to make trial of several ways to produce green, by the composition of blue and yellow: and shall in this place both recapitulate most of the things I have dispersedly delivered already concerning that subject, and recruit them.

AND first, whereas painters (as I noted above) are wont to make green by tempering blue and yellow, both of them made into a soft consistence, with either water or oil, or some liquor of kin to one of those two, according as the picture is to be drawn with those they call water-colours, or those they term oil-colours; I found, that by chusing fit ingredients, and mixing them in the form of dry powders, I could do, what I could not if the ingredients were tempered up with a liquor: but the blue and yellow powders must not only be finely ground, but such as that the corpuscles of the one may not be too unequal to those of the other, lest by their disproportionate minuteness the smaller cover and hide the greater. We used with good success a slight mixture of the fine powder of bise, with that of orpiment, or that of good yellow oker; I say, a slight mixture, because we found that an exquisite mixture did not do so well; but by lightly mingling the two pigments in several little parcels, those of them in which the proportion and manner of mixture was more lucky, afforded us a good green.

2. WE also learned in the dye-houses, that cloth being dyed blue with woad, is afterwards by the yellow decoction of woad, wax or wood, wax dyed into a green colour.

3. You may also remember what we above related, where we intimated, that having in a darkened room taken two bodies, a blue and a yellow, and cast the light reflected from the one upon the other, we likewise obtained a green.

4. AND you may remember, that we observed a green to be produced, when in the same darkened room we looked at the hole at which alone the light entered, through the green and yellow parts of a sheet of marbled paper laid over one another.

5. WE found too, that the beams of the sun being trajected through two pieces of glass, the one blue and the other yellow, laid over one another, did upon a sheet of white paper, on which they were made to fall, exhibit a lovely green.

6. I HOPE also, that you have not already forgot, what was so lately delivered, concerning the composition of a green, with a blue and yellow; of which most authors would call the one a real, and the other an emphatical.

7. AND I presume, you may have yet fresh in your memory, what the fourteenth experiment informs you, concerning the exhibiting of a green, by the help of a blue and yellow, that were both of them emphatical.

8. WHEREFORE we will proceed to take notice, that we also devised a way of trying whether or no metalline solutions, though one of them at least had its colour adventitious, by the mixture of the menstruum employed to dissolve it, might not be made to compound a green after the manner of other bodies. And though this seemed not easy to be performed by reason of the difficulty of finding metalline solutions of the colour requisite, that would mix without precipitating each other; yet after a while having considered the matter, the first trial afforded me the following experiment. I took a high yellow solution of good gold in aqua regis, (made of aqua-fortis, and as I remember half its weight of spirit of salt;) to this I put a due proportion of a deep and lovely blue solution of crude copper, (which I have elsewhere taught to be readily dissolvable in strong spirit of urine.) And these two liquors, though at first they seemed a little to curdle one another, yet being thoroughly mingled by shaking, they presently, as had been conjectured, united into a transparent green liquor, which continued so for divers days, that I kept it in a small glass wherein it was made, only letting fall a little blackish powder to the bottom. The other phænomena of this experiment belong not to this place, where it may suffice to take notice of the production of a green, and that the experiment was more than once repeated with success.

9. AND lastly, to try whether this way of compounding colours would hold even in ingredients actually melted by the violence of the fire, provided their texture were capable of safely enduring fusion, we caused some blue and yellow ammel to be long and well wrought together in the flame of a lamp, which being strongly and incessantly blown on them, kept them in some degree of fusion, and at length (for the experiment requires some patience as well as skill) we obtained the expected ammel of a green colour.

I KNOW not, *Pyrophilus*, whether it be worth while to acquaint you with the ways that came into my thoughts, whereby in some measure to explicate the first of the mentioned ways of making a green; for I have sometimes conjectured, that the mixture of the bise and the orpiment produced a green by so altering the

superficial asperity, which each of those ingredients had apart, that the light incident on the mixture was reflected with differing shades, as to quantity, or order, or both, from those of either of the ingredients, and such as the light is wont to be modified with, when it reflects from grass, or leaves, or some of those other bodies that we are wont to call green. And sometimes too I have doubted, whether the produced green might not be partly at least derived from this, that the beams that rebound from the corpuscles of the orpiment, giving one kind of stroke upon the retina, whose perception we call yellow, and the beams reflected from the corpuscles of the bise giving another stroke upon the same retina, like to objects that are blue; the contiguity and minuteness of these corpuscles may make the appulse of the reflected light fall upon the retina within so narrow a compass, that the part they beat upon being as it were a physical point, they may give a compounded stroke, which may consequently exhibit a compounded and new kind of sensation: as we see that two strings of a musical instrument being struck together, making two noises that arrive at the ear at the same time as to sense, yield a sound differing from either of them, and as it were compounded of both; inasmuch that if they be discordantly tuned, though each of them struck apart would yield a pleasing sound, yet being struck together they make but a harsh and troublesome noise. But this not being so fit a place to prosecute speculations, I shall not insist, neither upon these conjectures nor any others, which the experiment we have been mentioning may have suggested to me. And I shall leave it to you, *Pyrophilus*, to derive what instruction you can from comparing together the various ways whereby a yellow and a blue can be made to compound a green: that which I now pretend to, being only to shew that the first of those mentioned ways, (not to take at present notice of the rest) does far better agree with our conjectures about colours, than either with the doctrine of the schools, or with that of the chymists, both which seem to be very much disfavoured by it.

FOR first, since in the mixture of the two mentioned powders I could by the help of a very excellent microscope (for ordinary ones will scarce serve the turn) discover that which seemed to the naked eye a green body, to be but a heap of distinct, though very small grains of yellow orpiment and blue bise confusedly enough blended together, it appears that the coloured corpuscles of either kind did each retain its own nature and colour; by which it may be guessed, what meet transposition and juxtaposition of minute and singly unchanged particles of matter can do to produce a new colour. For that this local motion and new disposition of the small parts of the orpiment did intervene, is much more manifest than it is easy to explicate how they should produce this new green, otherwise than by the new manner of their being put together, and consequently

consequently by their new disposition to modify the incident light, by reflecting it otherwise than they did before they were mingled together.

SECONDLY, The green thus made, being (if I may so speak) mechanically produced, there is no pretence to derive it from I know not what incomprehensible substantial form, from which yet many would have us believe that colours must flow; nor does this green, though a real and permanent, not a phantastical and vanid colour, seem to be such an inherent quality as they would have it, since not only each part of the mixture remains unaltered in colour, and consequently of a differing colour from the heap they compose; but if the eye be assisted by a microscope to discern things better and more distinctly than before it could, it sees not a green body, but a heap of blue and yellow corpuscles.

AND in the third place, I demand what either sulphur, or salt, or mercury has to do in the production of this green; for neither the bise nor the orpiment were indued with that colour before; and the bare juxtaposition of the corpuscles of the two powders that work not upon each other, but might, if we had convenient instruments, be separated, unaltered, cannot, with any probability, be imagined either to increase or diminish any of the three hypostatical principles, (to which of them soever the chymists are pleased to ascribe colours;) nor does there here intervene so much as heat to afford them any colour to pretend, that at least there is made an extraversion (as the Helmontians speak) of the sulphur, or of any of the two other supposed principles. But upon this experiment we have already reflected enough, if not more than enough for once.

EXPERIMENT XVIII.

BUT here, *Pyrophilus*, I must advertise you, that 'tis not every yellow and every blue that, being mingled, will afford a green; for in case one of the ingredients do not act only as endowed with such a colour, but as having a power to alter the texture of the corpuscles of the other, so as to indispose them to reflect the light, as corpuscles that exhibit a blue or a yellow are wont to reflect it; the emergent colour may be not green, but such as the change of texture in the corpuscles of one or both of the ingredients qualifies them to shew forth: as for instance, if you let fall a few drops of syrup of violets upon a piece of white paper, though the syrup being spread will appear blue, yet mingling with it two or three drops of the lately mentioned solution of gold, I obtained not a green but a reddish mixture, which I expected from the remaining power of the acid salts abounding in the solution, such salts or saline spirits being wont, as we shall see anon, though weakened, so to work upon that syrup as to change it into a red or reddish colour. And to confirm that for which I alledge the former experiment, I shall add this other, that having made a very strong and high-coloured solution of filings of copper with spirit of urine, though

the menstruum seemed glutted with the metal, because I put in so much filings, that many of them remained for divers days undissolved at the bottom; yet having put three or four drops of syrup of violets upon white paper, I found that the deep blue solution proportionably mingled with this other blue liquor, did not make a blue mixture, but, as I expected, a fair green, upon the account of the urinous salt that was in the menstruum.

EXPERIMENT XIX.

TO shew the chymists, that colours may be made to appear or vanish, where there intervenes no accession or change either of the sulphureous, or the saline, or the mercurial principle (as they speak) of bodies; I shall not make use of the iris afforded by the glass-prism, nor of the colours to be seen in a fair morning in those drops of dew that do in a convenient manner reflect and refract the beams of light to the eye: but I will rather mind them of what they may observe in their own laboratories, namely, that divers, if not all, chymical essential oils, as also good spirit of wine, being shaken till they have good store of bubbles, those bubbles will (if attentively considered) appear adorned with various and lovely colours, which all immediately vanish, upon the relapsing of the liquor that affords those bubbles their skins, into the rest of the oil, or spirit of wine; so that a colourless liquor may be made in a trice to exhibit variety of colours, and may lose them in a moment without the accession or diminution of any of its hypostatical principles. And, by the way, 'tis not unworthy our notice, that some bodies, as well colourless as coloured, by being brought to a great thinness of parts, acquire colours though they had none before, or colours differing from them they were before endued with: For, not to insist on the variety of colours, that water, made somewhat glutinous by soap, acquires when 'tis blown into such spherical bubbles as boys are wont to make and play with; turpentine (though it have a colour deep enough of its own) may (by being blown into after a certain manner) be brought to afford bubbles adorned with variety of orient colours, which though they vanish some while upon the breaking of the bubbles, yet they would in all likelihood always exhibit colours upon their superficies, (though not always the same in the same parts of them, but varied according to the incidence of the sight, and the position of the eye) if their texture were durable enough. For I have seen one that was skilled at fashioning glasses by the help of a lamp, blowing some of them so strongly as to burst them; whereupon it was found, that the tenacity of the metal was such, that before it broke, it suffered itself to be reduced into films so extremely thin, that being kept clean they constantly shewed on their surfaces (but after the manner newly mentioned) the varying colours of the rain-bow, which were exceedingly vivid, as I had often opportunity to observe in some, that I caused purposely to be made, to keep by me.

BUT lest it should be objected, that the above-mentioned instances are drawn from transparent liquors, it may possibly appear not impertinent to add, what I have sometimes thought upon, and several times tried, when I was considering the opinions of the chymists about colours. I took then a feather of a convenient bigness and shape, and holding it at a fit distance betwixt my eye and the sun when he was near the horizon, methought there appeared to me a variety of little rainbows, with differing and very vivid colours, of which none was constantly to be seen in the feather; the like phænomenon I have at other times (though not with altogether so good success) produced, by interposing at a due distance a piece of black ribband betwixt the almost setting sun and my eye; not to mention the trials I have made to the same purpose, with other bodies.

EXPERIMENT XX.

TAKE good syrup of violets, impregnated with the tincture of the flowers, drop a little of it upon a white paper, (for by that means the change of colour will be more conspicuous, and the experiment may be practised in smaller quantities) and on this liquor let fall two or three drops of spirit either of salt or vinegar, or almost any other eminently acid liquor, and upon the mixture of these you shall find the syrup immediately turned red: and the way of effecting such a change has not been unknown to divers persons, who have produced the like, by spirit of vitriol, or juice of lemons, but have groundlessly ascribed the effect to some peculiar quality of those two liquors, whereas (as we have already intimated) almost any acid salt will turn syrup of violets red. But to improve the experiment, let me add what has not (that I know of) been hitherto observed, and has, when we first shewed it them, appeared something strange, even to those that have been inquisitive into the nature of colours; namely, that if instead of spirit of salt, or that of vinegar, you drop upon the syrup of violets a little oil of tartar *per deliquium*, or the like quantity of solution of pot-ashes, and rub them together with your finger, you shall find the blue colour of the syrup turned in a moment into a perfect green; and the like may be performed by divers other liquors, as we may have occasion elsewhere to inform you.

Annotation upon the Twentieth EXPERIMENT.

THE use of what we lately delivered concerning the way of turning syrup of violets red or green, may be this; that, though it be a far more common and procurable liquor than the infusion of *lignum nephriticum*, it may yet be easily substituted in its room, when we have a mind to examine, whether or no the salt predominant in a liquor or other body, wherein it is loose and abundant, belong to the tribe of acid salts or not. For if such a body turn the syrup of a red or reddish purple colour, it does for the most part argue the body (especially if it be a distilled liquor) to abound with acid

salt. But if the syrup be made green, that argues the predominant salt to be of a nature repugnant to that of the tribe of acids. For, as I find that either spirit of salt, or oil of vitriol, or aqua-fortis, or spirit of vinegar, or juice of lemons, or any of the acid liquors I have yet had occasion to try, will turn syrup of violets of a red, or at least of a reddish colour; so I have found, that not only the volatile salts of all animal substances I have used, as spirit of hartshorn, of urine, of sal-armoniack, of blood, &c. but also all the alcalizate salts I have employed, as the solution of salt of tartar, of pot-ashes, of common wood-ashes, lime-water, &c. will immediately change the blue syrup into a perfect green. And by the same way (to hint that upon the by) I elsewhere show you, both the changes that nature and time produce, in the more saline parts of some bodies, may be discovered, and also how even such chymically prepared bodies, as belong not either to the animal kingdom, or to the tribe of alcalies, may have their new and superinduced nature successfully examined. In this place I shall only add, that not alone the changing the colour of the syrup requires, that the changing body be more strong of the acid, or other sort of salt, that is predominant in it, than is requisite for the working upon the tincture of *lignum nephriticum*; but that in this also, the operation of the formerly mentioned salts upon our syrup, differs from their operation upon our tinctures; that in this liquor, if the ceruleous colour be destroyed by an acid salt, it may be restored by one that is either volatile, or lixiviate; whereas in syrup of violets, though one of these contrary salts will destroy the action of the other, yet neither of them will restore the syrup to its native blue; but each of them will change it into the colour which itself doth (if I may so speak) affect, as we shall have occasion to shew in the notes on the twenty-fifth experiment.

EXPERIMENT XXI.

THERE is a weed, more known to plowmen than beloved by them, whose flowers from their colour are commonly called blue-bottles, and corn-weed from their growing among corn. These flowers, some ladies do, upon the account of their lovely colour, think worth the being candied, which when they are, they will long retain so fair a colour, as makes them a very fine salad in the winter. But I have tried, that when they are freshly gathered, they will afford a juice, which when newly expressed, (for in some cases it will soon enough degenerate) affords a very deep and pleasant blue. Now, (to draw this to our present scope) by dropping on this fresh juice a little spirit of salt, (that being the acid spirit I had then at hand) it immediately turned (as I predicted) into a red. And if instead of the sour spirit, I mingled with it a little strong solution of an alcalizate salt, it did presently disclose a lovely green; the same changes being, by those differing sorts of saline liquors, producible in this natural juice, that we lately mentioned to

Herbarists
are wont
to call
this plant
Cyanus
vulgus
minor.

have happened to that factitious mixture, the syrup of violets. And I remember, that finding this blue liquor, when freshly made, to be capable of serving in a pen for an ink of that colour, I attempted by moistening one part of a piece of white paper with the spirit of salt I have been mentioning, and another with some alcalizate or volatile liquor, to draw a line on the leisurely dried paper, that should even before the ink was dry appear partly blue, partly red, and partly green: but though the latter part of the experiment succeeded not well, (whether because volatile salts are too fugitive to be retained in the paper, and alcalizate ones are too unctuous, or so apt to draw moisture from the air, that they keep the paper from drying well) yet the former part succeeded well enough; the blue and the red being conspicuous enough to afford a surprizing spectacle to those, I acquaint not with (what I willingly allow you to call) the trick.

Annotation upon the one and twentieth
EXPERIMENT.

BUT lest you should be tempted to think (*Pyrophilus*) that volatile or alcalizate salts change blues into green, rather upon the score of the easy transition of the former colour into the latter, than upon the account of the texture, wherein most vegetables, that afford a blue, seem, though otherwise differing, to be allied; I will add, that when I purposely dissolved blue vitriol in fair water, and thereby imbued sufficiently that liquor with that colour, a lixiviate liquor, and a urinous salt being copiously poured upon distinct parcels of it, did each of them, though perhaps with some difference, turn the liquor not green, but of a deep yellowish colour, almost like that of yellow oker; which colour, the precipitated corpuscles retained, when they had leisurely subsided in the bottom. What this precipitated substance is, it is not needful now to inquire in this place, and in another I have shewn you, that notwithstanding its colour, and its being obtainable from an acid menstruum by the help of salt of tartar, it is yet far enough from being the true sulphur of vitriol.

EXPERIMENT XXII.

OUR next experiment (*Pyrophilus*) will perhaps seem to be of a contrary nature to the two former, made upon syrup of violets and juice of blue-bottles. For, as in them, by affusion of oil of tartar, a blueish liquor is made green, so in this, by the sole mixture of the same oil, a greenish liquor becomes blue. The hint of this experiment was given us by the practice of some Italian painters, who being wont to counterfeit *Ultra-marine Azure* (as they call it) by grinding verdigrease with sal-armoniack, and some other saline ingredients, and letting them rot (as they imagine) for a good while together in a dunghill, we supposed that the change of colour wrought in the verdigrease by this way of preparation must

proceed from the action of certain volatile and alcalizate salts, abounding in some of the mingled concretes, and brought to make a further dissolution of the copper abounding in the verdigrease; and therefore we conjectured, that if both the verdigrease, and such salts were dissolved in fair water, the small parts of both being therein more subdivided and set at liberty, would have better access to each other, and thereby incorporate much the more suddenly. And accordingly we found, that if upon a strong solution of good French verdigrease (for it is that we are wont to employ, as the best) you pour a just quantity of oil of tartar, and shake them well together, you shall immediately see a notable change of colour, and the mixture will grow thick, and not transparent; but if you stay a while, till the grosser part be precipitated to, and settled in the bottom, you may obtain a clear liquor of a very lovely colour, and exceeding delightful to the eye. But, you must have a care to drop in a competent quantity of oil of tartar, for else the colour will not be so deep and rich; and if instead of this oil you employ a clear lixivium of pot-ashes, you may have an azure somewhat lighter or paler than, and therefore differing from, the former. And if instead of either of these liquors, you make use of spirit of urine, or of hartshorn, you may, according to the quantity and quality of the spirit you pour in, obtain some further variety (though scarce considerable) of ceruleous liquors. And yet lately by the help of this urinous spirit we made a blue liquor, which not a few ingenious persons, and among them, some, whose profession makes them very conversant with colours, have looked upon with some wonder. But these azure-coloured liquors should be freed from the subsiding matter, which the salts of tartar or urine precipitate out of them, rather by being decanted, than by filtration. For by the latter of these ways, we have sometimes found the colour of them very much impaired, and little superiour to that of the grosser substance, that is left in the filtre.

EXPERIMENT XXIII.

THAT roses held over the fume of sulphur, may quickly by it be deprived of their colour, and have as much of their leaves, as the fume works upon, burned pale, is an experiment, that divers others have tried, as well as I. But (*Pyrophilus*) it may seem somewhat strange to one that has never considered the compounded nature of brimstone, that whereas the fume of sulphur will, as we have said, whiten the leaves of roses; that liquor, which is commonly called, oil of sulphur *per campanam*, because it is supposed to be made by the condensation of these fumes, in glasses shaped like bells, into a liquor, does powerfully heighten the tincture of red roses, and make it more red and vivid, as we have easily tried by putting some red-rose leaves, that had been long dried (and so had lost much of their colour) into a phial of fair water. For a while after the affusion of a convenient quantity

tity of the liquor we are speaking of, both the leaves themselves, and the water they were steeped in, discovered a very fresh and lovely colour.

EXPERIMENT XXIV.

IT may (*Pyrophilus*) somewhat serve to illustrate, not only the doctrine of pigments, and of colours, but divers other parts of the corpuscular philosophy, as that explicates odours, and many other things, not as the schools by airy qualities, but by real, though extremely minute bodies; to examine, how much of the colourless liquor a very small parcel of a pigment may imbue with a discernable colour. And though there be scarce any thing of preciseness to be expected from such trials, yet I presumed, that (at least) I should be able to show a much further subdivision of the parts of matter into visible particles, than I have hitherto found taken notice of, and than most men would imagine; no body, that I know of, having yet attempted to reduce this matter to any measure.

THE bodies, the most promising for such a purpose, might seem to be the metals, especially gold, because of the multitude and minuteness of its parts, which might be argued from the incomparable closeness of its texture: but though we tried a solution of gold made in aqua regia first, and then in fair water, yet in regard we were to determine the pigment we employed, not by bulk, but weight, and because also, that the yellow colour of gold is but a faint one in comparison of the deep colour of cochineal, we rather chose this to make our trials with. But among divers of these it will suffice to set down one, which was carefully made in vessels conveniently shaped, (and that in the presence of a witness, and an assistant;) the sum whereof I find among my *Adversaria*, registered in the following words. To which I shall only premise, (to lessen the wonder of so strange a diffusion of the pigment) that cochineal will be better dissolved, and have its colour far more heightened by spirit of urine, than (I say not by common water, but) by rectified spirit of wine itself.

THE note I spoke of is this: [One grain of cochineal dissolved in a pretty quantity of spirit of urine, and then dissolved further by degrees in fair water, imparted a discernable, though but a very faint colour, to about six glass-fulls of water, each of them containing about forty three ounces and a half, which amounts to above a hundred twenty five thousand times its own weight.]

EXPERIMENT XXV.

IT may afford a considerable hint (*Pyrophilus*) to him, that would improve the art of dying, to know what change of colours may be produced by the three several sorts of salts already often mentioned, (some or other of which may be procured in quantity at reasonable rates) in the juices, decoctions, infusions, and (in a word) the more soluble parts of ve-

getables. And, though the design of this discourse be the improvement of knowledge, not of trades; yet thus much I shall not scruple to intimate here, that the blue liquors, mentioned in the twentieth, and one and twentieth experiments, are far from being the only vegetable substances upon which acid, urinous, and alcalizate salts have the like operations to those recited in those two experiments. For ripe privet berries (for instance) being crushed upon white paper, though they stain it with a purplish colour, yet if we let fall on some part of it two or three drops of spirit of salt, and on the other part a little more of the strong solution of pot-ashes, the former liquor immediately turned that part of the thick juice or pulp, on which it fell, into a lovely red, and the latter turned the other part of it into a delightful green. Though I will not undertake, that those colours in that substance shall not be much more orient than lasting; and though (*Pyrophilus*) this experiment may seem to be almost the same with those already delivered concerning syrup of violets, and the juice of blue-bottles, yet I think it not amiss to take this occasion to inform you, that this experiment reaches much farther than perhaps you yet imagine, and may be of good use to those, whom it concerns to know how dying stuffs may be wrought upon by saline liquors. For, I have found this experiment to succeed in so many various berries, flowers, blossoms, and other finer parts of vegetables, that neither my memory, nor my leisure serves me to enumerate them. And it is somewhat surprizing to see, by how differinglly-coloured flowers, or blossoms, (for example) the paper being stained, will by an acid spirit be immediately turned red, and by any alcaly or any urinous spirit turned green; insomuch that even the crushed blossoms of meserion, (which I gathered in winter and frosty weather) and those of peas, crushed upon white paper, how remote soever their colours be from green, would in a moment pass into a deep degree of that colour, upon the touch of an alcalizate liquor. To which let us add, that either of those new pigments (if I may so call them) may, by the affusion of enough of a contrary liquor, be presently changed from red into green, and from green into red: which observation will hold also in syrup of violets, juices of blue-bottles, &c.

ANNOTATION.

AFTER what I have formerly delivered to evince that there are many instances, wherein new colours are produced or acquired by bodies, which chymists are wont to think destitute of salt, or to whose change of colours no new accession of saline particles does appear to contribute; I think we may safely enough acknowledge, that we have taken notice of so many changes made by the intervention of salts in the colours of mixed bodies, that it has lessened our wonder, that though many chymists are wont to ascribe the colours of such bodies to their sulphureous, and the rest to their mercurial principle; yet *Paracelsus* himself directs us

in the indagation of colours, to have an eye principally upon salts, as we find in that passage of his, wherein he takes upon him to oblige his readers much by instructing them, of what things they are to expect the knowledge from each of the three distinct principles of bodies. *Alias* (says he) *colorum similis ratio est: de quibus brevem institutionem hanc attendite, quod scilicet colores omnes ex sale prodeant. Sal enim dat colorem, dat balsamum.* And a little beneath; *Jam natura ipsa colores protrahit ex sale, cuique speciei dans illum, qui ipsi competit, &c.* After which he concludes; *Itaque qui rerum omnium corpora cognoscere vult, huic opus est, ut ante omnia cognoscat sulphur; ab hoc, qui desiderat novisse colores, is scientiam istorum petat à sale; qui scire vult virtutes, is scrutetur arcana Mercurii. Sic nimirum fundamentum habuerit mysteriorum, in quolibet crescenti indagandum, prout natura cuilibet speciei ea ingessit.* But though *Paracelsus* ascribes to each of his beloved hypostatical principles much more than I fear will be found to belong to it; yet if we please to consider colours, not as philosophers, but as dyers, the concurrence of salts to the striking and change of colours, and their efficacy, will, I suppose, appear so considerable, that we shall not need to quarrel much with *Paracelsus*, for ascribing in this place (for I dare not affirm that he uses to be still of one mind) the colours of bodies to their salts, if by salts he here understood not only elementary salts, but such also as are commonly taken for salts, as allom, crystals of tartar, vitriol, &c. because the saline principle does chiefly abound in them, though indeed they be, as we elsewhere declare, mixed bodies, and have most of them, besides what is saline, both sulphureous, aqueous, and gross or earthy parts.

BUT though (*Pyrophilus*) I have observed a red and green to be produced, the former, by acid salts, the latter by salts not acid, in the express'd juices of so many differing vegetable substances, that the observation, if pursued, may prove (as I said) of good use: yet to show you how much even these effects depend upon the particular texture of bodies, I must subjoin some cases wherein I (who am somewhat backwards to admit observations for universal) had the curiosity to discover, that the experiments would not uniformly succeed; and of these exceptions, the chief that I now remember, are reducible to the following three.

EXPERIMENT XXVI.

AND, (first) I thought fit to try the operation of acid salts upon vegetable substances, that are already and by their own nature red. And accordingly I made trial upon syrup of clove-julyflowers, the clear expressed juice of the succulent berries of *Spina Cervina*, or buckthorn, (which I had long kept by me for the sake of its deep colour) upon red roses, infusion of Brazil, and divers other vegetable substances, on some of which crushed (as is often mentioned) upon white paper (which is also to be understood in most of these experi-

ments, if no circumstance of them argue otherwise) spirit of salt either made no considerable change, or altered the colour but from a darker to a lighter red. How it will succeed in many other vegetable juices, and infusions of the same colour, I have at present so few at hand, that I must leave you to find it out your self. But as for the operation of the other sorts of salts upon these red substances, I found it not very uniform, some red, or reddish infusions, as of roses, being turned thereby into a dirty colour, but yet inclining to green. Nor was the syrup of clove-julyflowers turned by the solution of pot-ashes to a much better, though somewhat a greener colour. Another sort of red infusions was by an alcaly not turned into a green, but advanced into a crimson, as I shall have occasion to note ere long. But there were other sorts, as particularly the lovely coloured juice of buckthorn berries, that readily passed into a lovely green.

EXPERIMENT XXVII.

AMONG other vegetables, which we thought likely to afford exceptions to the general observation about the differing changes of colours produced by acid and sulphureous salts, we thought fit to make trial upon the flowers of jasmín, they being both white as to colour, and esteemed to be of a more oily nature than other flowers. Whereupon having taken the white parts only of the flowers, and rubbed them somewhat hard with my finger, upon a piece of clean paper, it appeared very little discoloured. Nor had spirit of salt, wherewith I moistened one part of it, any considerable operation upon it. But spirit of urine, and somewhat more effectually a strong alcalizate solution, did immediately turn the almost colourless paper moistened by the juice of the jasmín, not as those liquors are wont to do, when put upon the juices of other flowers, of a good green, but of a deep, though somewhat greenish yellow; which experiment I did afterwards at several times repeat with the like success. But it seems not that a great degree of unctuousness is necessary to the production of the like effects, for when we tried the experiment with the leaves of those purely white flowers that appear about the end of winter, and are commonly called snow-drops, the event was not much unlike that, which we have been newly mentioning.

EXPERIMENT XXVIII.

ANOTHER sort of instances to show how much changes of colours, effected by salts, depend upon the particular texture of the coloured bodies, has been afforded me by several yellow flowers, and other vegetables, as mary-gold leaves, early primroses, fresh madder, &c. For being rubbed upon white paper, till they imbued it with their colour, I found not, that by the addition of alcalizate liquors, nor yet by that of an urinous spirit, they would be turned either green or red: nor did

did so acid a spirit as that of salt, considerably alter their colour, save that it seemed a little to dilute it: Only in some early primroses it destroyed the greatest part of the colour, and made the paper almost white again. And madder also afforded something peculiar, and very differing from what we have newly mentioned: for having gathered some roots of it, and (whilst they were recent) expressed upon white paper the yellow juice, an alcalizate solution dropt upon it did not turn it either green or white, but red. And the bruised madder itself being drenched with the like alcalizate solution; exchanged also its yellowishness for a redness.

An admonition touching the four preceding EXPERIMENTS.

HAVING thus (*Pyrophilus*) given you divers instances, to countenance the general observation delivered in the twenty fifth experiment, and divers exceptions whereby it ought to be limited; I must leave the further inquiry into these matters to your own industry. For not remembering at present many of those other trials, long since made to satisfy my self about particulars, and not having now the opportunity to repeat them, I must content my self to have given you the hint, and the ways of prosecuting the search your self; and only declare to you in general, that, as I have made many trials, unmentioned in this treatise, whose events were agreeable to those mentioned in the twenty-fifth experiment, so (to name now no other instances) what I have tried with acid and sulphureous salts upon the pulp of juniper berries, rubbed upon white paper, inclines me to think, that among that vast multitude, and strange variety of plants that adorn the face of the earth, perhaps many other vegetables may be found, on which such menstrua may not have such operations, as upon the juice of violets, peas-blossoms, &c. no nor upon any of those three other sorts of vegetables, that I have taken notice of in the three foregoing experiments: it sufficiently appearing even by these, that the effects of a salt upon the juices of particular vegetables do very much depend upon their particular textures.

EXPERIMENT XXIX.

IT may be of some use towards the discovery of the nature of these changes, which the alimetal juice receives in some vegetables, according to the differing degrees of their maturity, and according to the differing kinds of plants of the same denomination, to observe what operation acid, urinous, and alcalizate salts will have upon the juices of the several sorts of the vegetable substances I have been mentioning.

To declare my meaning by an example; I took from the same cluster one blackberry full ripe, and another that had not yet gone beyond a redness; and rubbing a piece of white paper, with the former, I observed that the

juice adhering to it was of a dark reddish colour, full of little black specks, and that this juice, by a drop of a strong lixivium, was immediately turned into a greenish colour deep enough; by as much urinous spirit, into a colour much of kin to the former, though somewhat differing, and fainter; and by a drop of spirit of salt, into a fine and light some red: whereas the red berry being in like manner rubbed upon paper, left on it a red colour, which was very little altered by the acid spirit newly named, and by the urinous and lixiviate salts received changes of colour; differing from those that had been just before produced in the dark juice of the ripe blackberry.

I REMEMBER also, that though the infusion of damask roses would as well, though not so much, as that of red, be heightened by acid spirits to an intense degree of redness, and by lixiviate salts be brought to a darkish green; yet having for trial's sake taken a rose, whose leaves, which were large and numerous, like those of a *Provence* rose, were perfectly yellow, though in a solution of salt of tartar, they afforded a green blueish tincture, yet I did not by an acid liquor obtain a red one; all that the saline spirit I employed performed, being (if I much mis-remember not) to dilute somewhat the yellowness of the leaves. I would also have tried the tincture of yellow violets, but could procure none. And if I were in those islands of *Banda*, which are made famous as well as rich, by being the almost only place where cloves will prosper, I should think it worth my curiosity to try, what operation the three differing kinds of salts, I have so often mentioned, would have upon the juice of this spice, (expressed at the several seasons of it) as it grows upon the tree. Since good authors inform us, (of what is remarkable) that these whether fruits, or rudiments of fruits, are at first white, afterward green, and then reddish, before they be beaten off the tree; after which being dried before they are put up, they grow blackish, as we see them. And one of the recentest Herbarists informs us, that the flower grows upon the top of the clove itself, consisting of four small leaves, like a cherry-blossom, but of an excellent blue. But (*Pyrophilus*) to return to our own observations, I shall add, that I the rather chuse to mention to you an example drawn from roses, because that though I am apt to think, as I elsewhere advertise, that something may be guessed at about some of the qualities of the juices of vegetables, by the resemblance or disparity that we meet with in the changes made of their colours, by the operation of the same kinds of salts; yet that those conjectures should be very warily made, may appear, among other things, by the instance I have chosen to give in roses. For though, (as I formerly told you) the dried leaves, both of the damask, and of red ones, give a red tincture to water sharpened with acid salts, yet the one sort of leaves is known to have a purgative faculty, and the other are often, and divers ways employed for binding.

AND I also chuse (*Pyrophilus*) to subjoin this twenty-ninth experiment to those that pre-

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cede it, about the change of the colours of vegetables by salts, for these two reasons: the first, that you may not easily entertain suspicions, if in the trials of an experiment of some of the kinds formerly mentioned, you should meet with an event somewhat differing from what my relations may have made you expect. And the second, that you may hereby be invited to discern, that it may not be amiss to take notice of the particular seasons wherein you gather the vegetables which in nicer experiments you make use of. For, if I were not hindered both by haste and some justifiable considerations, I could perhaps add considerable instances, to those lately delivered; but for certain reasons I shall at present substitute a remarkable passage to be met with in that laborious Herbarist Mr. *Parkinson*, where treating of the virtues of the (already divers times mentioned) buckthorn berries, he subjoins the following account of several pigments that are made of them, not only according to the several ways of handling them, but according to the differing seasons of maturity, at which they are gathered. *Of these berries, (says he) are made three several sorts of colours as they shall be gathered, that is, being gathered while they are green, and kept dry, are called sapberries, which being steeped into some allom-water, or fresh bruised into allom-water, they give a reasonable fair yellow colour which painters use for their work, and book-binders to colour the edges of books, and leather-dressers to colour leather; as they use also to make a green colour, called sap-green, taken from the berries when they are black, being bruised and put into a brass or copper kettle or pan, and there suffered to abide three or four days, or a little heated upon the fire, and some beaten allom put unto them, and afterwards pressed forth; the juice or liquor is usually put into great bladders tied with strong thread at the head and hung up until it be dry, which is dissolved in water or wine, but sack (he affirms) is the best to preserve the colour from starving, (as they call it) that is, from decaying, and make it hold fresh the longer. The third colour (whereof none, says he, that I can find have made mention but only *Tragus*) is a purplish colour, which is made of the berries, suffered to grow upon the bushes until the middle or end of November, that they are ready to drop from the trees.*

AND, I remember (*Pyrophilus*) that I tried, with a success that pleased me well enough, to make such a kind of pigment, as the painters call sap-green, by a way not unlike that delivered here by our author, but I cannot now find any thing relating to that matter among my loose papers. And my trials were made so many years ago, that I dare not trust my memory for circumstances, but will rather tell you, that in a noted colour-shop I brought them by questions to confess to me, that they made their sap-green much after the ways by our Botanist here mentioned. And on this occasion I shall add an observation, which though it does not strictly belong to this place, may well enough be mentioned here; namely, that I find by an

account given us by the learned *Clusius*, of alaternus, that even the grosser parts of the same plant are some of them one colour, and some another: for speaking of that plant, he tells us, that the Portugals use the bark to dye their nets into a red colour, and with the chips of the wood, which are whitish, they dye a blackish blue.

EXPERIMENT XXX.

AMONG the experiments that tend to shew that the change of colours in bodies may proceed from the varied texture of their parts, and the consequent change of their disposition to reflect or refract the light, that sort of experiments must not be left unmentioned, which is afforded us by chymical digestions. For, if chymists will believe several famous writers about what they call the philosopher's stone, they must acknowledge that the same matter, sealed up hermetically in a philosophical egg, will, by the continuance of digestion, or if they will have it so (for it is not material in our case which of the two it be) of decoction, run through a great variety of differing colours, before it come to that of the noblest elixir; whether that be scarlet, or purple, or whatever other kind of red. But without building any thing on so obscure and questionable an operation, (which yet may be pertinently represented to those that believe the thing) we may observe, that divers bodies digested in carefully closed vessels, will in tract of time change their colour: As I have elsewhere mentioned my having observed even in rectified spirit of hartshorn, and as is evident in the precipitations of amalgams of gold and mercury, without addition, where, by the continuance of a due heat, the silver-coloured amalgam is reduced into a shining red powder. Further instances of this kind you may find here and there in divers places of my other essays. And indeed it has been a thing, that has much contributed to deceive many chymists, that there are more bodies than one, which by digestion will be brought to exhibit that variety and succession of colours, which they imagine to be peculiar to what they call the *true matter of the philosophers*. But concerning this, I shall refer you to what you may elsewhere find in the discourse written touching the passive deceptions of chymists, and more about the production of colours by digestion you will meet with presently. Wherefore I shall now make only this observation from what has been delivered, that in these operations there appears not any cause to attribute the new colours emergent to the action of a new substantial form, nor to any increase or decrement of either the salt, sulphur, or mercury of the matter that acquires new colours: for the vessels are closed, and these principles, according to the chymists, are ingenerable and incorruptible; so that the effect seems to proceed from hence, that the heat agitating and shuffling the corpuscles of the body exposed to it, does in process of time so change its texture, as that the transposed parts do

do modify the incident light otherwise, than they did when the matter appeared of another colour.

EXPERIMENT XXXI.

AMONG the several changes of colour, which bodies acquire or disclose by digestion, it is very remarkable, that chymists find a redness rather than any other colour in most of the tinctures they draw, and even in the more gross solutions they make of almost all concretes, that abound either with mineral or vegetable sulphur, though the menstruum employed about these solutions or tinctures be never so limpid or colourless.

THIS we have observed in I know not how many tinctures drawn with spirit of wine from jalap, guaiacum, and several other vegetables; and not only in the solutions of amber, benzoin, and divers other concretes made with the same menstruum, but also in divers mineral tinctures. And, not to urge that familiar instance of the ruby of sulphur, as chymists upon the score of its colour call the solution of flowers of brimstone, made with the spirit of turpentine, nor to take notice of other more known examples of the aptness of chymical oils to produce a red colour with the sulphur they extract, or dissolve; not to insist (I say) upon instances of this nature, I shall further represent to you, as a thing remarkable, that both acid and alcalizate salts, though in most other cases of such contrary operations, in reference to colours, will, with many bodies that abound with sulphureous, or with oily parts, produce a red; as is manifest partly in the more vulgar instances of the tinctures, or solutions of sulphur made with lixiviums, either of calcined tartar or pot-ashes, and other obvious examples, partly by this, that the true glass of antimony extracted with some acid spirits, with or without wine, will yield a red tincture, and that I know an acid liquor, which in a moment will turn oil of turpentine into a deep red. But among the many instances I could give you of the easy production of redness by the operation of saline spirit, as well as of spirit of wine; I remember two or three of those I have tried, which seem remarkable enough to deserve to be mentioned to you apart.

EXPERIMENT XXXII.

BUT before we set them down, it will not perhaps appear impertinent to premise,

THAT there seems to be a manifest disparity betwixt red liquors, so that some of them may be said to have a genuine redness in comparison of others, that have a yellowish redness: for if you take (for example) a good tincture of cochineal, dilute it ever so much with fair water, you will not (as far as I can judge by what I have tried) be able to make it a yellow liquor. Inasmuch that a single drop of a rich solution of cochineal in spirit of urine, being diluted with above an ounce of fair water, exhibited no yellowishness at all, but a fair (though somewhat faint) pink or carnation; and even when cochineal was by degrees

diluted much beyond the newly mentioned colour, by the way formerly related to you in the twenty fourth experiment, I remember not, that there appeared in the whole trial any yellow. But if you take balsam of sulphur (for instance) though it may appear in a glass, where it has a good thickness, to be of a deep red; yet if you shake the glass, or pour a few drops on a sheet of white paper, spreading them on it with your finger, the balsam that falls back along the sides of the glass, and that which stains the paper, will appear yellow, not red. And there are divers tinctures, such as that of amber made with spirit of wine (to name now no more) that will appear either yellow or red, according as the vessels that they fill, are slender or broad.

EXPERIMENT XXXIII.

BUT to proceed to the experiments I was about to deliver: First, oil or spirit of turpentine, though clear as fair water, being digested upon the purely white sugar of lead, has, in a short time, afforded us a high red tincture, that some artists are pleased to call the balsam of *Saturn*, which they very much (and probably not altogether without cause) extol as an excellent medicine in divers outward affections.

EXPERIMENT XXXIV.

NEXT, take of common brimstone finely powdered five ounces, of sal-armoniac likewise pulverized an equal weight, of beaten quick-lime six ounces, mix these powders exquisitely, and distil them through a retort placed in sand by degrees of fire, giving at length as intense a heat as you well can in sand; there will come over (if you have wrought well) a volatile tincture of sulphur, which may probably prove an excellent medicine, and should have been mentioned among the other preparations of sulphur, which we have elsewhere imparted to you, but that it is very pertinent to our present subject, the change of colours. For though none of the ingredients be red, the distilled liquor will be so: and this liquor, if it be well drawn, will, upon a little agitation of the phial first unstopped, (especially if it be held in a warmer hand) send forth a copious fume, not red, like that of nitre, but white; and sometimes this liquor may be so drawn, that I remember, not long since, I took pleasure to observe in a parcel of it, that ingredients not red, did not only yield by distillation a volatile spirit that was red, but though that liquor did upon the bare opening of the bottle it was kept in, drive us away with the plenty and sulphureous scent of a white steam which it sent forth, yet the liquor itself being touched by our fingers, did immediately dye them black.

EXPERIMENT XXXV.

THE third and last experiment I shall now mention, to shew how prone bodies abounding in sulphureous parts are to afford a red colour, is one, wherein by the operation of

a saline spirit upon a white or whitish body, which according to the chymists should be altogether sulphureous, a redness may be produced, not (as in the former experiments) slowly, but in the twinkling of an eye. We took then of the essential oil of aniseeds, which has this peculiarity, that in cold weather it loses its fluidity and the greatest part of its transparency, and looks like a white or whitish ointment, and near at hand seems to consist of a multitude of little soft scales: of this coagulated stuff we spread a little with a knife upon a piece of white paper, and letting fall on it, and mixing with it, a drop or two of oil of vitriol, immediately (as we fore-saw) there emerged together with some heat and smoke, a blood-red colour which therefore was in a trice produced by two bodies, whereof the one had but a whitish colour, and the other (if carefully rectified) had no colour at all.

EXPERIMENT XXXVI.

BUT on this occasion (*Pyrophilus*) we must add once for all, that in many of the above recited experiments, though the changes of colour happened as we have mentioned them; yet the emergent or produced colour is oft-times very subject to degenerate, both quickly and much. Notwithstanding which, since the changes, we have set down, do happen presently upon the operation of the bodies upon each other, or at the times by us specified, that is sufficient both to justify our veracity, and to shew what we intend; it not being essential to the genuineness of a colour to be durable. For a fading leaf, that is ready to rot, and moulder into dust, may have as true a yellow, as a wedge of gold, which so obstinately resists both time and fire. And the reason why I take occasion from the former experiment to subjoin this general advertisement, is, that I have several times observed, that the mixture resulting from the oils of vitriol, and of aniseeds, though it acquire a thicker consistence than either of the ingredients had, has quickly lost its colour, turning in a very short time into a dirty grey, at least in the superficial parts, where it is exposed to the air: which last circumstance I therefore mention, because that, though it seem probable, that this degeneration of colours may oft-times and in divers cases proceed from the further action of the saline corpuscles, and the other ingredients upon one another, yet in many cases much of the quick change of colours seems ascribable to the air, as may be made probable by several reasons: the first whereof may be fetched from the newly recited example of the two oils; the next may be, that we have sometimes observed long window-curtains of light colours to have that part of them, which was exposed to the air, when the window was open of one colour, and the lower part, that was sheltered from the air by the wall, of another colour: and the third argument may be fetched from divers observations, both of others, and our own; for of that pigment so well known in painters shops,

by the name of Turnsol, our industrious *Parkinson*, in the particular account he gives of the plant that bears it, tells us also, That *the berries, when they are at their full maturity, have within them between the outer skin and the inward kernel or seed, a certain juice or moisture, which being rubbed upon paper or cloth, at the first appears of a fresh and lovely green colour, but presently changeth into a kind of blueish purple, upon the cloth or paper; and the same cloth afterwards wet in water, and wrung forth, will colour the water into a claret-wine colour; and these (concludes he) are those rags of cloth, which are usually called turnsol in the druggists or grocers shops.* And to this observation of our Botanist we will add an experiment of our own, (made before we met with that) which, though in many circumstances very differing, serves to prove the same thing. For having taken of the deeply red juice of buckthorn berries, which I bought of the man that uses to sell it to the apothecaries, to make their syrup *de spina cervina*, I let some of it drop upon a piece of white paper, and having left it there for many hours, till the paper was grown dry again, I found what I was inclined to suspect, namely, that this juice was degenerated from a deep red to a dirty kind of greyish colour, which, in a great part of the stained paper, seemed not to have so much as an eye of red: though a little spirit of salt or dissolved alkali would turn this unpleasant colour (as formerly I told you it would change the not yet altered juice) into a red or green. And to satisfy my self, that this degeneration of colour did not proceed from the paper, I dropped some of the deep red or crimson juice upon a white glazed tile, and suffering it to dry on there, I found that even in that body, on which it could not soak, and by which it could not be wrought, it nevertheless lost its colour. And these instances (*Pyrophilus*) I am the more careful to mention to you, that you may not be much surpris'd or discouraged, if you should sometimes miss of performing punctually what I affirm my self to have done in point of changing colours; since in these experiments the over-sight or neglect of such little circumstances, as in many others would not be perhaps considerable, may occasion the mis-carrying of a trial. And I was willing also to take this occasion of advertising you in the repeating of the experiments mentioned in the treatise, to make use of the juices of vegetables, and other things prepared for your trials, as soon as ever they are ready, lest one or other of them grow less fit, if not quite unfit by delay; and to estimate the event of trials by the change, that is produced presently upon the due and sufficient application of actives to passives, (as they speak) because in many cases the effects of such mixtures may not be lasting, and the newly produced colour may in a little time degenerate. But (*Pyrophilus*) I forgot to add to the former observations lately made about vegetables, a third of the same import, made in mineral substances, by telling you, that the better to satisfy a friend or two in this particular, I sometimes made, according to some conjectures of mine, this experiment;

experiment; that having dissolved good silver in aqua-fortis, and precipitated it with spirit of salt, upon the first decanting of the liquor, the remaining matter would be purely white; but after it had lain a while uncovered, that part of it that was contiguous to the air, would not only lose its whiteness, but appear of a very dark and almost blackish colour; I say, that part that was contiguous to the air, because if that were gently taken off, the subjacent part of the same mass would appear very white, till that also, having continued a while exposed to the air, would likewise degenerate. Now whether the air perform these things by the means of a subtiler salt, which we elsewhere shew it not to be destitute of, or by a piercing moisture, that is apt easily to insinuate itself into the pores of some bodies, and thereby change their texture, and so their colour; or by solliciting the avolation of certain parts of the bodies, to which it is contiguous; or by some other way, (which possibly I may elsewhere propose and consider) I have not now the leisure to discourse. And for the same reason, though I could add many other instances, of what I formerly noted touching the emergency of redness upon the digestion of many bodies, inasmuch that I have often seen upon the borders of *France* (and probably we may have the like in *England*) a sort of pears, which digested for some time with a little wine, in a vessel exactly closed, will in not many hours appear throughout of a deep red colour, (as also that of the juice, wherein they are stewed, becomes) but even on pure and white salt of tartar, pure spirit of wine, as clear as rock-water, will (as we elsewhere declare) by long digestion acquire a redness: though I say such instances might be multiplied, and though there be some other obvious changes of colours, which happen so frequently, that they cannot but be as well considerable as notorious; such as is the blackness of almost all bodies burned in the open air; yet our haste invites us to resign you the exercise of inquiring into the causes of these changes. And certainly, the reason both why the soots of such differing bodies are almost all of them all black, why so much the greater part of vegetables should be rather green than of any other colour, and particularly (which more directly concerns the place) why gentle heats do so frequently in chymical operations produce rather a redness than any other colour in digested menstruums, not only sulphureous, as spirit of wine, but saline, as spirit of vinegar, may be very well worth a serious inquiry; which I shall therefore recommend to *Pyrophilus* and his ingenious friends.

EXPERIMENT XXXVII.

IT may seem somewhat strange, that if you take the crimson solution of cochineal, or the juice of black cherries, and of some other vegetables that afford the like colour, (which because many take but for a deep red, we do with them sometimes call it so) and let

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some of it fall upon a piece of paper, a drop or two of an acid spirit, such as spirit of salt, or aqua-fortis, will immediately turn it into a fair red. Whereas, if you make an infusion of brazil in fair water, and drop a little spirit of salt or aqua-fortis into it, that will destroy its redness, and leave the liquor of a yellow, (sometimes pale) I might perhaps plausibly enough say on this occasion, that if we consider the case a little more attentively, we may take notice, that the action of the acid spirit seems in both cases but to weaken the colour of the liquor on which it falls. And so though it destroy redness in the tincture of brazil, as well as produce red in the tincture of cochineal, its operations may be uniform enough, since as crimson seems to be little else than a very deep red, with (perhaps) an eye of blue, so some kinds of red seem (as I have lately noted) to be little else than heightened yellow. And consequently in such bodies, the yellow seems to be but a diluted red. And accordingly alcalizate solutions and urinous spirits, which seem disposed to deepen the colours of the juices and liquors of most vegetables, will not only restore the solution of cochineal and the infusion of brazil to crimson, whence the spirit of salt had changed them into a truer red; but will also (as I lately told you) not only heighten the yellow juice of madder into red, but advance the red infusion of brazil to a crimson. But I know not whether it will not be much safer to derive these changes from varied textures, than certain kinds of bodies; and you will perhaps think it worth while, that I should add on this occasion, that it may deserve some speculation, why notwithstanding what we have been observing, though blue and purple seem to be deeper colours than red, and therefore the juices of plants of either of the two former colours may (congruously enough to what has been just now noted) be turned red by spirit of salt or aqua-fortis, yet blue syrup of violets and some purples should both by oil of tartar and spirit of urine be changed into green, which seems to be not a deeper, but a more diluted colour than blue, if not also than purple.

EXPERIMENT XXXVIII.

IT would much contribute to the history of colours, if chymists would in their laboratories take a heedful notice, and give us a faithful account of the colours observed in the steams of bodies either sublimed or distilled, and of the colours of those productions of the fire, that are made up by the coalition of those steams. As (for instance) we observe in the distilling of pure salt-petre, that at a certain season of the operation, the body, though it seem either crystalline, or white, affords very red fumes: whereas though vitriol be green or blue, the spirit of it is observed to come over in whitish fumes. The like colour I have taken notice of in the fumes of several other concretes of differing colours, and natures, especially when distilled with strong

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fires. And we elsewhere note, that even foot, as black as it is, has filled our receivers with such copious white fumes, that they seemed to have had their insides washed with milk. And no less observable may be the distilled liquors, into which such fumes convene, (for though we will not deny, that by skill and care a reddish liquor may be obtained from nitre) yet the common spirit of it, in the making even of which, store of these red fumes are wont to pass over into the receiver, appears not to be at all red. And besides, that neither the spirit of vitriol, nor that of foot is any thing white; and, besides also, that as far as I have observed, most (for I say not all) of the empyreumatical oils of wood, and other concretes, are either of a deep red, or of a colour between red and black; besides this, I say, it is very remarkable, that notwithstanding that great variety of colours to be met with in the herbs, flowers, and other bodies wont to be distilled *in balneo*; yet (as far at least as our common distillers experience reacheth) all the waters and spirits that first come over by that way of distillation, leave the colours of their concretes behind them, though indeed there be one or two vegetables not commonly taken notice of, whose distilled liquors I elsewhere observe to carry over the tincture of the concrete with them. And as in distillations, so in sublimate, it were worth while to take notice of what comes up, in reference to our present scope, but purposely performing them (as I have in some cases done) in conveniently shaped glasses, that the colour of the ascending fumes may be discerned, for it may afford a Naturalist good information to observe the congruities or the differences betwixt the colours of the ascending fumes, and those of the flowers they compose by their convention. For it is evident, that these flowers do many of them, in point of colour, much differ, not only from one another, but oft times from the concretes that afforded them. Thus, (not here to repeat what I formerly noted of the black soots of very differently coloured bodies) though camphire and brimstone afford flowers much of their own colour, save that those of brimstone are wont to be a little paler, than the lumps that yielded them; yet even of red benzoin, that sublimed substance, which chymists call its flowers, is wont to be white or whitish. And to omit other instances, even one and the same black mineral, antimony, may be made to afford flowers, some of them red, and some grey, and, which is more strange, some of them purely white. And it is the prescription of some glass-men by exquisitely mingling a convenient proportion of brimstone, sal-armoniack, and quicksilver, and subliming them together, to make a sublimate of an excellent blue; and though having caused the experiment to be made, we found the produced sublimate to be far from being of a lovely colour, (as was promised) that here and there it seemed blueish, and at least was of a colour differing enough from either of the ingredients, which is sufficient for our present purpose. But a much finer colour is promised by some of the empi-

ricks, that pretend to secrets, who tell us, that orpiment being sublimed, will afford among the parts of it that fly upward, some little masses, which, though the mineral itself be of a good yellow, will be red enough to emulate rubies, both in colour and translucency. And this experiment may, for aught I know, sometimes succeed; for I remember, that having in a small bolt-head purposely sublimed some powdered orpiment, we could in the lower part of the sublimate discern here and there some reddish lines, though much of the upper part of the sublimate consisted of a matter, which was not alone purely yellow, but transparent almost like a powder. And we have also this way obtained a sublimate, the lower part whereof though it consisted not of rubies, yet the small pieces of it, which were numerous enough, were of a pleasant reddish colour, and glistened very prettily. But to insist on such kind of trials and observations, (where the ascending fumes of bodies differ in colour from the bodies themselves) though it might indeed enrich the history of colours, would rob me of too much of the little time I have to dispatch what I have further to tell you concerning them.

EXPERIMENT XXXIX.

TAKE the dried buds (or blossoms) of the pomegranate tree, (which are commonly called in the shops *Balaustiums*;) pull off the reddish leaves, and by a gentle ebullition of them in fair water, or by a competent infusion of them in like water well heated, extract a faint reddish tincture; which, if the liquor be turbid, you may clarify it by filtrating it. Into this, if you pour a little good spirit of urine, or some other spirit abounding in the like sort of volatile salts, the mixture will presently turn of a darkish green colour; but if instead of the forementioned liquor, you drop into the simple infusion a little rectified spirit of sea-salt, the pale and almost colourless liquor will immediately not only grow more transparent, but acquire a high redness, like that of rich claret wine; which so suddenly acquired colour may as quickly be destroyed, and turned into a dirty blueish green, by the infusion of a competent quantity of the above-mentioned spirit of urine.

ANNOTATION.

THIS experiment may bring some light to, and receive some from a couple of other experiments, that I remember I have met with in the ingenious *Gassendus's* animadversions upon *Epicurus's* philosophy, whilst I was turning over the leaves of those learned commentaries, (my eyes being too weak to let me read such voluminous books quite through;) and I the less scruple (notwithstanding my contrary custom in this treatise) to set down these experiments of another, because I shall a little improve the latter of them, and because by comparing therewith that which I have last cited, we may be assisted to conjecture upon what account

account it is, that oil of vitriol heightens the tincture of red-rose leaves, since spirit of salt, which is a highly acid menstruum, but otherwise differing enough from oil of vitriol, does the same thing. Our author's experiments then, as we made them, are these: We took about a glass-full of lukewarm water, and in it immergd a quantity of the leaves of fenna, and presently upon the immersion there did not appear any redness in the water, but dropping into it a little oil of tartar, the liquor soon discovered a redness to the watchful eye; whereas by a little of that acid liquor of vitriol, which is like the former undeservedly called oil, such a colour would not be extracted from the infused fenna. On the other side, we took some red-rose leaves dried, and having shaken them into a glass of fair water, they imparted to it no redness, but upon the affusion of a little oil of vitriol the water was immediately turned red, which it would not have been, if instead of oil of vitriol, we had employed oil of tartar to produce that colour. That these were *Gassendus* his experiments, I partly remember, and was assured by a friend, who lately transcribed them out of *Gassendus* his book, which, I therefore add, because I have not now that book at hand. And the design of *Gassendus* in these experiments our friend affirms to be, to prove, that of things not red a redness may be made only by mixture, and the varied position of parts, wherein the doctrine of that subtle philosopher doth not a little authorize what we have formerly delivered concerning the emergence and change of colours. But the instances, that we have out of him set down, seem not to be the most eminent, that may be produced of this truth: for our next experiment will shew the production of several colours out of liquors, which have not any of them any such colour, nor indeed any discernable one at all. And whereas though our author tells us, that there was no redness either in the water, or the leaves of fenna, or the oil of tartar; and though it be true, that the predominant colour of the leaves of fenna be another than red, yet we have tried, that by steeping that plant a night even in cold water, it would afford a very deep yellow or reddish tincture without the help of the oil of tartar, which seems to do little more than assist the water to extract more nimbly a plenty of that red tincture, wherewith the leaves of fenna do of themselves abound, and having taken off the tincture of fenna, made only with fair water, before it grew to be reddish, and decanted it from the leaves, we could not perceive, that by dropping some oil of tartar into it, that colour was considerable, though it were a little heightened into a redness, which might have been expected, if the particles of the oil did eminently co-operate, otherwise than we have expressed, to the production of this redness.

AND as for the experiment with red-rose leaves, the same thing may be alledged; for we found that such leaves, by bare infusion for a night and day in fair water, did afford us a tincture bordering at least upon redness; and that colour being conspicuous in the leaves

themselves, would not by some seem so much to be produced as to be extracted by the affusion of oil of vitriol. And the experiment tried with the dry leaves of damask roses succeeded but imperfectly, but that is indeed observable to our author's purpose, that oil of tartar will not perform in this experiment what oil of vitriol doth: but because this last named liquor is not so easily to be had, give me leave to advertise you, that the experiment will succeed, if instead of it you employ aqua fortis. And though some trials of our own formerly made, and others easily deducible from what we have already delivered, about the different families and operations of salt, might enable us to present you an experiment upon red-rose leaves, more accommodated to our author's purpose than that which he hath given us; yet our reverence to so candid a philosopher, invites us rather to improve his experiment, than substitute another in its place. Take therefore of the tincture of red-rose leaves, (for with damask-rose leaves the experiment succeedeth not well) made as before hath been taught with a little oil of vitriol, and a good quantity of fair water; pour off this liquor into a clear phial half filled with limpid water, till the water held against the light have acquired a competent redness, without losing its transparency; into this tincture drop leisurely a little good spirit of urine, and shaking the phial, which you must still hold against the light, you shall see the red liquor immediately turned into a fine greenish blue, which colour was not to be found in any of the bodies, upon whose mixture it emerged: and this change is the more observable, because in many bodies the degenerating of blue into red is usual enough, but the turning of red into blue is very unfrequent. If at every drop of spirit of urine you shake the vial containing the red tincture, you may delightfully observe a pretty variety of colours in the passage of that tincture from a red to a blue, and sometimes we have this way hit upon such a liquor, as being looked upon against and from the light, did seem faintly to emulate the abovementioned tincture of *Lignum Nephriticum*. And if you make the tincture of red-roses very high, and, without diluting it with fair water, pour on the spirit of urine, you may have a blue so deep as to make the liquor opacous; but being dropt upon white paper, the colour will soon disclose itself. Also having made the red, and consequently the blue tincture very transparent, and suffered it to rest in a small open phial for a day or two, we found, according to our conjecture, that not only the blue, but the red colour also vanished; the clear liquor being of a bright amber colour, at the bottom of which subsided a light, but copious feculency of almost the same colour, which seems to be nothing but the tinted parts of the rose-leaves drawn out by the acid spirits of the oil of vitriol, and precipitated by the volatile salt of the spirit of urine: which makes it the more probable, that the redness drawn by the oil of vitriol, was at least as well an extraction of the tinging parts of the roses, as a production of redness. And lastly, if you be

be destitute of spirit of urine, you may change the colour of the tincture of roses with many other sulphureous salts, as a strong solution of pot-ashes, oil of tartar, &c. which yet are seldom so free from feculency, as the spirituous parts of urine becomes by repeated distillation.

ANNOTATION.

ON this occasion, I call to mind, that I found a way of producing, though not the same kind of blue, as I have been mentioning, yet a colour near of kin to it, namely, a fair purple, by employing a liquor not made red by art, instead of the tincture of red-roses made with an acid spirit: and my way was, only to take log-wood, (a wood very well known to dyers) having by infusion the powder of it a while in fair water made that liquor red, I dropt into it a tantillum of an urinous spirit, as that of sal-armoniack, (and I have done the same thing with an alcali) by which the colour was in a moment turned into a rich, and lovely purple. But care must be had, that you let not fall into a spoonful above two or three drops, lest the colour become so deep, as to make the liquor too opacous. And (to answer the other part of *Gassendus* his experiment) if instead of fair water, I infused the logwood in water made somewhat sour by the acid spirit of salt, I should obtain neither a purple liquor, nor a red, but only a yellow one.

EXPERIMENT XL.

THE experiment I am now to mention to you, *Pyrophilus*, is that which both you, and all the other Virtuosi that have seen it, have been pleased to think very strange; and indeed of all the experiments of colours I have yet met with, it seems to be the fittest to recommend the doctrine proposed in this treatise, and to shew that we need not suppose, that all colours must necessarily be inherent qualities, flowing from the substantial forms of the bodies they are said to belong to, since by a bare mechanical change of texture in the minute parts of bodies, two colours may in a moment be generated quite *de novo*, and utterly destroyed. For there is this difference betwixt the following experiment, and most of the others delivered in these papers, that in this, the colour that the body already had, is not changed into another, but betwixt two bodies, each of them apart devoid of colour, there is in a moment generated a very deep colour, and which if it were let alone, would be permanent; and yet by a very small parcel of a third body, that has no colour of its own, (lest some may pretend I know not what antipathy betwixt colours) this otherwise permanent colour will be in another trice so quite destroyed, that there will remain no foot-steps either of it or of any other colour in the whole mixture.

THE experiment is very easy, and it is thus performed: Take good common sublimate,

and fully satiate with it what quantity of water you please, filtre the solution carefully through clean and close paper, that it may drop down as clear and colourless as fountain water. Then, when you'll shew the experiment, put of it about a spoonful into a small wine-glass, or any other convenient vessel made of clear glass, and dropping in three or four drops of good oil of tartar *per deliquium*, well filtered, that it may likewise be without colour: these two limpid liquors will in the twinkling of an eye turn into an opacous mixture of a deep orange colour, which by keeping the glass continually shaking in your hand, you must preserve from settling too soon to the bottom; and when the spectators have a little beheld this first change, then you must presently drop in about four or five drops of the oil of vitriol, and continuing to shake the glass pretty strongly, that it may the nimbler diffuse it self, the whole colour, if you have gone skilfully to work, will immediately disappear, and all the liquor in the glass will be clear and colourless as before, without so much as a sediment at the bottom. But for the more graceful trial of this experiment, it will not be amiss to observe, first, that there should not be taken too much of the solution of sublimate, nor too much of the oil of tartar dropped in, to avoid the necessity of putting in so much oil of vitriol as may make an ebullition, and perhaps run over the glass. Secondly, that it is convenient to keep the glass always a little shaking, both for the better mixing of the liquors, and to keep the yellow substance from subsiding, which else it would in a short time do; though when it is subsided it will retain its colour, and also be capable of being deprived of it by the oil newly mentioned. Thirdly, that if any yellow matter stick at the sides of the glass, it is but inclining the glass, till the clarified liquor can wash along it, and the liquor will presently imbibe it, and deprive it of its colour.

MANY have sometimes wondered, how I came to light upon this experiment; but the notions or conjectures I have about the differing natures of the several tribes of salts, having led me to devise the experiment, it will not be difficult for me to give you the chymical reason, if I may so speak, of the phenomenon. Having then observed, that mercury, being dissolved in some menstruums, would yield a dark yellow precipitate, and supposing that, as to this, common water, and the salts that stick to the mercury would be equivalent to those acid menstruums, which work upon the quicksilver, upon the account of their saline particles, I substituted a solution of sublimate in fair water, instead of a solution of mercury in aqua-fortis, or spirit of nitre, that simple solution being both clearer and free from that very offensive smell, which accompanies the solutions of mercury made with those other corrosive liquors. Then I considered, that that which makes the yellow colour, is indeed but a precipitate made by the means of the oil of tartar, which we drop in, and which, as the chymists know, does generally precipitate metalline bodies

bodies corroded by acid salts: so that the colour in our case results from the coalition of the mercurial particles with the saline ones, wherewith they were formerly associated, and with the alcalizate particles of the salt of tartar that swim up and down in the oil. Wherefore considering also, that very many of the effects of lixiviate liquors, upon the solutions of other bodies, may be destroyed by acid menstruums, as I elsewhere more particularly declare, I concluded, that if I chose a very potently acid liquor, which by its incisive power might undo the work of the oil of tartar, and disperse again those particles, which the other had by precipitation associated, into such minute corpuscles as were before singly inconspicuous, they would become inconspicuous again, and consequently leave the liquor as colourless as before the precipitation was made.

THIS, as I said, *Pyrophilus*, seems to be the chymical reason of this experiment; that is such a reason, as, supposing the truth of those chymical notions I have elsewhere I hope evinced, may give such an account of the phenomena as chymical notions can supply us with: but I both here and elsewhere make use of this way of speaking, to intimate that I am sufficiently aware of the difference betwixt a chymical explication of a phenomenon, and one that is truly philosophical or mechanical; as in our present case, I tell you something, when I tell you that the yellowness of the mercurial solution, and the oil of tartar, is produced by the precipitation occasioned by the affusion of the latter of those liquors, and that the destruction of the colour proceeds from the dissipation of that curdled matter, whose texture is destroyed, and which is dissolved into minute and invisible particles by the potently acid menstruum: which is the reason, why there remains no sediment in the bottom, because the infused oil takes it up, and resolves it into hidden or invisible parts, as water does salt or sugar. But when I have told you all this, I am far from thinking I have told all that such an inquisitive person as your self would know: for I presume you would desire, as well as I, to learn (at least) why the particles of the mercury, of the tartar, and of the acid salts convening together, should make rather an orange colour than a red, or a blue, or a green. For it is not enough to say what I related a little before, that divers mercurial solutions, though otherwise made, would yield a yellow precipitate, because the question will recur concerning them; and to give it a satisfactory answer, is, I freely acknowledge, more than I dare as yet pretend to.

BUT to confirm my conjecture about the chymical reason of our experiment, I may add, that as I have (*viz.* pag. 111. of this treatise) elsewhere (on another occasion) told you, with saline liquors of another kind and nature than salt of tartar, (namely, with spirit of urine, and liquors of kin to that) I can make the mercury precipitate out of the first simple solution quite of another colour than that hitherto mentioned; nay, if instead of altering the precipitating liquor, I altered the texture of the sublimate in such a way as my notions about salt

required, I could produce the same phenomenon. For having purposely sublimed together equal parts (or thereabout) of sal-armoniack and sublimate, first diligently mixed, the ascending flowers being dissolved in fair water, and filtered, gave a solution limpid and colourless, like that of the other sublimates, and yet an alcaly dropped into this liquor did not turn it yellow but white. And upon the same grounds we may with quicksilver, without the help of common sublimate, prepare another sort of flowers dissoluble in water without discolouring it, with which I could likewise do what I newly mentioned; to which I shall add, (what possibly you will somewhat wonder at) that so much does the colour depend upon the texture resulting from the convention of the several sorts of corpuscles, that though, in our experiment, oil of vitriol destroys the yellow colour, yet with quicksilver and fair water, by the help of oil of vitriol alone, we may easily make a kind of precipitate of a fair and permanent yellow, as you will ere long (in the forty second experiment of this third part) be taught. And I may further add, that I chose oil of vitriol, not so much for any other or peculiar quality, as for its being, when it is well rectified, (which it is somewhat hazardous to bring it to be) not only devoid of colour and ill smells, but extremely strong and incisive. For though common and undephlegmated aqua fortis will not perform the same thing well, yet that which is made exceeding strong, by being carefully dephlegmed, will do it pretty well, though not so well as oil of vitriol; which is so strong, that even without rectification it may for a need be made use of. I will not here tell you what I have tried, that I may be able to deprive at pleasure the precipitate that one of the sulphureous liquors had made, by the copious affusion of the other; because I found, though this experiment is too ticklish to let me give a full account of it in few words, I shall therefore tell you, that it is not only for once, that the other above-mentioned experiment may be made, the same numerical parcels of liquor being still employed in it. For after I have clarified the orange-coloured liquor, by the addition of as little of the oil of vitriol as will suffice to perform the effect, I can again at pleasure reproduce the opacous colour, by the dropping in of fresh oil of tartar, and destroy it again by the re-affusion of more of the acid menstruum; and yet oftener, if I please, can I with these two contrariant liquors recall and disperse the colour, though by reason of the addition of so much new liquor, in reference to the mercurial particles, the colour will at length appear more dilute and faint.

An Improvement of the fortieth EXPERIMENT.

AND, *Pyrophilus*, to confirm yet further the notions that led me to think on the proposed experiment, I shall acquaint you with another; which, when I had conveniency, I have sometimes added to it, and which has to the spectators appeared little less odd than the first. And though because the liquor, requisite to make the trial succeed well, must be on purpose

pose prepared a-new a while before, because it will not long retain its fitness for this work, I do but seldom annex this experiment to the other; yet I shall tell you how I devised it, and how I make it. If you boil crude antimony in a strong and clear lixivium, you shall separate a substance from it, which some modern chymists are pleased to call its sulphur, but how deservedly I shall not here examine, having elsewhere done it in an opportune place; wherefore I shall now but need to take notice, that when this supposed sulphur (not now to call it rather a kind of crocus) is let fall by the liquor upon its refrigeration, it often settles in flakes, or such-like parcels of a yellow substance, (which being by the precedent dissolution reduced into minute parts, may peradventure be made to take fire much more easily than the grosser powder of unprepared antimony would have done.) Considering therefore, that common sulphur boiled in a lixivium, may be precipitated out of it by rhenish-wine or white-wine, which are sourish liquors, and have in them, as I elsewhere shew, an acid salt; and having found also by trial, that with other acid liquors I could precipitate out of lixivate solvents some other mineral concretions abounding with sulphureous parts, of which sort is crude antimony; I concluded it to be easy to precipitate the antimony dissolved, as was lately mentioned, with the acid oil of vitriol. And though common sulphur yields a white precipitate, which the chymists call *lac sulphuris*, yet I supposed the precipitated antimony would be of a deep yellow colour, as well if made with oil of vitriol, as if made only by refrigeration and length of time. From this it was easy to deduce this experiment, that if you put into one glass some of the freshly impregnated and filtrated solution of antimony, and into another some of the orange-coloured mixture, (which I formerly shewed you how to make with a mercurial solution and oil of tartar) a few drops of oil of vitriol dropped into the last mentioned glass would, as I told you before, turn the deep yellow mixture into a clear liquor; whereas a little of the same oil dropped out of the same phial into the other glass, would presently (but not without some ill scent) turn the moderately clear solution into a deep yellow substance. But this, as I said, succeeds not well, unless you employ a lixivium that has but newly dissolved antimony, and has not yet let it fall. But yet in summer-time, if your lixivium have been duly impregnated and well filtered after it is quite cold, it will for some days (perhaps much longer than I had occasion to try) retain antimony enough to exhibit, upon the affusion of the corrosive oil, as much of a good yellow substance as is necessary to satisfy the beholders of the possibility of the experiment.

Reflections upon the XLth experiment, compared with the XIth and XXth.

THE knowledge of the distinction of salts which we have proposed, whereby they are discriminated into acid, volatile, or

falsuginous (if I may for distinction sake so call the fugitive salts of animal substances) and fixed or alcalizate, may possibly (by that little part which we have already delivered, of what we could say of its applicableness) appear of so much use in natural philosophy (especially in the practick part of it) that I doubt not but it will be no unwelcome corollary of the preceding experiment, if by the help of it I teach you to distinguish which of those salts is predominant in chymical liquors, as well as whether any of them be so or not. For though in our notes upon the tenth and twentieth experiments I have shown you a way, by means of the tincture of *Lignum Nephriticum*, or of syrup of violets, to discover whether a propounded salt be acid or not; yet you can thereby only find in general that such and such salts belong not to the tribe of acids, but cannot determine whether they belong to the tribe of urinous salts, (under which, for distinction sake, I comprehend all those volatile salts of animal or other substances that are contrary to acids) or to that of alcalies. For as well the one as the other of these salino-sulphureous salts will restore the ceruleous colour to the tincture of *Lignum Nephriticum*, and turn that of syrup of violets into green. Wherefore this XLth experiment does opportunely supply the deficiency of those. For being solicitous to find out some ready ways of discriminating the tribes of chymical salts, I found that all those I thought fit to make trial of, would, if they were of a lixivate nature, make with sublimate dissolved in fair water an orange tawny precipitate; whereas if they were of an urinous nature, the precipitate would be white and milky. So that having always by me some syrup of violets and some solution of sublimate, I can by the help of the first of those liquors discover in a trice, whether the propounded salt or saline body be of an acid nature or no, if it be, I need (you know) inquire no further; but if it be not, I can very easily, and as readily distinguish between the other two kinds of salts, by the white or orange-colour that is immediately produced, by letting fall a few drops or grains of the salt to be examined, into a spoonful of the clear solution of sublimate. For example, it has been supposed by some eminently learned, that when sal armoniack being mingled with an alcali is forced from it by the fire in close vessels, the volatile salt that will thereby be obtained (if the operation be skilfully performed,) is but a more fine and subtile sort of sal-armoniack, which, it is presumed, this operation does but more exquisitely purify than common solutions, filtrations, and coagulations. But this opinion may be easily shown to be erroneous, as by other arguments, so particularly by the lately delivered method of distinguishing the tribes of salts. For the saline spirit of sal-armoniack, as it is in many other manifest qualities very like the spirit of urine, so like, that it will in a trice make syrup of violets of a lovely green, turn a solution of good verdigrease into an excellent azure, and make the solution of a sublimate yield a white precipitate; insomuch that in most (for I say not all of the experiments) where I aim

aim only at producing a sudden change of colour, I scruple not to use spirit of sal-armoniack when it is at hand, instead of spirit of urine, as indeed it seems chiefly to consist (besides the phlegm that helps to make it fluid) of the volatile urinous salt (yet not excluding that of foot) that abounds in the sal armoniack and is set at liberty from the sea-salt wherewith it was formerly associated, and clogged, by the operation of the alcali, that divides the ingredients of sal armoniack, and retains that sea-salt with it self: What use may be made of the like way of exploration in that inquiry which puzzles so many modern Naturalists, whether the rich pigment (which we have often had occasion to mention) belongs to the vegetable or animal kingdom, you may find in another place, where I give you some account of what I tried about cochineal. But I think it needless to exemplify here our method by any other instances, many such being to be met with in divers parts of this treatise; but I will rather advertise you, that by this way of examining chymical liquors, you may not only in most cases conclude affirmatively, but in some cases negatively. As since spirit of wine, and, as far as I have tried, those chymical oils which artists call essential, did not (when I used them as I had used the several families of salts upon that syrup) turn syrup of violets red or green, nor the solution of sublimate white or yellow; I inferred it may thence be probably argued, that either they are destitute of salt, or have such as belongs not to either of the three grand families often already mentioned. When I went to examine the spirit of oak, or of such like concretes forced over through a retort, I found by this means amongst others, that (as I elsewhere show) those chymists are much mistaken in it, that account it a simple liquor, and one of their hypostatical principles. For not to mention what phlegm it may have, I found that with a few drops of one of this sort of spirits mixed with a good proportion of syrup of violets, I could change the colour and make it purplish, by the affinity of which colour to redness, I conjectured that this spirit had some acid corpuscles in it; and accordingly I found, that as it would destroy the blueness of a tincture of *Lignum Nephriticum*, so being put upon corals, it would corrode them, as common spirit of vinegar, and other acid liquors are wont to do. And farther to examine whether there were not a great part of the liquor that was not of an acid nature, having separated the four or vinegar-like part from the rest, which (if I mistake not) is far the more copious; we concluded, as we had conjectured, the other or remaining part, though it had a strong taste as well as smell, to be of a nature differing from that of either of the three sorts of salts above-mentioned, since it did as little as spirit of wine, and chymical oils, alter the colour either of syrup of violets or solution of sublimate: whence we also inferred, that the change that had been made of that syrup into a purple colour, was effected by the vinegar, that was one of the two ingredients of the liquor, which was wont to pass for a simple or

uncompounded spirit. And, upon this account, it was of the spirit of oak (and the like concretes) freed from its vinegar, that I elsewhere told you, that I had not then observed it (and I have repeated the trial but very lately) to destroy the ceruleous tincture of *Lignum Nephriticum*. But this only *en passant*; for the chief thing I had to add was this: That by the same way may be examined and discovered divers changes that are produced in bodies, either by nature only, or by art; either of them being able, by changing the texture of some concretes I could name, to qualify them to operate after a new manner upon the above mentioned syrup, or solution, or both: And by this means, to tell you that, upon the by, I have been able to discover, that there may be made bodies, which though they run *per deliquium*, as readily as salt of tartar, belong in other respects, not to the family of alcalies, much less to that of salfuginous or that of acid salts. Perhaps too, I may know a way of making a highly operative saline body, that shall neither change the colour of syrup of violets, nor precipitate the solution of sublimate; and I can likewise, if I please, conceal by what liquors I perform such changes of colour, as I have been mentioning to you, by quite altering the texture of some ordinary chymical productions, the exploration of which is the main use of the fortieth experiment, which I think teaches not a little, if it teach us to discover the nature of those things (in reference to salt) that are obtained by the ordinary chymical analysis of mixed bodies, though perhaps there may be other bodies prepared by chymistry, which may have the same effects in the change of colours, and yet be produced not from what chymists call the resolution of bodies, but from their composition. But the discoursing of things of this nature is more proper for another place. I shall now only add, what might perhaps have been more seasonably told you before; That the reason why the way of exploration of salts hitherto delivered succeeds in the solution of sublimate, depends upon the particular texture of that solution, as well as upon the differing natures of the saline liquors employed to precipitate it. For gold dissolved in aqua regia, whether you precipitate it with oil of tartar, which is an alcali, or with spirit of urine, or sal armoniack, which belongs to the family of volatile salts, will either way afford a yellow substance: though with such an acid liquor as, I say not spirit of salt, the body that yields it, being up the matter an ingredient of aqua regis, but oil of vitriol it self, I did not find that I could precipitate the metal out of the solution, or destroy the colour of it; though the same oil of vitriol would readily precipitate silver dissolved in aqua-fortis. And if you dissolve pure silver in aqua-fortis, and suffer it to shoot into crystals, the clear solution of these made in fair water, will afford a very white precipitate, whether it be made with an alcali, or an acid spirit, as that of salt; whereas, which may seem somewhat strange, with spirit of sal armoniack (that I used was made of quick-lime)

I could obtain no such white precipitate: that volatile spirit, nor (as I remember) that of urine, scarce doing any more than striking down a very small quantity of matter, which was neither white nor whitish; so that the remaining liquor being suffered to evaporate till the superfluous moisture was gone, the greatest part of the metalline corpuscles with the saline ones that had imbibed them, concoagulated into salt, as is usual in such solutions, wherein the metal has not been precipitated.

EXPERIMENT XLI.

OF kin to the last or fortieth experiment is another which I remember I have sometimes shewn to Virtuosi that were pleased not to dislike it. I took spirit of urine made by fermentation, and with a due proportion of copper brought into small parts, I obtained a very lovely azure solution; and when I saw the colour was such as was requisite, pouring into a clean glass about a spoonful of this tinted liquor, (of which I used to keep a quantity by me) I could, by shaking into it some drops of strong oil of vitriol, deprive it in a trice of its deep colour, and make it look like common water.

ANNOTATION.

THIS experiment brings into my mind this other, which oftentimes succeeds well enough, though not quite so well as the former; namely, that if into about a small spoonful of a solution of good French verdigrease made in fair water, I dropt and shook some strong spirit of salt, or rather dephlegmed aqua fortis, the greenness of the solution would be made in a trice almost totally to disappear, and the liquor held against the light would scarce seem other than clear or limpid, to any but an attentive eye: which is therefore remarkable, because we know that aqua fortis corroding copper, which is it that gives the colour to verdigrease, is wont to reduce it to a green blue solution. But if into the other altogether or almost colourless liquor I was speaking of, you drop a just quantity either of oil of tartar or spirit of urine, you shall find that after the ebullition is ceased, the mixture will disclose a lively colour, though somewhat differing from that which the solution of verdigrease had at first.

EXPERIMENT XLII.

THAT the colour (*Pyrophilus*) of a body may be changed by a liquor which of itself is of no colour, provided it be saline, we have already manifested by a multitude of instances. Nor doth it seem so strange, because saline particles swimming up and down in liquors, have been by many observed to be very operative in the production and change of colours. But divers of our friends, that are not acquainted with chymical operations, have thought it very strange that a white body, and a dry one too, should immediately acquire a rich new colour upon the bare affusion of

spring-water destitute as well of adventitious salt as of tincture. And yet (*Pyrophilus*) the way of producing such a change of colours may be easily enough lighted on, by those that are conversant in the solutions of mercury. For we have tried, that though by evaporating a solution of quicksilver in aqua fortis, and abstracting the liquor till the remaining matter began to be well, but not too strongly dried, fair water poured on the remaining calx made it but somewhat yellowish; yet when we took good quicksilver, and three or four times its weight of oil of vitriol, in case we in a glass retort placed in sand drew off the saline menstruum from the metalline liquor, till there remained a dry calx at the bottom, though this precipitate were a snow-white body, yet upon pouring on it a large quantity of fair water, we did almost in a moment perceive it to pass from a milky colour to one of the loveliest light yellows that ever we had beheld. Nor is the turbith mineral, that chymists extol for its power to salivate, and for other virtues, of a colour much inferior to this, though it be often made with a differing proportion of the ingredients, a more troublesome way. For *Beguinus*, who Beguinus Tyr. Chy. Lib. 2. cap. 13. calls it *Mercurius precipitatus optimus*, takes to one part of quicksilver but two of liquor, and that is rectified oil of sulphur, which is (in *England* at least) far more scarce and dear than oil of vitriol; he also requires a previous digestion, two or three cohobations, and frequent abluitions with hot distilled water; with other prescriptions, which though they may conduce to the goodness of the medicine, which is that he aims at, are troublesome, and, our trials have informed you, unnecessary to the obtaining the lemon colour, which he regards not. But though we have very rarely seen either in painters shops, or elsewhere, a finer yellow than that which we have divers times this way produced, (which is the more considerable, because durable and pleasant yellows are very hard to be met with, as may appear by the great use which painters are for its colour's sake vain to make of that pernicious and heavy mineral, orpiment;) yet I fear our yellow is too costly, to be like to be employed by painters, unless about choice pieces of work, nor do I know how well it will agree with every pigment, especially, with oiled colours. And whether this experiment, though it have seemed somewhat strange to most we have shewn it to, be really of another nature than those wherein saline liquors are employed, may, as we formerly also hinted, be so plausibly doubted, that whether the water poured on the calx, do barely by imbibing some of its saline parts alter its colour, by altering its texture, or whether by dissolving the concoagulated salts, it does become a saline menstruum, and, as such, work upon the mercury, I freely leave to you, *Pyrophilus*, to consider. And that I may give you some assistance in your inquiry, I will not only tell you, that I have several times with fair water washed from this calx, good store of strongly-tasted corpuscles, which by the abstraction of the menstruum, I could reduce into salt; but I will also subjoin an experiment, which I devised,

devised, to shew among other things, how much a real and permanent colour may be as it were drawn forth by a liquor that has neither colour, nor so much as saline or other active parts, provided it can but bring the parts of the body it imbibes to convene into clusters disposed after the manner requisite to the exhibiting of the emergent colour. The experiment was this.

EXPERIMENT XLIII.

WE took good common vitriol, and having beaten it to powder, and put it into a crucible, we kept it melted in a gentle heat, till by the evaporation of some parts, and the shuffling of the rest, it had quite lost its former colour; what remained we took out, and found it to be a friable calx, of a dirty grey. On this we poured fair water, which it did not colour green or blue, but only seemed to make a muddy mixture with it, then stopping the phial wherein the ingredients were put, we let it stand in a quiet place for some days, and after many hours the water having dissolved a good part of the imperfectly calcined body, the vitriolate corpuscles swimming to and fro in the liquor, had time by their opportune excursions to constitute many little masses of vitriol, which gave the water they impregnated a fair vitriolate colour; and this liquor being poured off, the remaining dirty powder did in process of time communicate the like colour, but not so deep, to a second parcel of clear water that we poured on it. But this experiment, *Pyrophilus*, is (to give you that hint by the way) of too luciferous a nature to be fit to be fully prosecuted, now that I am in haste, and willing to dispatch what remains. And we have already said of it, as much as is requisite to our present purpose.

EXPERIMENT XLIV.

IT may (*Pyrophilus*) somewhat contribute towards the shewing how much some colours depend upon the less or greater mixture, and (as it were) contemperation of the light with shades, to observe how that sometimes the number of particles, of the same colour, received into the pores of a liquor, or swimming up and down in it, do seem much to vary the colour of it. I could here present you with particular instances to show, how in many (if not most) consistent bodies, if the colour be not a light one, as white, yellow, or the like, the closeness of parts in the pigments makes it look blackish, though when it is displayed and laid on thinly, it will perhaps appear to be either blue, or green, or red. But the colours of consistent pigments, not being those which the preamble of this experiment has led you to expect examples in, I shall take the instances I am now to give you, rather from liquors than dry bodies. If then you put a little fair water into a clear and slender phial, (or rather into one of those pipes of glass, which we shall by and by mention;) and let fall into it a few drops of a strong decoction

or infusion of cochineal, or (for want of that) of brazil; you may see the tinted drops descend like little clouds into the liquor; through which, if, by shaking the phial, you diffuse them, they will turn the water either of a pink colour, or like that which is wont to be made by the washing of raw flesh in fair water; by dropping a little more of the decoction, you may heighten the colour into a fine red, almost like that which ennobles rubies; by continuing the affusion, you may bring the liquor to a kind of a crimson, and afterwards to a dark and opacous redness, somewhat like that of clotted blood. And in the passage of the liquor from one of these colours to the other, you may observe, if you consider it attentively, divers other less noted colours belonging to red, to which it is not easy to give names; especially considering how much the proportion of the decoction to the fair water, and the strength of that decoction, together with that of the trajected light and other circumstances, may vary the phenomena of this experiment. For the convenienter making whereof, we use, instead of a phial, any slender pipe of glass of about a foot or more in length, and about the thickness of a man's little finger; for, if leaving one end of this pipe open, you seal up the other hermetically, (or at least stop it exquisitely with a cork well fitted to it, and overlaid with hard sealing wax melted, and rubbed upon it;) you shall have a glass, wherein may be observed the variations of the colours of liquors much better than in large phials, and wherein experiments of this nature may be well made with very small quantities of liquor. And if you please, you may in this pipe produce variety of colours in the various parts of the liquor, and keep them swimming upon one another unmixed for a good while. And some have marvelled to see, what variety of colours we have sometimes (but I confess rather by chance than skill) produced in those glasses, by the bare infusion of brazil, variously diluted with fair water, and altered by the infusion of several chymical spirits and other saline liquors devoid themselves of colour: and when the whole liquor is reduced to an uniform degree of colour, I have taken pleasure to make that very liquor seem to be of colours gradually differing, by filling with it glasses of a conical figure, (whether the glass have its basis in the ordinary position, or turned upwards.) And yet you need not glasses of an extraordinary shape, to see an instance of what the various mixture of light and shadow can do in the diversifying of the colour. For if you take but a large round phial, with a somewhat long and slender neck, and filling it with our red infusion of brazil, hold it against the light, you will discern a notable disparity betwixt the colour of that part of the liquor which is in the body of the phial, and that which is more pervious to the light in the neck. Nay, I remember, that I once had a glass and a blue liquor (consisting chiefly, or only, if my memory deceive me not, of a certain solution of verdigrease) so fitted for my purpose, that though in other glasses the experiment would

not succeed, yet when that particular glass was filled with that solution, in the body of the phial it appeared of a lovely blue, and in the neck, (where the light did more dilute the colour,) of a manifest green; and though I suspected there might be some latent yellowness in the substance of the neck of the glass, which might with the blue compose that green, yet was I not satisfied my self with my conjecture, but the thing seemed odd to me, as well as to divers curious persons to whom it was shown. And I lately had a broad piece of glass, which being looked on against the light seemed clear enough, and held from the light appeared very lightly discoloured; and yet it was a piece knocked off from a great lump of glass, to which if we rejoined it, where it had been broken off, the whole mass was as green as grass. And I have several times used bottles and stopples that were both made (as those, I had them from, assured me) of the very same metal; and yet whilst the bottle appeared but inclining towards a green, the stopple (by reason of its great thickness) was of so deep a colour, that you would hardly believe they could possibly be made of the same materials. But to satisfy some ingenious men, on another occasion, I provided my self of a flat glass, (which I yet have by me) with which if I look against the light with the broad side obverted to the eye, it appears like a good ordinary window-glass; but if I turn the edge of it to my eye, and place my eye in a convenient posture in reference to the light, it may contend for deepness of colour with an emerald. And this greenness puts me in mind of a certain thickish, but not consistent pigment I have sometimes made, and can show you when you please, which being dropped on a piece of white paper appears, where any quantity of it is fallen, of a somewhat crimson colour; but being with one's finger spread thinly on the paper, does presently exhibit a fair green: which seems to proceed only from its disclosing its colour upon the extenuation of its depth into superficies, if the change be not somewhat helped by the colours degenerating upon one or other of the accounts formerly mentioned. Let me add, that having made divers trials with that blue substance, which in painters shops is called *Litmase*, we have sometimes taken pleasure to observe, that being dissolved in a due proportion of fair water, the solution either opposed to the light, or dropped upon white paper, did appear of a deep colour betwixt crimson and purple; and yet that being spread very thin on the paper, and suffered to dry on there, the paper was wont to appear stained of a fine blue. And to satisfy my self, that the diversity came not from the paper, which one might suspect capable of imbibing the liquor, and altering the colour, I made the trial upon a flat piece of purely white glazed earth, (which I sometimes make use of about experiments of colours) with an event not unlike the former.

AND now I speak of *litmase*, I will add, that having this very day taken a piece of it, that I had kept by me these several years, to make trials about colours, and having let fall a

few drops of the strong infusion of it in fair water, into a fine crystal glass, shaped like an inverted cone, and almost full of fair water, I had now (as formerly) the pleasure to see, and to shew others, how these few tinted drops variously dispersing themselves through the limpid water, exhibited divers colours, or varieties of purple and crimson. And when the corpuscles of the pigment seemed to have equally diffused themselves through the whole liquor, I then by putting two or three drops of spirit of salt, first made an odd change in the colour of the liquor, as well as a visible commotion among its small parts, and in a short time changed it wholly into a very glorious yellow, like that of a topaz. After which if I let fall a few drops of the strong and heavy solution of pot-ashes, whose weight would quickly carry it to the sharp bottom of the glass, there would soon appear four very pleasant and distinct colours; namely, a bright, but dilute colour at the picked bottom of the glass; a purple, a little higher; a deep and glorious crimson, (which crimson seemed to terminate the operation of the salt upward) in the confines betwixt the purple and the yellow; and an excellent yellow, the same that before ennobled the whole liquor, reaching from thence to the top of the glass. And if I pleased to pour very gently a little spirit of sal-armoniack upon the upper part of this yellow, there would also be a purple or a crimson, or both generated there, so that the unaltered part of the yellow liquor appeared intercepted betwixt the two neighbouring colours.

My scope in this third experiment (*Pyrophilus*) is manifold, as first to invite you to be wary in judging of the colour of liquors in such glasses as are therein recommended to you, and consequently as much, if not more, when you employ other glasses. Secondly, that you may not think it strange, that I often content my self to rub upon a piece of white paper the juice of bodies I would examine; since not only I could not easily procure a sufficient quantity of the juices of divers of them, but in several cases the trials of the quantities of such juices in glasses would make us more liable to mistakes, than the way that in those cases I have made use of. Thirdly, I hope you will by these and divers other particulars delivered in this treatise, be easily induced to think that I may have set down many phænomena very faithfully, and just as they appeared to me, and yet by reason of some unheeded circumstance in the conditions of the matter, and in the degree of light, or the manner of trying the experiment, you may find some things to vary from the relations I make of them. Lastly, I designed to give you an opportunity to free your self from the amazement which possesses most men, at the tricks of those mountebanks that are commonly called water-drinkers. For though not only the vulgar, but even many persons that are far above that rank, have so much admired to see a man, after having drunk a great deal of fair water, to spurt it out again in the form of claret-wine, sack, and milk, that they have suspected the intervening of magick,

gick, or some forbidden means to effect what they conceived above the power of art; yet having once by chance had occasion to oblige a wanderer that made profession of that and other juggling tricks, I was easily confirmed by his ingenuous confession to me, that this so much admired art, indeed consisted rather in a few tricks, than in any great skill, in altering the nature and colours of things. And I am easy to be persuaded, that there may be a great deal of truth in a little pamphlet printed divers years ago in English, wherein the author undertakes to discover, and that (if I mistake not) by the confession of some of the accomplices themselves, that a famous water-drinker, then much admired in *England*, performed his pretended transmutations of liquors by the help of two or three inconsiderable preparations and mixtures of not unobvious liquors, and chiefly of an infusion of brazil variously diluted and made pale or yellowish (and otherwise altered) with vinegar; the rest of their work being performed by the shape of the glasses, by craft and legerdemain. And for my part, that which I marvel at in this business, is the drinkers being able to take down so much water, and spout it out with that violence; though custom and a vomit seasonably taken before hand, may in some of them much facilitate the work. But as for the changes made in the liquors, they were but few and slight in comparison of those, that the being conversant in chymical experiments, and dextrous in applying them to the transmuting of colours, may easily enough enable a man to make, as even what has been newly delivered in this, and the foregoing experiment; especially if we add to it the things contained in the twentieth, the thirty-ninth, and the fortieth experiments, may perhaps have already persuaded you.

EXPERIMENT XLV.

YOU may, I presume, (*Pyrophilus*) have taken notice, that in this whole treatise I purposely decline (as far as I well can) the mentioning of elaborate chymical experiments, for fear of frightening you by their tediousness and difficulty; but yet, in confirmation of what I have been newly telling you about the possibility of varying the colours of liquors, better than the water-drinkers are wont to do, I shall add, that *Helmont* used to make a preparation of steel, which a very ingenious chymist, his son's friend, whom you know, sometimes employs for a succedaneum to the Spawwaters, by diluting this *essentia martis liquida* (as he calls it) with a due proportion of water. Now that for which I mention to you this preparation (which as he communicated to me, I know he will not refuse to *Pyrophilus*) is this, that though the liquor (as I can shew you when you please) be almost of the colour of a German (not an Oriental) amethyst, and consequently remote enough from green, yet a very few drops being let fall into a large proportion of good Rhenish, or (in want of that) white-wine, (which yet does not quite so well) immediately turned the liquor into a lovely green, as I have

not without delight shown several curious persons. By which phenomenon you may learn, among other things, how requisite it is in experiments about the changes of colours heedfully to mind the circumstances of them: for water will not, as I have purposely tried, concur to the production of any such green, nor did it give that colour to moderate spirit of wine, wherein I purposely dissolved it, and wine it self is a liquor that few would suspect of being able to work suddenly any such change in a metalline preparation of this nature. And to satisfy my self that this new colour proceeds rather from the peculiar texture of the wine, than from any greater acidity, that Rhenish or white-wine (for that may not absurdly be suspected) has in comparison of water; I purposely sharpened the solution of this essence in fair water, with a good quantity of spirit of salt, notwithstanding which, the mixture acquired no greenness. And to vary the experiment a little, I tried, that if into a glass of Rhenish wine made green by this essence, I dropped an alcalizate solution, or urinous spirit, the wine would presently grow turbid, and of an odd dirty colour: but if instead of dissolving the essence in wine, I dissolved it in fair water, sharpened perhaps with a little spirit of salt, then either the urinous spirit of sal armoniack, or the solution of the fixed salt of pot-ashes, would immediately turn it of a yellowish colour, the fixed or urinous salt precipitating the vitriolate substance contained in the essence. But here I must not forget to take notice of a circumstance that deserves to be compared with some part of the foregoing experiment; for whereas our essence imparts a greenness to wine, but not to water, the industrious *Olaus Wormius* in his late *Museum* tells us of a rare kind of turnsol, which he calls *Bezetta Rubra*, given him by an apothecary that knew not how it was made, whose lovely redness would be easily communicated to water, if it were immersed in it; but scarce to wine, and not at all to spirit of wine: in which last circumstance it agrees with what I lately told you of our essence, notwithstanding their disagreement in other particulars.

EXPERIMENT XLVI.

WE have often taken notice, as of a remarkable thing, that metals, as they appear to the eye, before they come to be farther altered by other bodies, do exhibit colours very different from those which the fire and the menstruum, either apart, or both together, do produce in them; especially considering that these metalline bodies are after all these disguises reducible not only to their former metalline consistence, and other more radical properties, but to their colour too; as if nature had given divers metals to each of them a double colour, an external, and an internal. But though upon a more attentive consideration of this difference of colours, it seemed probable to me that divers (for I say not all) of those colours which we have just now called internal, are rather produced by the coalition of metalline

metalline particles with those of the salts, or other bodies employed to work on them, than by the bare alteration of the parts of the metals themselves; and though therefore we may call the obvious colours natural or common, and the others adventitious: yet because such changes of colours, from whatsoever cause they be resolved to proceed, may be properly enough taken in to illustrate our present subject, we shall not scruple to take notice of some of them, especially because there are among them such as are produced without the intervention of saline menstruums. Of the adventitious colours of metalline bodies the chief sorts seem to be these three: The first, such colours as are produced without other additaments by the action of the fire upon metals. The next, such as emerge from the coalition of metalline particles with those of some menstruum employed to corrode a metal or precipitate it; and the last, the colours afforded by metalline bodies either colligated with, or otherwise penetrating into, other bodies, especially fusible ones. But these (*Pyrophilus*) are only, as I told you, the chief sorts of the adventitious colours of metals, for there may others belong to them, of which I shall hereafter have occasion to take notice of some, and of which also there possibly may be others that I never took notice of.

AND to begin with the first sort of colours, it is well enough known to chymists, that tin being calcined by fire alone is wont to afford a white calx, and lead calcined by fire alone affords that most common red powder we call minium: copper also calcined *per se*, by a long or violent fire, is wont to yield (as far as I have had occasion to take notice of it) a very dark or blackish powder; that iron likewise may by the action of reverberated flames be turned into a colour almost like that of saffron, may be easily deduced from the preparation of that powder, which by reason of its colour and of the metal it is made of, is by chymists called *Crocus Martis per se*. And that mercury, made by the stress of fire, may be turned into a red powder, which chymists call precipitate *per se*, I elsewhere more particularly declare.

ANNOTATION I.

IT is not unworthy the admonishing you, (*Pyrophilus*) and it agrees very well with our conjectures about the dependence of the change of a body's colour upon that of its texture, that the same metal may by the successive operation of the fire receive divers adventitious colours, as is evident in lead, which before it come to so deep a colour as that of minium, may pass through divers others.

ANNOTATION II.

NOT only the calces, but the glasses of metals, vitrified *per se*, may be of colours differing from the natural or obvious colour of the metal; as I have observed in the glass of lead, made by long exposing crude lead to a violent fire, and what I have observed about the glass or slag of copper (of which I can show you some of an odd kind of texture) may be elsewhere more conveniently related.

I have likewise seen a piece of very dark glass, which an ingenious artificer that showed it me professed himself to have made of silver alone by an extreme violence (which seems to be no more than is needful) of the fire.

ANNOTATION III.

MINERALS also by the action of the fire may be brought to afford colours very differing from their own, as I not long since noted to you about the variously coloured flowers of antimony; to which we may add the whitish grey-colour of its calx, and the yellow or reddish colour of the glass, whereinto that calx may be fluxed.

AND I remember, that I elsewhere told you, that vitriol calcined with a very gentle heat, and afterwards with higher and higher degrees of it, may be made to pass through several colours before it descends to a dark purplish colour, whereto a strong fire is wont at length to reduce it. But to insist on the colours produced by the operation of fire upon several minerals, would take up far more time than I have now to spare.

EXPERIMENT XLVII.

THE adventitious colours produced upon metals, or rather with them, by saline liquors, are many of them so well known to chymists, that I would not here mention them, but that besides a not un-needed testimony, I can add something of my own, to what I shall repeat about them; and divers experiments which are familiar to chymists, are as yet unknown to the greatest part of ingenious men.

THAT gold dissolved in aqua-regia ennobles the menstruum with its own colour, is a thing that you cannot (*Pyrophilus*) but have often seen. The solutions of mercury in aqua-fortis are not generally taken notice of, to give any notable tincture to the menstruum; but sometimes when the liquor first falls upon the quick-silver, I have observed a very remarkable, though not durable greenness, or blueness to be produced; which is a phenomenon not unfit for you to consider, though I have not now the leisure to discourse upon it. Tin corroded by aqua-fortis till the menstruum will work no farther on it, becomes exceeding white; but, as we elsewhere note, does very easily of it self acquire the consistence, not of a metalline calx, but of a coagulated matter, which we have observed with pleasure to look so like, either to curdled milk, or curdled whites of eggs, that a person unacquainted with such solutions may easily be mistaken in it. But when I purposely prepared a menstruum that would dissolve it as aqua-fortis dissolves silver, and not barely corrode it, and quickly let it fall again, I remember not that I took notice of any particular colour in the solution, as if the more whitish metals did not much tinge their menstruums, though the conspicuously coloured metals as gold, and copper, do. For lead dissolved in spirit of vinegar or aqua-fortis gives a solution clear enough, and if the menstruum

struum be abstracted appears either diaphanous or white. Of the colour of iron we have elsewhere said something: and it is worth noting, that though if that metal be dissolved in oil of vitriol diluted with water, it affords a salt or magistery so like in colour, as well as some other qualities, to other green vitriol, that chymists do not improperly call it *Vitriolum Martis*; yet I have purposely tried, that, by changing the menstruum, and pouring upon the filings of steel, instead of oil of vitriol, aqua fortis, (whereof, as I remember, I used four parts to one of the metal) I obtained not a green, but a saffron colour solution; or rather a thick liquor of a deep but yellowish red. Common silver, such as is to be met with in coins, being dissolved in aqua fortis, yields a solution tinged like that of copper, which is not to be wondered at, because in the coining of silver, they are wont (as we elsewhere particularly inform you) to give it an alloy of copper, and that, which is sold in shops for refined silver, is not (so far as we have tried) so perfectly free from that ignobler metal, but that a solution of it in aqua fortis will give a venereal tincture to the menstruum. But we could not observe upon the solution of some silver, which was perfectly refined, (such as some that we have, from which eight or ten times its weight of lead has been blown off) that the menstruum, though held against the light in a crystal phial, did manifestly disclose any tincture, only it seemed sometimes not to be quite destitute of a little, but very faint blueishness.

BUT here I must take notice, that of all the metals, there is not any, which doth so easily and constantly disclose its unobvious colour, as copper doth. For not only in acid menstrua, as aqua fortis and spirit of vinegar, it gives a blueish green solution, but if it be almost any way corroded, it appears of one of those two colours, as may be observed in verdigrise made several ways, in that odd preparation of Venus, which we elsewhere teach you to make with sublimate, and in the common vitriols of Venus delivered by chymists. And so constant is the disposition of copper, notwithstanding the disguise artists put upon it, to disclose the colour we have been mentioning, that we have by forcing it up with sal-armoniack obtained a sublimate of a blueish colour. Nay, a famous Spagyrist affirms, that the very mercury of it is green; but till he teach us an intelligible way of making such a mercury, we must content ourselves to inform you, that we have had a cupreous body, that was precipitated out of a distilled liquor, that seemed to be the sulphur of Venus, and seemed, even when flaming, of a greenish colour. And indeed copper is a metal so easily wrought upon by liquors of several kinds, that I should tell you, I know not any mineral, that will concur to the production of such a variety of colours as copper dissolved in several menstrua, as spirit of vinegar, aqua fortis, aqua regis, spirit of nitre, of urine, of soot, oils of several kinds, and I know not how many other liquors, if the variety of somewhat differing colours

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(that copper will be made to assume, as it is wrought upon by several liquors) were not comprehended within the limits of greenish blue, or bluish green.

AND yet I must advertise you (*Pyrophilus*) that being desirous to try, if I could not make with crude copper a green solution without the blueishness, that is wont to accompany its vulgar solutions, I bethought my self of using two menstrua, which I had not known employed to work on this metal, and which I had certain reasons to make trial of, as I successfully did. The one of these liquors (if I much misremember not) was spirit of sugar distilled in a retort, which must be warily done, (if you will avoid breaking your glasses;) and the other oil or spirit of turpentine, which affords a fine green solution, that is useful to me on several occasions. And yet to shew, that the adventitious colour may result, as well from the true and permanent copper it self, as the salts wherewith it is corroded, I shall add, that if you take a piece of good *Dantzick* copperas, or any other vitriol, wherein Venus is predominant, and having moistened it in your mouth, or with fair water, rub it upon a whetted knife, or any other bright piece of steel or iron, it will (as we have formerly told you) presently stain the steel with a reddish colour, like that of copper; the reason of which we must not now stay to inquire.

ANNOTATION I.

I PRESUME you may have taken notice (*Pyrophilus*) that I have borrowed some of the instances mentioned in this 47th experiment from the laboratories of chymists; and because in some (though very few) other passages of this essay, I have likewise made use of experiments mentioned also by some spagyric writers, I think it not amiss to represent to you on this occasion once for all some things, besides those which I intimated in the preamble of this present experiment. For besides, that it is very allowable for a writer to repeat an experiment, which he invented not, in case he improve it; and besides that many experiments familiar to chymists are unknown to the generality of learned men, who either never read chymical processes, or never understood their meaning, or never durst believe them; besides these things, I say, I shall represent, that, as to the few experiments I have borrowed from the chymists, if they be very vulgar, it would perhaps be difficult to ascribe each of them its own author, and it is more than the generality of chymists themselves can do: and if they be not of very known and familiar practice among them, unless the authors, wherein I found them, had given me cause to believe themselves had tried them, I know not why I might not set them down, as a part of the phenomena of colours, which I present you; many things unanimously enough delivered as matters of fact by I know not how many chymical writers, being not to be relied on, upon the single authority of such authors: for instance, as some Spagyrist deliver

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(perhaps amongst several deceitful processes) that *saccharum Saturni* with spirit of turpentine will afford a balsam, so *Beguinus* and many more tell us, that the same concrete (*saccharum Saturni*) will yield an incomparably fragrant spirit, and a pretty quantity of two several oils. And yet since many have complained, as well as I have done, that they could find no such odoriferous, but rather an ill-scented liquor, and scarce any oil in their distillation of that sweet vitriol, a wary person would as little build any thing on what they say of the former experiment, as upon what they aver of the latter; and therefore I scrupled not to mention this red balsam, of which I have not seen any, (but what I made) among my other experiments about redness.

ANNOTATION II.

WE have sometimes had the curiosity to try, what colours minerals, as tin-glass, antimony, spelter, &c. would yield in several menstruums; nor have we forbore to try the colours of stones, of which that famous one, (which *Helmont* calls *Paracelsus's Ludus*) though it be digged out of the earth, and seem a true stone, has afforded in menstruums capable to dissolve so solid a stone, sometimes a yellowish, sometimes a red solution, of both which I can shew you. But though I have from minerals obtained with several menstruums very differing colours, and some such as, perhaps, you would be surprized to see drawn from such bodies; yet I must now pass by the particulars, being desirous to put an end to this treatise, before I put an end to your patience and my own.

ANNOTATION III.

AND yet before I pass to the next experiment, I must put you in mind, that the colours of metals may in many cases be further altered by employing, either precipitating salts, or other convenient substances to act upon their solutions. Of this you may remember that I have given you several instances already, to which may be added such as these; that if quicksilver be dissolved in aqua fortis, and precipitated out of the solution, either with water impregnated with sea-salt, or with the spirit of the concrete, it falls to the bottom in the form of a white powder; whereas if it be precipitated with an alkali, it will afford a yellowish or tawny powder; and if there be no precipitation made, and the menstruum be drawn off with a convenient fire, the corroded mercury will remain in the bottom, in the form of a substance, that may be made to appear of differing colours by differing degrees of heat: As I remember, that lately having purposely abstracted aqua fortis from some quicksilver, that we had dissolved in it, so that there remained a white calx, exposing that to several degrees of fire, and afterwards to a naked one, we obtained some new colours, and at length the greatest part of the calx lying at the bottom of the phial, and being brought partly to a deep yellow, and partly to a red colour, the rest appeared elevated to the upper part and neck of the phial, some in the form of reddish,

and some of an ash-colour sublimate. But of the differing colours, which by differing ways and working of quicksilver with fire, and saline bodies, may be produced in precipitates, I may elsewhere have occasion to take further notice. I also told you not long since, that if you corrode quicksilver with oil of vitriol instead of aqua fortis, and abstract the menstruum, there will remain a white calx, which by the affusion of fair water presently turns into a lemon colour. And even the succedaneum to a menstruum may sometimes serve the turn, to change the colours of a metal. The lovely red, which painters call vermilion, is made of mercury, which is of the colour of silver; and of brimstone, which is of kin to that of gold, sublimed up together in a certain proportion, as is vulgarly known to Spagyrist.

EXPERIMENT XLVIII.

THE third chief sort of the adventitious colours of metals is that, which is produced by associating them (especially when calcined) with other fusible bodies, and principally *Venice*, and other fine glass, devoid of colour.

I HAVE formerly given you an example, whereby it may appear, that a metal may impart to glass a colour much differing from its own, when I told you how with silver I had given glass a lovely golden colour. And I shall now add, that I have learned from one of the chief artificers, that sells painted glass, that those of his trade colour it yellow with a preparation of the calx of silver. Though having lately had occasion among other trials to mingle a few grains of shell-silver (such as is employed with the pencil with the pen) with a convenient proportion of powdered crystal glass, having kept them two or three hours in fusion, I was surprized to find the colligated mass to appear, upon breaking the crucible, of a lovely saphirine blue; which made me suspect my servant might have brought me a wrong crucible; but he constantly affirmed it to be the same, wherein the silver was put, and considerable circumstances countenanced his assertion, so that till I have opportunity to make farther trial, I cannot but suspect, either that silver, which is not (which is not very probable) brought to a perfect fusion and colligation with glass, may impart to it other colours than when nealed upon it; or else (which is less unlikely) that though silver-beaters usually chuse the finest coin they can get, as that which is most extensive under the hammer, yet the silver leaves, of which this shell-silver was made, might retain so much copper, as to enable it to give the predominant tincture to the glass.

FOR, I must proceed to tell you (*Pyrophilus*) as another instance of the adventitious colours of metals, that, which is something strange, namely, that, though copper calcined *per se* affords but a dark and basely coloured calx, yet the glass-men do with it, as themselves inform me, tinge their glass green. And I remember, that when once we took some crude copper, and by frequent ignition quenching it in

water

water had reduced it to a dark and ill-coloured powder, and afterwards kept it in fusion in about a hundred times its weight of fine glass, we had, though not a green, yet a blue coloured mass; which would perhaps have been green, if we had hit right upon the proportion of the materials, and the degree of fire, and the time wherein it ought to be kept in fusion; so plentifully does that metal abound in a venereal tincture, as artists call it, and in so many ways does it disclose that richness. But though copper do, as we have said, give somewhat near the like colour to glass, which it does to aqua fortis, yet it seems worthy to enquire, whether these new colours, which mineral bodies disclose in melted glass, proceed from the coalition of the corpuscles of the mineral with the particles of the glass as such, or from the action (excited or actuated by fire) of the alcalizate salt (which is a main ingredient of glass) upon the mineral body, or from the concurrence of both these causes, or else from any other. But to return to that which we were saying, we may observe, that putty made by calcining together a proportion of tin and lead, as it is itself a white calx, so does it turn the *pitta di crystallo* (as the glass-men call the matter of the purer sort of glass, wherewith it is colligated) into a white mass; which, if it be opacous enough, is employed, as we elsewhere declare, for white amel. But of the colours, which the other metals may be made to produce in colourless glass, and other vitrifiable bodies, that have native colours of their own, I must leave you to inform your self upon trial; or at least must forbear to do it till another time, considering how many annotations are to follow, upon what has in this and the two former experiments been said already.

A N N O T A T I O N I.

WHEN the materials of glass being melted with calcined tin, have composed a mass undiaphanous and white, this white amel is as it were the basis of all those fine concretes, that goldsmiths and several artificers employ in the curious art of enamelling. For this white and fusible substance will receive into it self, without spoiling them, the colours of divers other mineral substances, which like it will endure the fire.

A N N O T A T I O N II.

SO that as by the present (XLVIII) experiment it appears, that divers minerals will impart to fusible masses colours differing from their own; so by the making and compounding of amels, it may appear, that divers bodies will both retain their colour in the fire, and impart the same to some others wherewith they were vitrified, and in such trials as that mentioned in the seventeenth experiment, where I told you, that even in amels a blue and yellow will compound a green. It is pretty to behold, not only that some colours are of so fixed a nature, as to be capable of mixture without receiving any detriment by the fire, that does so easily destroy or spoil those of other bodies;

but mineral pigments may be mingled by fire little less regularly and successfully, than in ordinary dying fatts, the vulgar colours are wont to be mingled by the help of water.

A N N O T A T I O N III.

IT is not only metalline, but other mineral bodies, that may be employed, to give tinctures unto glass; and it is worth noting how small a quantity of some mineral substances will tinge a comparatively vast proportion of glass; and we have sometimes attempted to colour glass, even with precious stones, and had cause to think the experiment not cast away. And it is known by them, that have looked into the art of glass, that the artificers used to tinge their glass blue with that dark mineral zaffora (some of my trials on which I elsewhere acquaint you) which some would have to be a mineral earth, others a stone, and others neither the one nor the other, but which is confessedly of a dark, but not a blue colour, though it be not agreed of what particular colour it is. It is likewise though a familiar yet a remarkable practice among those, that deal in the making of glass, to employ (as some of themselves have informed me) what they call manganese, and some authors call *Magnesia* (of which I make particular mention in another treatise) to exhibit in glass not only other colours than its own, (which is so like in darkness or blackishness to the loadstone, that is given by mineralists for one of the reasons of its Latin name) but colours differing from one another. For though they use it, (which is somewhat strange) to clarify their glass, and free it from that blueish greenish colour, which else it would too often be subject to; yet they also employ it in certain proportions, to tinge their glass both with red colour, and with a purplish or murry; and putting in a greater quantity, they also make with it that deep obscure glass, which is wont to pass for black, which agrees very well with, and may serve to confirm what we noted near the beginning of the 44th experiment, of the seeming blackness of those bodies, that are over-charged with the corpuscles of such colours, as red, or blue, or green, &c. And as by several metals and other minerals we can give various colours to glass, so on the other side, by the differing colours, that mineral ores, or other mineral powders, being melted with glass, disclose in it, a good conjecture may be oftentimes made of the metal or known mineral, that the ore proposed either holds, or is most of kin to. And this easy way of examining ores may be in some cases of good use; and is not ill delivered by *Glauber*, to whom I shall at present refer you for a more particular account of it: unless your curiosity command also what I have observed about these matters. Only I must here advertise you that great circumspection is requisite to keep this way from proving fallacious, upon the account of the variations of colour, that may be produced by the differing proportions, that may be used betwixt the ore and the glass, by the richness or poorness of the

the ore it self, by the degree of fire, and especially by the length of time, during which the matter is kept in fusion; as you will easily gather from what you will quickly meet with in the following annotation upon this 48th experiment.

ANNOTATION IV.

THERE is another way, and differing enough from those already mentioned, by which metals may be brought to exhibit adventitious colours: for by this, the metal does not so much impart a colour to another body, as receive a colour from it, or rather both bodies do by the new texture resulting from their mixture produce a new colour. I will not insist to this purpose upon the examples afforded us by yellow orpiment, and common sea-salt, from which, sublimed together, chymists unanimously affirm their white or crystalline arsenick to be made: but it is not unworthy our noting, that though yellow orpiment be acknowledged to be the copiouslest by far of the two ingredients of arsenick, yet this last named body being duly added to the highest coloured metal copper, when it is in fusion, gives it whiteness both within and without. Thus *Lapis Calaminaris* changes and improves the colour of copper, by turning it into brass. And I have sometimes, by the help of zink duly mixed after a certain manner, given copper one of the richest golden colours, that ever I have seen the best true gold ennobled with. But pray have a care, that such hints fall not into any hands, that may mis-employ them.

ANNOTATION V.

UPON the knowledge of the differing ways of making minerals and metals produce their adventitious colours in bodies capable of vitrification, depends the pretty art of making what chymists by a barbarous word are pleased to call *Amanfes*, that is, counterfeit or factitious gems, as emeralds, rubies, sapphires, topazes, and the like. For in the making of these, though pure sand or calcined crystal give the body, yet it is for the most part some metalline or mineral calx, mingled in a small proportion, that gives the colour. But though I have many years since taken delight to divert myself with this pleasing art, and have seen very pretty productions of it, yet besides that I fear I have now forgot most of the little skill I had in it, this is no place to entertain you with what would rather take up an entire discourse, than be comprehended in an annotation. Wherefore the few things, which I shall here take notice of to you, are only what belong to the present argument, namely,

FIRST, that I have often observed, that calcined lead colligated with fine white sand or crystal, reduced by ignitions and subsequent extinctions in water to a subtil powder, will of itself be brought by a due decoction to give a clear mass coloured like a German amethyst. For though this glass of lead is looked upon by them, that know no better way of making *Amanfes*, as the grand work of them all; yet,

which is an inconvenience, that much blemishes this way, the calcined lead it self does not only afford matter to the *Amanfes*, but has also as well as other metals a colour of its own, which, as I was saying, I have often found to be like that of German (as many call them) not Eastern amethysts.

SECONDLY, That nevertheless this colour may be easily over-powered by those of divers other mineral pigments (if I may so call them) so that with glass of lead you may emulate (for instance) the fresh and lovely greenness of an emerald, though in divers cases the colour, which the lead itself upon vitrification tends to, may vitiate that of the pigment, which you would introduce into the mass.

THIRDLY, That so much even these colours depend upon texture, that in the glass of lead it self made of about three parts of litharge or minium colligated with one of very finely powdered crystal or sand, we have taken pleasure to make the mixture pass through differing colours, as we kept it more or less in the fusion. For it was not usually till after a pretty long decoction, that the mass attained to the amethystine colour.

FOURTHLY and lastly, That the degrees of coction and other circumstances may so vary the colour produced in the same mass, that in a crucible that was not great I have had fragments of the same mass, in some of which, perhaps not so big as a hazel-nut, you may discern four distinct colours.

ANNOTATION VI.

YOU may remember (*Pyrophilus*) that when I mentioned the three sorts of adventitious colours of metals, I mentioned them but as the chief, not the only. For there may be other ways, which though they do not in so strict a sense belong to the adventitious colours of metals, may not inconveniently be reduced to them. And of these I shall name now a couple, without denying, that there may be more.

THE first may be drawn from the practice of those, that dye scarlet. For the famouslest master in that art, either in *England* or *Holland*, has confessed to me, that neither others nor he can strike that lovely colour, which is now wont to be called the Bow-dye, without their materials be boiled in vessels, either made of, or lined with a particular metal. But of what I have known attempted in this kind, I must not as yet, for fear of prejudicing or displeasing others, give you any particular account.

THE other way, (*Pyrophilus*) of making metals afford unobvious colours, is by imbuing divers bodies with solutions of them made in their proper menstrua: as (for instance,) though copper plentifully dissolved in aquafortis will imbue several bodies with the colour of the solution; yet some other metals will not (as I elsewhere tell you) and have often tried. Gold dissolved in aqua regia will (which is not commonly known) dye the nails and skin, and hafts of knives, and other things made of ivory, not with a golden, but a purple colour, which though it manifest but slowly, is very durable,

See the latter end of the fifth experiment.

durable, and scarce ever to be washed out. And if I misremember not, I have already told you in this treatise, that the purer crystals of fine silver made with aqua fortis, though they appear white, will presently dye the skin and nails with a black, or at least a very dark colour, which water will not wash off, as it will ordinary ink from the same parts. And divers other bodies may the same way be dyed, some of a black, and others of a blackish colour.

AND as metalline, so likewise mineral solutions may produce colours differing enough from those of the liquors themselves. I shall not fetch an example of this, from what we daily see happen in the powdering of beef, which by the brine employed about it (especially if the flesh be over-salted) does oftentimes appear at our tables of a green, and sometimes of a reddish colour, (deep enough;) nor shall I insist on the practice of some that deal in saltpetre, who, (as I suspected, and as themselves acknowledged to me) do, with the mixture of a certain proportion of that, and common salt, give a fine redness, not only to neats tongues, but, which is more pretty as well as difficult, to such flesh, as would otherwise be purely white: these examples, I say, I shall decline insisting on, as chusing rather to tell you, that I have several times tried, that a solution of the sulphur of vitriol, or even of common sulphur, though the liquor appeared clear enough, would immediately tinge a piece of new coin, or other clean silver, sometimes with a golden, sometimes with a deeper and more reddish colour, according to the strength of the solution, and the quantity of it, that chanced to adhere to the metal; which may take off your wonder, that the water of the hot spring at *Bath*, abounding with dissolved substances of a very sulphureous nature, should for a while as it were gild the new or clean pieces of silver coin, that are for a due time immersed in it. And to these may be added those formerly mentioned examples of the adventitious colours of mineral bodies: which brings into my mind, that even vegetable liquors, whether by degeneration, or by altering the texture of the body that imbibes them, may stain other bodies with colours differing enough from their own, of which very good herbarists have afforded us a notable example, by affirming, that the juice of alcanna being green (in which state I could never here procure it) does yet dye the skin and nails of a lasting red. But I see this treatise is like to prove too bulky, without the addition of further instances of this nature.

EXPERIMENT XLIX.

MEETING the other day, *Pyrophilus*, in an Italian book, that treats of other matters, with a way of preparing what the author calls a lacca of vegetables, by which the Italians mean a kind of extract fit for painting, like that rich lacca in English commonly called

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lake, which is employed by painters as a glorious red: and finding the experiment not to be inconsiderable, and very defectively set down; it will not be amiss to acquaint you with what some trials have informed us, in reference to this experiment, which both by our Italian author, and by divers of his countrymen, is looked upon as no trifling secret.

TAKE then the root called in Latin *Curcuma*, and in English turmeric, (which I made use of, because it was then at hand, and is among vegetables fit for that purpose one of the most easiest to be had;) and when it is beaten, put what quantity of it you please into fair water, adding to every pound of water about a spoonful or better of as strong a lixivium or solution of pot-ashes as you can well make, clarifying it by filtration before you put it to the decocting water. Let these things boil, or rather simmer over a soft fire in a clean glazed earthen vessel, till you find by the immersion of a sheet of white paper (or by some other way of trial) that the liquor is sufficiently impregnated with the golden tincture of the turmeric; then take the decoction off the fire, and filter or strain it, that it may be clean; and leisurely dropping into it a strong solution of roch-allom, you shall find the decoction as it were curdled, and the tinted part of it either to emerge, to subside, or to swim up and down, like little yellow flakes; and if you pour this mixture into a tunnel lined with cap-paper, the liquor, that filtered formerly so yellow, will now pass clean through the filtre, leaving its tinted and as it were curdled parts in the filtre, upon which fair water must be so often poured, till you have dulcified the matter therein contained, the sign of which dulcification is (you know) when the water, that has passed through it, comes from it as tasteless as it was poured on it. And if without filtration you would gather together the flakes of this vegetable lake, you must pour a great quantity of fair water upon the decoction after the affusion of the alluminous solution, and you shall find the liquor to grow clearer, and the lake to settle together at the bottom, or emerge to the top of the water; though sometimes having not poured out a sufficient quantity of fair water, we have observed the lake partly to subside, and partly to emerge, leaving all the middle of the liquor clear. But to make this lake fit for use, it must, by repeated affusions of fresh water, be dulcified from the adhering salts, as well as that separated by filtration, and be spread and suffered to dry leisurely upon pieces of cloth, with brown paper, or chalk, or bricks under them to imbibe the moisture. *

ANNOTATION I.

WHEREAS it is presumed, that the magistry of vegetables obtained this way consists but of the more soluble and coloured parts of the plants that afford it, I must take

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the

* The curious reader that desires further information concerning lakes, may resort to the 7th book of *Neri's* art of glass, Englished (6 or 7 years since the writing of this 49th experiment) and illustrated with learned observations, by the inquisitive and experienced Dr. *Charles Merret*.

the liberty to question the supposition; and for my so doing, I shall give you this account.

ACCORDING to the notions (such as they were) that I had concerning salts; allom, though to sense a homogeneous body, ought not to be reckoned among true salts, but to be itself looked upon as a kind of magistery, in regard that as native vitriol (for such I have had) contains both a saline substance and a metal, whether copper, or iron, corroded by it, and associated with it; so allom, which may be of so near a kin to vitriol, that in some places of *England* (as we are assured by good authority the same stone will sometimes afford both) seems manifestly to contain a peculiar kind of acid spirit, generated in the bowels of the earth, and some kind of stony matter dissolved by it. And though in making our ordinary allom the workmen use the ashes of a sea-weed (vulgarly called kelp) and urine; yet those, that should know, inform us, that, here in *England*, there is besides the factitious allom, allom made by nature without the help of those additaments. Now, *Pyrophilus*, when I considered this composition of allom, and that alcalizate salts are wont to precipitate what acid salts have dissolved, I could not but be prone to suspect, that the curdled matter, which is called the magistery of vegetables, may have in it no inconsiderable proportion of a stony substance precipitated out of the allom by the lixivium, wherein the vegetable had been decocted. And to shew you, that there is no necessity, that all the curdled substance must belong to the vegetable, I shall add, that I took a strong solution of allom, and having filtered it, by pouring in a convenient quantity of a strong solution of pot-ashes, I presently, as I expected, turned the mixture into a kind of white curds, which being put to filtre, the paper retained a stony calx, copious enough, very white, and which seemed to be of a mineral nature, both by some other signs, and this, that little bits of it being put upon a live coal, which was gently blown whilst they were on it, they did neither melt nor fly away, and you may keep a quantity of this white substance for a good while, (nay, for aught I can guess, for a very long one) in a red-hot crucible, without losing or spoiling it; nor did hot water, wherein I purposely kept another parcel of such calx, seem to do any more than wash away the looser adhering salts from the stony substance, which therefore seemed unlikely to be separable by ablutions (though reiterated) from the precipitated parts of the vegetable, whose lake is intended. And to shew you, that there is likewise in allom a body, with which the fixed salt of the alcalizate solution will concoagulate into a saline substance differing from either of them, I shall add, that I have taken pleasure to recover out of the slowly exhaled liquor, that passed through the filtre, and left the aforementioned calx behind, a body, that at least seemed a salt very pretty to look on, as being very white, and consisting of an innumerable company of exceeding slender and shining particles, which would in part easily melt at the flame of a candle, and in part fly away with

some little noise. But of this substance, and its odd qualities, more, perhaps, elsewhere; for now I shall only take notice to you, that I have likewise with urinous salts, such as the spirit of sal armoniac, as well as with the spirit of urine itself, nay, (if I much mistake not) even with stale urine undistilled, easily precipitated such a white calx, as I was formerly speaking of, out of a limpid solution of allom: so that there is need of circumspection in judging of the natures of liquors by precipitations, wherein allom intervenes; else we may sometimes mistakingly imagine, that to be precipitated out of a liquor by allom, which is rather precipitated out of allom by the liquor. And this puts me in mind to tell you, that it is not unpleasent to behold, how quickly the solution of allom (or injected lumps of allom) does occasion the severing of the coloured parts of the decoction from the liquor, that seemed to have so perfectly imbibed them.

ANNO TATION II.

THE above-mentioned way of making lakes we have tried not only with turmeric, but also with madder, which yielded us a red lake; and with rue, which afforded us an extract, of (almost, if not altogether) the same colour with that of the leaves.

BUT in regard that it is principally the alcalizate salt of the pot-ashes, which enables the water to extract so powerfully the tincture of the decocted vegetables, I fear, that our author may be mistaken, by supposing, that the decoction will always be of the very same colour with the vegetable it is made of. For lixiviate salts, to which pot-ashes eminently belong, though by piercing and opening the bodies of vegetables, they prepare and dispose them to part readily with their tincture; yet some tinctures they do not only draw out, but likewise alter them, as may be easily made appear by many of the experiments already set down in this treatise. And though allom being of an acid nature, its solutions may in some cases destroy the adventitious colours produced by the alcali, and restore the former; yet besides that allom is not, as I have lately shown, a mere acid salt, but a mixt body; and besides that its operations are languid in comparison of the activity of salts freed by distillation, or by incineration and dissolution, from the most of their earthy parts, we have seen already examples, that in divers cases an acid salt will not restore a vegetable substance to the colour, of which an alcalizate one had deprived it, but makes it assume a third very differing from both; as we formerly told you, that if syrup of violets were by an alcali turned green, (which colour, as I have tried, may be the same way produced in the violet-leaves themselves without any relation to a syrup) an acid salt would not make it blue again, but red. And though I have, by this way of making lakes, made magisteries (for such they seem to be) of brazil, and as I remember of cochineal itself, and of other things, red, yellow, or green, which lakes were ennobled with a rich colour, and others had no bad one; yet in some

some the colour of the lake seemed rather inferior than otherwise to that of the plant, and in others it seemed both very differing, and much worse. But writing this in a time and place, where I cannot provide myself of flowers and other vegetables to prosecute such trials in a competent variety of subjects, I am content not to be positive in delivering a judgment of this way of lakes, till experience, or you, *Pyrophilus*, shall have afforded me a fuller and more particular information.

ANNOTATION III.

AND on this occasion, *Pyrophilus*, I must here (having forgot to do it sooner) advertise you, once for all, that having written several of the foregoing experiments, not only in haste, but at seasons of the year, and in places wherein I could not furnish myself with such instruments, and such a variety of materials, as the design of giving you an introduction into the history of colours required; it can scarce be otherwise, but that divers of the experiments, that I have set down, may afford you some matter of new trials, if you think fit to supply the deficiencies of some of them, (especially the freshly mentioned about lakes, and those that concern emphatical colours;) which deficiencies, for want of being befriended with accommodations, I could better discern than avoid.

ANNOTATION IV.

THE use of allom is very great as well as familiar in the dyers trade, and I have not been ill pleased with the use I have been able to make of it, in preparing other pigments than those they employ with vegetable juices. But the lucrative practices of dyers and other tradesmen I do, for reasons that you may know when you please, purposely forbear in this essay, though not strictly from pointing at, yet from making it a part of my present work explicitly and circumstantially to deliver; especially since I now find (though late, and not without some blushes at my prolixity) that what I intended but for a short essay, is already swelled into almost a volume.

EXPERIMENT L.

YET here, *Pyrophilus*, I must take leave to insert an experiment, though perhaps you will think its coming in here an intrusion: For I confess its more proper place would have been among those experiments, that were brought as proofs and applications of our notions concerning the differences of salts; but not having remembered to insert it in its fittest place, I had rather take notice of it in this, than leave it quite unmentioned: partly, because it doth somewhat differ from the rest of our experiments about colours, in the way whereby it is made; and partly because the grounds, upon which I devised it, may hint to you somewhat of the method I use in defining and varying experiments about colours. And upon this account I shall inform you, not only what I did, but why I did it.

I CONSIDERED then, that the work of the former experiments was either to change the colour of a body into another, or quite to destroy it, without giving it a successor; but I had a mind to give you also a way, whereby to turn a body endued with one colour into two bodies, of colours as well as consistencies, very distinct from each other, and that by the help of a body, that had itself no colour at all. In order to this, I remembered, that finding the acidity of spirit of vinegar to be wholly destroyed by its working upon minium (or calcined lead) whereby the saline particles of the menstruum have their taste and nature quite altered, I had, among other conjectures I had built upon that change, rightly concluded, that the solution of lead in spirit of vinegar would alter the colour of the juices and infusions of several plants, much after the like manner that I had found oil of tartar to do; and accordingly I was quickly satisfied upon trial, that the infusion of rose-leaves would, by a small quantity of this solution well mingled with it, be immediately turned into a somewhat sad green.

AND further, I had often found, that oil of vitriol, though a potently acid menstruum, will yet precipitate many bodies, both mineral and others, dissolved not only in aquafortis (as some chymists have observed) but particularly in spirit of vinegar. And I have further found, that the calces or powders precipitated by this liquor were usually fair and white.

LAYING these things together, it was not difficult to conclude, that if upon a good tincture of red rose-leaves made with fair water, I dropped a pretty quantity of a strong and sweet solution of minium, the liquor would be turned into the like muddy green substance, as I have formerly intimated to you, that oil of tartar would reduce it to; and that if then I added a convenient quantity of good oil of vitriol, this last named liquor would have two distinct operations upon the mixture; the one, that it would precipitate that resolved lead in the form of a white powder; the other, that it would clarify the muddy mixture, and both restore and exceedingly heighten the redness of the infusion of roses, which was the most copious ingredient of the green composition. And accordingly trying the experiment in a wine-glass sharp at the bottom (like an inverted cone) that the subsiding powder might seem to take up the more room, and be the more conspicuous, I found, that when I had shaken the green mixture, that the coloured liquor might be the more equally dispersed, a few drops of the rectified oil of vitriol did presently turn the opacous liquor into one that was clear and red, almost like a ruby, and threw down good store of a powder, which, when it was settled, would have appeared very white, if some interspersed particles of the red liquor had not a little allayed the purity, though not blemished the beauty of the colour. And to shew you, *Pyrophilus*, that these effects do not flow from the oil of vitriol, as it is such, but as it is a strongly acid menstruum, that has the

the property both to precipitate lead, as well as some other concretes out of spirit of vinegar, and to heighten the colour of red rose-leaves; I add, that I have done the same thing, though perhaps not quite so well, with spirit of salt; and that I could not do it with aqua fortis, because though that potent menstruum does, as well as the others, heighten the redness of roses, yet it would not, like them, precipitate lead out of spirit of vinegar, but would rather have dissolved it, if it had not found it dissolved already.

AND as by this way we have produced a red liquor, and a white precipitate out of a dirty green magistery of rose-leaves; so by the same method, you may produce a fair yellow, and sometimes a red liquor, and the like precipitate, out of an infusion of a curious purple colour. For you may call to mind, that in the annotation upon the 39th experiment I intimated to you, that I had with a few drops of an alcali turned the infusion of logwood into a lovely purple. Now if instead of this alcali I substituted a very strong and well-filtrated solution of minium, made with spirit of vinegar, and put about half as much of this liquor as there was of the infusion of logwood, (that the mixture might afford a pretty deal of precipitate,) the affusion of a convenient proportion of spirit of salt would (if the liquors were well and nimbly stirred together) presently strike down a precipitate like that formerly mentioned, and turn the liquor, that swam above it, for the most part, into a lovely yellow.

BUT for the advancing of this experiment a little further, I considered, that in case I first turned a spoonful of the infusion of logwood purple, by a convenient proportion of the solution of minium, the affusion of spirit of sal-armoniack would precipitate the corpuscles of lead concealed in the solution of minium, and yet not destroy the purple colour of the liquor; whereupon I thus proceeded: I took about a spoonful of the fresh tincture of logwood, (for I found, that if it were stale, the experiment would not always succeed,) and having put to it a convenient proportion of the solution of minium to turn it into a deep and almost opaque purple, I then dropped in as much spirit of sal armoniack, as I guessed would precipitate about half or more (but not all) of the lead, and immediately stirring the mixture well together, I mingled the precipitated parts with the others, so that they fell to the bottom, partly in the form of a powder, and partly in the form of a curdled substance, that (by reason of the predominancy of the tinged corpuscles over the white) retained, as well as the supernatant liquor, a blueish purple colour sufficiently deep, and then instantly (but yet warily) pouring on a pretty quantity of spirit of salt, the matter first precipitated was, by the above specified figure of the bottom of the glass preserved from being reached by the spirituous salt; which hastily precipitated upon it a new bed (if I may so call it) of white powder, being the remaining corpuscles of the lead, that the urinous spirit had not struck down. So that

there appeared in the glass three distinct and very differing coloured substances; a purple or violet-coloured precipitate at the bottom, a white and carnation (sometimes a variously coloured) precipitate over that, and at the top of all a transparent liquor of a lovely yellow, or red.

THUS you see, *Pyrophilus*, that though to some I may have seemed to have lighted on this (50th) Experiment by chance, and though others may imagine, that to have excogitated it must have proceeded from some extraordinary insight into the nature of colours; yet indeed the devising of it need not be looked upon as any great matter, especially to one, that is a little versed in the notions I have in these, and other papers hinted concerning the differences of salts. And perhaps I might add, upon more than conjecture, that these very notions, and some particulars scatteringly delivered in this treatise, being skilfully put together, may suggest divers matters (at least) about colours, that will not be altogether despicable. But those hinted, *Pyrophilus*, I must now leave such as you to prosecute, having already spent far more time than I intended to allow myself, in acquainting you with particular experiments and observations concerning the changes of colour; to which I might have added many more, but that I hope I may have presented you with a competent number, to make out, in some measure, what I have, at the beginning of this essay, either proposed as my design in this tract, or delivered as my conjectures concerning these matters. And it not being my present design, as I have more than once declared, to deliver any positive hypothesis or solemn theory of colours, but only to furnish you with some experiments towards the framing of such a theory; I shall add nothing to what I have said already, but a request, that you would not be forward to think I have been mistaken in any thing I have delivered as matter of fact concerning the changes of colours, in case you should not, every time you try it, find it exactly to succeed. For besides the contingencies, to which we have elsewhere shewn some other experiments to be obnoxious, the omission or variation of a seemingly inconsiderable circumstance may hinder the success of an experiment, wherein no other fault has been committed. Of which truth I shall only give you that single and almost obvious, but yet illustrious instance of the art of dying scarlets: for though you should see every ingredient, that is used about it; though I should particularly inform you of the weight of each; and though you should be present at the kindling of the fire, and at the increasing and remitting of it, whenever the degree of heat is to be altered; and though (in a word) you should see every thing done so particularly, that you would scarce harbour the least doubt of your comprehending the whole art; yet if I should not disclose to you, that the vessels, that immediately contain the tinging ingredients, are to be made of or to be lined with tin, you would never be able, by all that I could tell you else (at least, if the famousst and candidest

didest artificers do not strangely delude themselves) to bring your tincture of cochineal to dye a perfect scarlet. So much depends upon the very vessel, wherein the tinging mat-

ters are boiled, and so great an influence may an unheeded circumstance have on the success of experiments concerning colours.

A short Account of some *OBSERVATIONS* made by Mr. BOYLE, about a *DIAMOND*, that shines in the *Dark*.

First enclosed in a *LETTER* written to a *FRIEND*:

And now, together with it, annexed to the foregoing Treatise, upon the score of the affinity between *LIGHT* and *COLOURS*.

A Copy of the *LETTER*, that Mr. BOYLE wrote to Sir ROBERT MORRAY, to accompany the *Observations* touching the *Shining Diamond*.

S I R,
THOUGH Sir Robert Morray and Monsieur Zulichem be persons, that have deserved so well of the commonwealth of learning, that I should think myself unworthy to be looked upon as a member of it, if I declined to obey them, or to serve them; yet I should not without reluctancy send you the notes you desire for him, if I did not hope, that you will transmit, together with them, some account, why they are not less unworthy of his perusal: which that you may do, I must inform you, how the writing of them was occasioned, which in short was thus. As I was just going out of town, hearing that an ingenious gentleman of my acquaintance, lately returned from *Italy*, had a diamond, that being rubbed, would shine in the dark, and that he was not far off; I snatched time from my occasions to make him a visit; but finding him ready to go abroad, and having in vain tried to make the stone yield any light in the day-time, I borrowed it of him for that night, upon condition to restore it him within a day or two at furthest, at *Gresham* College, where we appointed to attend the meeting of the society, that was then to be at that place. And hereupon I hastened that evening out of town, and finding after supper, that the stone, which in the day-time would afford no discernable light, was really conspicuous in the dark, I was so taken with the novelty, and so desirous to make some use of an opportunity, that was like to last so little a while, that though at that time I had no body to assist me but a foot-boy, yet sitting up late, I made a shift that night to try a pretty number of such of the things, that then came into my thoughts, as were not in that place and time unpracticable. And the next day, being otherwise employed, I was fain to make use of a drowsy part of the night to set down hastily in writing what I had observed; and with-

out having the time in the morning to stay the transcribing of it, I ordered the observations to be brought after me to *Gresham* College; where you may remember, that they were, together with the stone itself, shown to the Royal Society, by which they had the good fortune not to be disliked, though several things were, through haste, omitted, some of which you will find in the margin of the inclosed paper. The substance of this short narrative I hope you will let Monsieur Zulichem know, that he may be kept from expecting any thing of finished in the observations, and be disposed to excuse the want of it. But such as they are, I hope they will prove (without a clinch) luciferous experiments, by setting the speculations of the curious on work, in a diligent inquiry after the nature of light, towards the discovery of which, perhaps, they have not yet met with so considerable an experiment; since here we see light produced in a dead and opacous body, and that not as in rotten wood, or in fishes, or as in the *Bolonian* stone, by a natural corruption, or by a violent destruction of the texture of the body, but by so slight a mechanical operation upon its texture, as we seem to know what it is, and as is immediately performed, and that several ways, without at all prejudicing the body, or making any sensible alterations in its manifest qualities. And I am the more willing to expose my hasty trials to Monsieur Zulichem, and to you, because he, being upon the consideration of dioptricks, so odd a phenomenon relating to the subject, as probably he treats of, *Light*, will, I hope, excite a person to consider it, that is wont to consider things he treats of very well. And for you, Sir, I hope you will both recruit and perfect the observations you receive; for you know, that I cannot add to them, having a good while since restored to Mr. Clayton the stone, which, though it be now in the hands of a prince; that so highly deserves;

deserves, by understanding them, the greatest curiosities; yet he vouchsafes you that access to him, as keeps me from doubting, you may easily obtain leave to make further trials with it, of such a monarch as ours, that is not more inquisitive himself, than a favourer of them that are so. I doubt not but these notes will put you in mind of the motion you made to the society, to impose upon me the task of bringing in what I had on other occasions observed concerning shining bodies. But though I deny not, that I sometimes made observations about the Bolonian stone, and tried some experiments about some other shining bodies; yet the same reasons, that reduced me then to be unwilling to receive even their commands, must now be my apology for not answering your expectations, namely, the abstruse nature of light, and my being already overburdened, and but too much kept employed by the urgency of the press, as well as by more concerning and distracting occasions. But yet I will tell you some part of what I have met with in reference to the stone, of which I send you an account. Because I find, on the one side, that a great many think it no rarity, upon a mistaken persuasion, that not only there are a store of carbuncles, of which this is one; but that all diamonds, and other glittering jewels, shine in the dark. Whereas, on the other side, there are very learned men, who (plausibly enough) deny, that there are any carbuncles or shining stones at all.

AND certainly, those judicious men have much more to say for themselves, than the others commonly plead; and therefore did deservedly look upon Mr. Clayton's diamond as a great rarity. For not only *Boëtius de Boot*, who is judged the best author on this subject, ascribes no such virtue to diamonds, but begins what he delivers of carbuncles, with this passage; *Magna fama est carbunculi. Is vulgo putatur in tenebris carbonis instar lucere; fortassis quia pyropus seu anthrax appellatus à veteribus fuit. Verum hætenus nemo unquam verè asserere ausus fuit, se gemmam noctu lucentem vidisse. Garcias ab Horto proregis Indiæ medicus refert se allocutum fuisse, qui se vidisse affirmarent. Sed iis fidem non habuit.* And a later author, the diligent and judicious *Johannes de Laet*, in his chapter of carbuncles and of rubies, has this passage; *Quia autem carbunculi, pyropi & anthraces à veteribus nominantur, vulgo creditum fuit, carbonis instar in tenebris lucere, quod tamen nullâ gemmâ hætenus deprehensum, licet à quibusdam temerè jactentur.* And the recentest writer I have met with on this subject, *Olaus Wormius*, in his account of his well-furnished *Museum*, does, where he treats of rubies, concur with the former writers by these words: *Sunt, qui rubinum veterum carbunculum esse existimant, sed deest una illa nota, quod in tenebris instar anthracis non luceat: Ast talem carbunculum in rerum naturâ non inveniri major pars authorum existimant. Licet unum aut alterum in India apud magnates quosdam reperiri scribant, cum tamen ex aliorum relatione id habeant saltem, sed ipsi non viderint.* In confirmation of which I shall only add, that hear-

ing of a ruby, so very vivid, that the jewellers themselves have several times begged leave of the fair lady, to whom it belonged, that they might try their choicest rubies by comparing them with that, I had the opportunity, by the favour of this lady and her husband, (both which I have the honour to be acquainted with) to make a trial of this famous ruby in the night, and in a room well darkned, but not only could not discern any thing of light, by looking on the stone before any thing had been done to it, but could not, by all my rubbing, bring it to afford the least glimmering of light.

BUT, Sir, though I be very backward to admit strange things for truths, yet I am not very forward to reject them as impossibilities; and therefore I would not discourage any from making further inquiry, whether or no there be really *in rerum natura* any such thing as a true carbuncle or stone, that without rubbing will shine in the dark. For if such a thing can be found, it may afford no small assistance to the curious in the investigation of light, besides the nobleness and rarity of the thing itself. And though *Vartomannus* was not an eye-witness of what he relates, that the king of *Pegu*, one of the chief kings of the *East-Indies*, had a true carbuncle of that bigness and splendour, that it shined very gloriously in the dark; and though *Garcias ab Horto*, the *Indian Vice-Roy's* physician, speaks of another carbuncle, only upon the report of one, that he discoursed with, who affirmed himself to have seen it; yet as we are not sure, that these men, that gave themselves out to be eye-witnesses, speak true, yet they may have done so for aught we know to the contrary. And I could present you with a much considerabler testimony to the same purpose, if I had the permission of a person concerned, without whose leave I must not do it. I might tell you, that *Marcus Paulus Venetus* (whose supposed fables divers of our later travellers and navigators have since found to be truths) speaking of the king of *Zeilan*, that then was, tells us, that he was said to have the best ruby in the world, a palm long, and as big as a man's arm, without spot, shining like a fire: and he subjoins, that the Great Cham, under whom *Paulus* was a considerable officer, sent and offered the value of a city for it; but the king answered, he would not give it for the treasure of the world, nor part with it, having been his ancestors. And I could add, that in the relation made by two *Russian* Cossacks of their journey into *Catay*, written to their emperor, they mention their having been told by the people of those parts, that their king had a stone, which lights as the sun both day and night, called in their language *Sarra*, which those Cossacks interpret a ruby. But these relations are too uncertain for me to build any thing upon; and therefore I shall proceed to tell you, that there came hither, about two years since, out of *America*, the governour of one of the principal colonies there, an ancient virtuoso, and one that has the honour to be a member of the *Royal Society*: this gentleman, finding some of the chief affairs of his country committed to another and me, made

Boëtius de Boot. Gem. & Lapid. Histor. Lib. 2. Cap. 8.

Musei Wormiani, Cap. 17.

Purchas's Pilgrim, lib. 1. cap. 4. pag. 104.

In the year 1619.

me divers visits; and in one of them, when I inquired what rare stones they had in those parts of the *Indies* he belonged to, he told me, that the Indians had a tradition, that in a certain hardly accessible hill, a pretty way up in the country, there was a stone, which in the night-time shined very vividly, and to a great distance; and he assured me, that though he thought it not fit to venture himself so far among those savages, yet he purposely sent thither a bold Englishman, with some natives, to be his guides; and that this messenger brought him back word, that at a distance from the hillock he had plainly perceived such a shining substance as the Indians tradition mentioned; and being stimulated by curiosity, had slighted those superstitious fears of the inhabitants, and with much ado, by reason of the difficulty of the way, had made a shift to clamber up to that part of the hill, where, by a very heedful observation, he supposed himself to have seen the light. But whether 'twere, that he had mistaken the place, or for some other reason, he could not find it there; though when he was returned to his former station, he did again see the light shining in the same place where it shone before. A further account of this light I expect from the gentleman, that gave me this, who lately sent me the news of his being landed in that country. And though I reserve to myself a full liberty of believing no more than I see cause, yet I do the less scruple to relate this, because a good part of it agrees well enough with another story, that I shall in the next place have occasion to subjoin: in order whereunto, I shall tell you, that though the learned authors I formerly mentioned, tell us, that no writer has affirmed his having himself seen a real carbuncle, yet, considering the light of Mr. Clayton's diamond, it recalled into my mind, that some years before, when I was inquisitive about stones, I had met with an old Italian book highly extolled to me by very competent judges; and that, though the book was very scarce, I had purchased it at a dear rate, for the sake of a few considerable passages I met with in it, and particularly one, which being very remarkable in itself, and pertinent to our present argument, I shall put it for you, though not word for word, which I fear I have forgot to do, yet as to the sense, into English.

' HAVING promised, (says our author) ' to say something of that most precious sort of jewels, carbuncles, because they are very rarely to be met with, we shall briefly deliver what we know of them. In *Clement* the VIIth's time I happened to see one of them at a certain Ragusian merchant's, named *Beigoio di Bona*: this was a carbuncle white, of that kind of whiteness, which we said was to be found in those rubies, of which we made mention a little above,' (where he had said, that those rubies had a kind of livid whiteness, or paleness, like that of a *Calcidonian*) ' but it had in it a lustre so pleasing, and so marvelous, that it shined in the dark, but not as much as coloured carbuncles; though it be true, that in an exceeding dark place I saw

' it shine in the manner of fire almost gone out.' But as for coloured carbuncles, it has not been my fortune to have seen any: wherefore I will only set down what I learned about them, discoursing in my youth with a Roman gentleman of ancient experience in matters of jewels, who told me, that one *Jacopo Cola* being by night in a vineyard of his, and espying something in the midst of it, that shined like a little glowing coal, at the foot of a vine, went near towards the place, where he thought himself to have seen that fire; but not finding it, he said, that being returned to the same place, whence he had first descried it, and perceiving there the same splendor as before, he marked it so heedfully, that he came at length to it, where he took up a very little stone, which he carried away with transports and joy. And the next day, carrying it about to show it divers of his friends, whilst he was relating after what manner he found it, there casually intervened a Venetian ambassador, exceedingly expert in jewels, who presently knowing it to be a carbuncle, did craftily, before he and the said *Jacopo* parted, (so that there was no body present, that understood the worth of so precious a gem) purchase it for the value of ten crowns, and the next day left *Rome* to shun the being necessitated to restore it; and, as he affirmed, it was known within some while after, that the said Venetian gentleman did, in *Constantinople*, sell that carbuncle to the then Grand Signior, newly come to the empire, for a hundred thousand crowns.'

AND this is what I can say concerning carbuncles; and this is not a little at least as to the first part of this account, where our *Cellini* affirms himself to have seen a real carbuncle with his own eyes, especially since this author appears wary in what he delivers, and is inclined rather to lessen, than increase the wonder of it. And his testimony is the more considerable, because though he were born a subject neither to the pope nor the then king of *France*, (that royal virtuoso *Francis* I.) yet both the one and the other of those princes employed him much about making of their noblest jewels. What is now reported concerning a shining substance to be seen in one of the islands about *Scotland*, were very improper for me to mention to Sir *Robert Morray*, to whom the first information was originally brought, and from whom I expect a farther (for I scarce dare expect a convincing) account of it. But I must not omit, that some virtuosi questioning me the other day at *Whitehall* about Mr. Clayton's diamond, and meeting amongst them an ingenious Dutch gentleman, whose father was long ambassador for the *Netherlands* in *England*, I learned of him, that he is acquainted with a person, whose name he told, (but I do not well remember it,) who was admiral of the Dutch in the *East-Indies*, and who assured this gentleman, Monsieur *Boreel*, that at his return from thence, he brought back with him into *Holland* a stone, which though it looked but like a pale dull diamond,

Benvenuto Cellini nell'Arte del Gioiellare, lib. 1. pag. 10.

diamond, such as he saw Mr. Clayton's to be, yet was it a real carbuncle; and did without rubbing shine so much, that when the admiral had occasion to open a chest, which he kept under deck in a dark place, where it was forbidden to bring candles for fear of mischances, as soon as he opened the trunk, the stone would, by its native light, shine so as to illustrate a great part of it. And this gentleman having very civilly and readily granted me the request I made him, to write to the admiral, who is yet alive in *Holland*, (and probably may still have the jewel by him,) for a particular account of this stone, I hope ere long to receive it; which will be the more welcome to me, not only because so unlikely a thing needs a clear evidence, but because I have had some suspicion, that (supposing the truth of the thing) what may be a shining stone in a very hot country, as the *East-Indies*, may perhaps cease to be so (at least in certain seasons) in one as cold as *Holland*. For I observed in the diamond I send you an account of, that not only rubbing, but a very moderate degree of warmth, though excited by other ways, would make it shine a little. And it is not impossible, that there may be stones as much more susceptible than that, of the alterations requisite to make a diamond shine, as that appears to be more susceptible of them than ordinary diamonds. And I confess to you, that this is not the only odd suspicion, (for they are not so much as conjectures,) that what I tried upon this diamond suggested to me. For not here to entertain you with the changes I think may be effected even in harder sort of stones, by ways not vulgar, nor very promising, because I may elsewhere have occasion to speak of them, and this letter is but too prolix already; that which I shall now acknowledge to you is, that I began to doubt, whether there may not in some cases be some truth in what is said of the right turquois, that it often changes colour as the wearer is sick or well, and manifestly loses its splendour at his death. For when I found, that even the warmth of an affliction, that lasted not above a quarter of a minute, nay, that of my body, (whose constitution, you know, is none of the hottest) would make a manifest change in the solidest of stones, a diamond; it seemed not impossible, that certain warm and saline steams, issuing from the body of a living man, may by their plenty or paucity, or by their peculiar nature, or by the total absence of them,

diversify the colour and the splendour of so soft a stone as the turquois. And though I admired to see, that I know not how many men, otherwise learned, should confidently ascribe to jewels such virtues, as seem no way compatible to inanimate agents, if to any corporeal ones at all; yet as to what is affirmed concerning the turquois's changing colour, I know not well how to reject the affirmation of so learned (and which in this case is much more considerable) so judicious a lapidary as *Boëtius de Boot* *, who upon his own particular and repeated experience delivers so memorable a narrative of the turquois's changing colour, that I cannot but think it worth your perusal; especially since a much later and very experienced author, *Olaus Wormius*, where he treats of that stone, confirms it with this testimony: *Imprimis memorandum exemplum, quod Anselmus Boëtius de seipso refert, tam mutati coloris quam à casu preservationis. Cui & ipse haud dissimile adferre possum, nisi ex Anselmo petittum quis putaret.* I remember, that I saw two or three years since a turquois (worn in a ring) wherein there were some small spots, which the virtuoso, whose it was, assured me he had observed to grow sometimes greater, sometimes less, and to be sometimes in one part of the stone, sometimes in another. And I having encouraged to make pictures from time to time of the stone, and of the situation of the cloudy parts, that so their motion may be more indisputable, and better observed, he came to me about the middle of this very week, and assured me, that he had, as I wished, made from time to time schemes or pictures of the differing parts of the stone; whereby the several removes and motions of the above-mentioned clouds are very manifest, though the cause seemed to him very occult. These pictures he has promised to show me, and is very ready to put the stone itself into my hands. But the ring having been the other day casually broken upon his finger, unless it can be taken out, and set again without any considerable heat, he is loth to have it meddled with, for fear its peculiarity should be thereby destroyed. And possibly his apprehension would have been strengthened, if I had had opportunity to tell him what is related by the learned *Wormius* of an acquaintance of his, that had a nephritick stone, of whose eminent virtues he had often experience even in himself, and for that cause wore it still about his wrist; and yet going upon a time into a bath of fair water only,

* The narrative in the author's own words, is this: Ego (says he) sanctè affirmare possum me unam aureo annulo inclusam perpetuo gestare, cujus facultatem (si gemmæ est) nunquam satis admirari potui. Gestaverat enim aucte triginta annos Hispanus quidem non procul à paternis ædibus habitans. Is cum vitâ functus esset, & ipsius supellex (ut moris apud nos est) venum exposita esset, inter cætera etiam turcois exponebatur. Verum nemo (licet complures eo concurrissent, ut eam propter coloris elegantiam, quam vivo domino habuerat, emerent) sibi emptam voluit, pristinum enim nitorem & colorem prorsus amiserat, ut potius malachites, quam turcois videretur. Aderat tum temporis gemmæ habendæ desiderio etiam parens & frater meus, qui antea sapius gratiam & elegantiam ipsius viderant, mirabundi eam nunc tam esse deformem: emit eam nihilominus pater, satisque vili pretio, qua omnibus contemptui erat, ac præsentès non eam esse quam Hispanus gestarat, arbitrarentur. Domum reversus pater, qui tam turpem gemmam gestare sibi indecorum putabat, eam mihi dono dat, inquit; Quandoquidem, fili mi, vulgi fama est, turcoidem, ut facultates suas exercere possit, dono dari debere, tibi eam devoveo: ego acceptam gemmam sculptori trado, ut gentilitia mea insignia illi, quemadmodum fieri solet, in jaspide chalcedonio, aliisque ignobilioribus gemmis, insculperet. Turpe enim existimabam, hujusmodi gemmâ ornatus gratia, dum gratiam nullam haberet, uti. Pater sculptor, reddiditque gemmam, quam gesto pro annulo signatorio. Vix per mentem gestaram, redit illi pristinus color, sed non ita nitens propter sculpturam, ac inæqualem superficiem. Miramur omnes gemmam, atque id præcipue, quod color indies pulchrior fieret. Id quia observabam, nunquam fere eam à manu deposui, ita ut nunc adhuc eandem gestem.

Olaus Wormius
in Musæ.
18 pag.
186.

Museum
15. Worm.
pag. 99.

only, wherein certain herbs had been boiled, the stone, by being wetted with this decoction, was deprived of all its virtue; whence *Wormius* takes occasion to advertise the sick, to lay by such stones, whensoever they make use of a bath. And we might expect to find turquois likewise, easily to be wrought upon in point of colour, if that were true, which the curious *Antonino Neri*, in his ingenious *Arte Vetraria*, teaches of it; namely, that turquois's discoloured, and grown white, will regain and acquire an excellent colour, if you but keep them two or three days at most covered with oil of sweet almonds, kept in a temperate heat by warm ashes: I say, if it were true, because I doubt whether it be so, and have not as yet had opportunity to satisfy my self by trials; because I find, by the confession of the most skilful persons, among whom I have laid out for turquoises, that the true ones are great rarities, though others be not at all so. And therefore I shall now only mind you of one thing, that you know as well as I, namely, that the rare stone, which is called *Oculus Mundi*, if it be good in its kind, will have so great a change made in its texture by being barely left a while in the languidest of liquors, common water, that from opacous it will become transparent, and acquire a lustre of which, it will again be deprived, without using any other art or violence, by leaving it a while in the air. And before experience had satisfied us of the truth of this, it seemed as unlikely, that common water or air should work such great changes in that gem, as it now seems that the effluvioms of a human body should effect lesser changes in a turquois, especially if more susceptible of them, than other stones of the same kind. But both my watch and my eyes tell me, that it is now high time to think of going to sleep; matters of this nature will be better, as well as more easily, cleared by conference than writing. And therefore since I think you know me too well to make it needful for me to disclaim credulity, notwithstanding my having entertained you with all these extravagancies; for you know well, how wide a difference I am wont to put betwixt things, that barely may be, and things that are; and between those relations, that are but not unworthy to be inquired into, and those that are not worthy to be actually believed; without making apologies for my ravings, I shall readily comply with the drowsiness, that calls upon me to release you: and the rather because *Monfieur Zulichem* being concerned in your desire to know the few things I have observed about

Arte Vetraria, lib. 7. cap. 102.

the shining stone; to entertain those with suspicions, that are accustomed not to acquiesce but in demonstrations, were a thing, that cannot be looked upon as other than very improper by,

S I R,

Your most affectionate and

most faithful servant,

R. BOYLE.

OBSERVATIONS made * this 27th of October, 1663. about Mr. Clayton's Diamond.

BEING looked on in the † day-time, though in a bed, whose curtains were carefully drawn, I could not discern it to shine at all, though well rubbed; but about a little after sun-set, whilst the twilight yet lasted, nay, this morning a pretty while after sun-rising, (but before I had been abroad in the more freely inlightned air of the chamber) I could upon a light affriction easily perceive the stone to shine.

2. THE candles being removed, I could not in a dark place discern the stone to have any light, when I looked on it, without having rubbed or otherwise prepared it.

3. BY two white pebbles, though hard rubbed, one against another, nor by the long and vehement affriction of rock crystal against a piece of red cloth, nor yet by rubbing two diamonds set in a ring, as I had rubbed this stone, I could produce any sensible degree of light.

4. I FOUND this diamond hard enough, not only to enable me to write readily with it upon glass, but to grave on rock-crystal it self.

5. I FOUND ‡ this to have, like other diamonds, an electrical faculty.

6. BEING rubbed upon my clothes, as is usual for the exciting of amber, wax, and other electrical bodies, it did in the dark manifestly shine like rotten wood, or the scales of whittings, or other putrified fish.

7. BUT this conspicuousness was fainter than that of the scales and slabber (if I may so call it) of whittings, and much fainter than the light of a glow-worm, by which I have been sometimes able to read a short word; whereas after an ordinary affriction of this diamond, I was not able to discern distinctly by the

* These were brought in and read before the Royal Society, (the day following) Oct. 28. 1663.

The stone it self being to be shown to the Royal Society, when the observations were delivered, I was willing (being in haste) to omit the description of it; which is in short; That it was a flat or table diamond, of about a third part of an inch in length, and somewhat less in breadth; that it was a dull stone, and of a very bad water, having in the day-time very little of the vividness of even ordinary diamonds, and being blemished with a whitish cloud about the middle of it, which covered near a third part of the stone.

† Haste made me forget to take notice, that I went abroad the same morning, the sun shining forth clear enough, to look upon the diamond through a microscope, that I might try whether by that magnifying glass any thing of peculiar could be discerned in the texture of the stone, and especially of the whitish cloud, that possess a good part of it. But for all my attention I could not discover any peculiarity worth mentioning.

‡ 5. For it drew light bodies like amber, jet, and other concretes, that are noted to do so; but its attractive power seemed inferior to theirs.

the light of it any of the nearest bodies. And this glimmering also did very manifestly and considerably decay presently, upon the ceasing of the affriction, though the stone continued visible some while after.

8. BUT if it were rubbed upon a convenient body for a pretty while, and briskly enough, I found the light would be for some moments much more considerable, almost like the light of a glow-worm; infomuch that after I ceased rubbing, I could with a chafed stone exhibit a little luminous circle, like that, but not so bright as that, which children make by moving a stick fired at the end: and in this case it would continue visible about seven or eight times as long as I had been in rubbing it.

9. I FOUND, * that holding it a while near the flame of a candle, (from which yet I was careful to avert my eyes) and being immediately removed into the dark, it disclosed some faint glimmering, but inferior to that it was wont to acquire by rubbing. And afterward holding it near a fire, that had but little flame, I found the stone to be rather less than more excited, than it had been by the candle.

10. I LIKEWISE endeavoured to make it shine, by holding it a pretty while in a very dark place, over a thick piece of iron, that was well heated, but not to that degree as to be visibly so. And though at length I found, that by this way also the stone acquired some glimmering, yet it was less than by either of the other ways above-mentioned.

11. I ALSO brought it to some kind of glimmering light, by taking it into bed with me, and holding it a good while upon a warm part of my naked body.

12. To satisfy myself, whether the motion introduced into the stone did generate the light upon the account of its producing heat there, I held it near the flame of a candle, till it was qualified to shine pretty well in the dark; and then immediately I applied a slender hair, to try whether it would attract it, but found not that it did so: though if it were made to shine by rubbing, it was, as I formerly noted, electrical. And for further confirmation, though I once purposely kept it so near the hot iron I just now mentioned, as to make it sensibly warm, yet it shined more dimly than it had done by affriction, or the flame of a candle, though by both those ways it had not acquired any warmth that was sensible.

13. HAVING purposely rubbed it upon several bodies differing as to colour and as to texture, there seemed to be some little disparity in the excitation (if I may so call it) of light. Upon white and red cloaths it seemed

to succeed best, especially in comparison of black ones.

14. BUT to try what it would do rubbed upon bodies more hard, and less apt to yield heat, upon a light affriction, than cloth, I first rubbed it upon a white wooden box, by which it was excited, and afterwards upon a piece of purely glazed earth; which seemed, during the attrition, to make it shine better than any of the other bodies had done, without excepting the white ones; which I add, lest the effect should be wholly ascribed to the disposition white bodies are wont to have to reflect much light.

15. HAVING † well excited the stone, I nimbly plunged it under water, that I had provided for that purpose, and perceived it to shine whilst it was beneath the surface of that liquor, and this I did divers times. But when I endeavoured to produce a light by rubbing it upon the lately mentioned cover of the box, the stone and it being both held beneath the surface of the water, I did not well satisfy myself in the event of the trial: but this I found, if I took the stone out, and rubbed it upon a piece of cloth, it would not, as else it was wont to do, presently acquire a luminousness, but needed to be rubbed manifestly much longer, before the desired effect was found.

16. I ALSO ‡ tried several times, that by covering it with my warm spittle (having no warm water at hand) it did not lose his light.

17. FINDING that by rubbing the stone with the flat side downwards, I did, by reason of the opacity of the ring, and the sudden decay of light upon the ceasing of the attrition, probably lose the sight of the stone's greatest vividness; and supposing that the commotion made in one part of the stone will be easily propagated all over; I sometimes held the piece of cloth, upon which I rubbed it, so, that one side of the stone was exposed to my eye, whilst I was rubbing the other; whereby it appeared more vivid than formerly, and to make luminous tracts by its motions to and fro. And sometimes holding the stone upwards, I rubbed its broad side with a fine smooth piece of transparent horn, by which means the light through that diaphanous substance did, whilst I was actually rubbing the stone, appear so brisk, that sometimes, and in some places, it seemed to have little sparks of fire.

18. I TOOK also a piece of flat blue glass, and having rubbed the diamond well upon a cloath, and nimbly clapt the glass upon it, to try whether, in case the light could pierce it, it would by appearing green, or of some other colour

* 9. We durst not hold it in the flame of a candle, no more than put it into a naked fire; for fear too violent a heat (which has been observed to spoil many other precious stones) should vitiate and impair a jewel, that was but borrowed, and was supposed to be the only one of its kind.

† 15. We likewise plunged it, as soon as we had excited it, under liquors of several sorts, as spirit of wine, oils both chymical and expressed, an acid spirit, and, as I remember, an alcalizate solution; and found not any of those various liquors to destroy its shining property.

‡ 16. Having found by this observation, that a warm liquor would not extinguish light in the diamond, I thought fit to try, whether, by reason of its warmth, it would not excite it; and divers times I found, that if it were kept therein, till the water had leisure to communicate some of its heat to it, it would often shine as soon as it was taken out; and probably we should have seen it shine more, whilst it was in the water, if some degree of opacity, which heated water is wont to acquire, upon the score of the numerous little bubbles generated in it, had not kept us from discerning the lustre of the stone.

colour than blue, assist me to guess, whether itself were sincere or no. But finding the glass impervious to so faint a light, I then thought it fit to try, whether hard bodies would not by attrition increase the diamond's light, so as to become penetrable thereby: and accordingly when I rubbed the glass briskly upon the stone, I found the light to be conspicuous enough, and somewhat dyed in its passage; but found it not easy to give a name to the colour it exhibited.

LASTLY, To comply with the suspicion I had upon the whole matter, that the chief manifest change wrought in the stone was by compression of its parts, rather than incautience; I took a piece of white tile well glazed, and if I pressed the stone hard against it, it seemed, though I did not rub it to and fro, to shine at the sides. And however it did both very manifestly and vigorously shine, if, whilst I so pressed it, I moved it any way upon the surface of the tile, though I did not make it draw a line of above a quarter of an inch long, or thereabouts, and though I made it not move to and fro, but only from one end of the short line to the other, without any return or lateral motion. Nay, after it had been often rubbed, and suffered to lose its light again, not only it seemed more easy to be excited than at the beginning of the night; but if I did press hard upon it with my finger, at the very instant that I drew it briskly off, it would disclose a very vivid but exceeding short-lived splendor, not to call it a little coruscation.* So that a Cartesian would scarce scruple to think, he had found in this stone no slight confirmation of his ingenious master's hypothesis, touching the generation of light in sublunary bodies, not sensibly hot.

A POSTSCRIPT, annexed some hours after the Observations were written.

SO † many particulars taken notice of in one night, may make this stone appear a kind of prodigy; and the rather, because having tried, as I formerly noted, not only a fine artificial crystal, and some also that is natural, but a ruby and two diamonds, I did not find, that any of these disclosed the like glimmering of light: yet after all, perceiving by the hardness, and the testimony of a skilful goldsmith, that this was rather a natural than artificial stone; for fear lest there might be some difference in the way of setting, or in the shape of the diamonds I made use of, neither of which was like this, a flat table-stone, I thought fit to make a further trial of my own diamonds, by such a brisk and assiduous friction, as might make amends for the disadvantages above-mentioned, in case they were the cause of the unsuccessfulness of the former attempts. And accordingly I found, that by this way I could easily bring a diamond I wore on my finger to disclose a light, that was sensible enough, and continued so, though I covered it with spittle, and used some other trials about it. And this will much lessen the wonder of all the formerly mentioned observations, by shewing, that the properties, that are so strange, are not peculiar to one diamond, but may be found in others also, and, perhaps, in divers other hard and diaphanous stones. Yet I hope, that what this discovery takes away from the wonder of these observations, it will add to the instructiveness of them, by affording pregnant hints towards the investigation of the nature of light.

* I after bethought myself of employing a way, which produced the desired effect, both sooner and better. For holding betwixt my fingers a steel bodkin, near the lower part of it, I pressed the point hard against the surface of the diamond, and much more if I struck the point against it, the coruscation would be extremely sudden, and very vivid, though very vanishing too: and this way, which commonly much surprized and pleased the spectators, seemed far more proper than the other, to shew, that pressure alone, if forcible enough, though it were so sudden and short, that it could not well be supposed to give the stone any thing near a sensible degree of warmth, as may be suspected of rubbing, yet 'tis sufficient to generate a very vivid light.

† We afterwards tried precious stones, as diamonds, rubies, sapphires, and emeralds, &c. but found not any of them to shine, except some diamonds; and of these we were not, upon so little practice, able to foretel beforehand, which would be brought to shine, and which would not: for several very good diamonds either would not shine at all, or much less than others, that were far inferior to them. And yet those ingenious men are mistaken, that think a diamond must be foul and cloudy, as Mr. Clayton's was, to be fit for shining; for as we could bring some such to afford a glimmering light, so with some clear and excellent diamonds we could do the like. But none of those many, that we tried of all kinds, were equal to the diamond, on which the observations were made, not only considering the degree of light it afforded, but the easiness wherewith it was excited, and the comparatively great duration of its shining.



S O M E

C O N S I D E R A T I O N S

T O U C H I N G T H E

S T Y L E *of the* H O L Y S C R I P T U R E S .

E X T R A C T E D

From several Parts of a DISCOURSE, concerning
divers Particulars belonging to the B I B L E ;

Written divers years since to a F R I E N D :

T O T H E

E A R L of O R R E R Y ,

One of the LORDS JUSTICES of the Kingdom of *Ireland*, LORD
PRESIDENT of the Province of *Munster*, &c.

My Dearest Brother,

THAT sacred book, which furnishes our preachers both with their texts and a great part of their discourses on them, being the subject, about which I am to entertain you, I presume it will not much surprize you, if what I shall say, in representing to you some considerations on that book, relish more of a sermon than of a letter of compliment. And indeed it would so little become a person, that writes of my subject, and with my design, to startle at the very beginning such readers, as he desires to find or make devout, with any thing written in the wonted strain of epistles dedicatory; and the nature of the treatise, to which this paper is premised, does allow so little of that, whereof custom, on such occasions, is wont to challenge so much; that I should let this book come forth undedicated, were it not that the motives, that induced me to address it to you, are of such a nature, that I hope, that merely by a plain representation of them I may comply with what makes me look upon this dedication as a duty, without departing from the serious design I proposed to my self in the dedicated book. Although then such readers, as having perused your writings, shall cast their eyes on mine, will, I fear, think it a bold presumption in me to address discourses, concerning a style, to a person so much and so justly applauded for his; yet as several reasons engage me to present you these thoughts, so the fear of passing for presumptuous for so doing obliges me to mention some of those reasons. Whereof the first shall be, that your kindness for, and your resemblance in many particulars to, *Theophilus*, makes me often fancy, that I am yet entertaining that rare person, when I

write on the behalf of the scripture unto you. Who may also, I presume, remember (which is my second reason,) that when, seven or eight years ago, I ventured to shew you divers of these papers, with others (that I yet suppress) belonging to the same treatise, you were pleased to give me such a permission, that in case they should ever be made publick, I might address what I had written at your friend's desire particularly to you, as I took for an engagement, if not a command. So that how unlike soever the following treatise is to that best of books it would recommend; yet since you have thus made the present address a duty, I must elect rather to betray to you my weaknesses, than not manifest my obedience. And to these I must subjoin this third consideration, (more prevalent perhaps with me than both the former,) that (as a homely digger may shew a man a rich mine) whatever the book may be that I present you, that which I recommend to you is a matchless one; and will, if so discerning a reader shall bring as much assiduity as capacity to discover its prerogatives, appear so worthy of what I have said of it, that I allow my self a hope, the following considerations will prove so happy, as either to endear the scripture to you, or (by not appearing such as so good a subject would suggest to a good pen,) invite you to substitute better in their rooms. And in either of these cases I shall not have cause to repent of having written them; since they will prove serviceable either to the book or to the man, to whom I most desire to be so. And this hope I must again own to be the chief inducement of my venturing to present a fragment of an unpolished treatise to a person, that

is wont to write such as are so eloquent and accomplished in their kind. For though severe, and not incompetent, judges of composures of this nature have been pleased to give these papers no disapproving character; yet since I present them to you, the chief thing I dare pretend to in them is only (as the singing rare songs ill is wont, by an unheeded indignation, to engage the possessors of rare voices to make them admired,) by disclosing my zeal and insufficiencies, to invite you to rescue so excellent a theme as the scripture from so dull a pen as mine, by employing your happy one in its defence and celebration: or, (if your partiality should make you place any value on so unfinished a piece) to convince you how capable of rare thoughts my subject is, by its being able to furnish so barren a brain as mine with acceptable ones. And certainly, your pen having no less served your fame than either your sword, or your employments (how high soever;) it could not but bring the scripture more than a few of the most witty and illustrious votaries, if that eloquence were employed to enamour them of that divine book, that hath made them so generally in love with your celebrated *Parthenissa*. I will not represent to you so pious an exercise of your rethorick and muse as a duty, for fear of lessening the disinterestedness of the employment I recommend to you, by implying, that you cannot decline it without a fault. I shall rather invite your pen to prefer itself to, and grace religious subjects, by assuring you, that as there are none more worthy of your pen, so there are few pens more likely to succeed upon some of them than yours. Those handsome essays your muse hath charmed me with upon some parts of the bible have given me longings equally great and just, to see her, by a devotedness to such heavenly themes, as happy in the choice of her subjects, as she is wont to be in the embellishing of them; and to have her make that her chief employment, wherein it is best to do, what she doth always, succeed well. And as with burning-glasses though we cannot make the sun shine, yet when he doth vouchsafe us his heavenly beams, we can, with those glasses, both increase light and heat, and carry and settle them here and there as we see cause: so though with wit and parts, their possessors could never have been able to engage God to send forth his light and his truth; yet now that revelation hath disclosed them, and now he hath been pleased to make them radiate in his heavenly word, men may, with knowledge and eloquence, happily recollect those scattered divine beams, and uniting them in particular subjects, and kindling with them the topicks proper to warm and work on our affections, may powerfully illustrate truths, and enflame zeal. Towards the latter end of the ensuing papers you will find something said to persuade our *Theophilus*, that the choicest poetical and rhetorical ornaments may, without injury to their lustre, be employed about such subjects as may be chosen in the scripture: but more and better things, to the same purpose, have since been said by our ingenious friend Mr. *Cowley*, who not on-

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ly has employed much eloquence to persuade that truth in his preface to his poems, but has in one of them given a noble example, and consequently a proof of it. I need not tell you, I mean his *Dauides*, a work and way of writing, which, since your muse has already thought fit to celebrate, I hope she will hereafter think fit to imitate. And this I wish the more earnestly, because it hath been observed, that secular persons of quality (of whom I have elsewhere occasion to name divers) are generally much successfuller in writing of religion, (to gentlemen especially,) than scholasticks or men in orders; not only because their style and way of writing is observed to have in it some pleasing *Je ne scay quoy*, something of easy, genuine and handsome, that's peculiar to it, (differing from regular eloquence, as a good mien doth from beauty) and relishes of the native gracefulness wont to attend on what they do or say; but because their writings attract more readers by the authors conspicuousness, and make deeper impressions in them, by being supposed more disinterested, and looked upon, not as suggested by their profession or self-ends, but as the sincere dictates of their unbridled souls. For my part, though I am not so happy as to be much concerned in all the precedent considerations, yet those, that you will find, towards the end of the longest digression in the following discourse, have been so prevalent with me, that though some very fair and very persuasive persons (whom perhaps I need not name to you) did, when I was writing the annexed treatise, labour to divert my pen to some more youthful and more fashionable composures, by flattering me with a persuasion, that in those attempts of that nature I had formerly occasion to make, I was not altogether unlucky; yet I, that would bring my self to prefer to a whole wood of bayes the least sprig of the tree of life, am inclined to think, that a Christian may possibly find a higher satisfaction in persuading men to pay praises to the scripture, than in receiving them from all the world besides; and would think it more desirable, (were the choice his) to discountenance prophane wit, than live unrivalled in the glory of it. And though, for my own particular, such a temper be, I fear, more my aim than my attainment; yet when I write of sacred subjects, I had rather a book of mine should resemble the moon, which, though she be but small, less elevated, and full of imperfections, lends yet an useful light to men, and produces here and there a motion that obeys a heavenly influence, than a star of the first magnitude, which though more high, more vast, and more flawless, shines only bright enough to make it self conspicuous. Pardon me therefore, my dearest brother, if my concern for religion and you have made me importunate in appearing so eagerly solicitous to see your applauded pen sanctified by, and adorn the best of subjects: to engage you to which, if the ensuing discourse may but be so fortunate as in any degree, or upon any score, to contribute any thing, I shall either not esteem it a trifle, or not regret the hav-

A a ing

The Epistle Dedicatory.

ing written it. For it is not always so de-
spicable a piece of service as may be ima-
gined, to endear, by particular considera-
tions, an excellent book, (and how much
more that incomparable book the scripture?)
to a person capable of discovering and making
use of the rare things it contains. To which
purpose I might offer you divers more serious
instances, but shall only at present (a little to
divert you) take this occasion to tell you, that
Ben. Johnson, passionately complaining to a
learned acquaintance of mine, that a man of
the long robe, whom his wit had raised to
great dignities and power, had refused to grant
him some very valuable thing he had begged
of him, concluded with saying, with an up-
braiding tone and gesture to my friend; *Why, the
ungrateful wretch knows very well, that before
he came to preferment, I was the man, that made
him relish Horace.*

BUT to return to the following book, though
I hope you do not think me so vain as to doubt,
that it is suffered to come abroad with imperfec-
tion enough to need my excuses and your par-
don; yet since the treatise itself is so unmeasurably
prolix (for a part of an essay,) it were unfit the
address of it should be so too; and give your pa-
tience as great an exercise upon the score of its
quantity, as upon that of its quality. And there-
fore, referring you for what I might say of apolo-

getical to what I say to the reader, I shall
only add, that though, in Epistles Dedicatory,
custom hath made it a kind of rudeness not to
expatiate in praises, and conclude with comple-
ments; and though what you have acted, and
what you have written, might supply a person
less concerned than I with matter for a pane-
gyrical address; yet since I told you, at the be-
ginning of this letter, I should rather preach
than compliment in it; and since praises fit to
be ascribed to my Lord *Orrery* would be un-
fit to be ascribed him by his brother; and
since also it were scarce more uneasy for me
to make you any other than seeming comple-
ments, than it were presumptuous to address any
at all to so great a master in the art; I shall
both decline praises, which not to seem flat-
teries, where you are not known, would perhaps
be thought detractions where you are; and ven-
ture to conclude this letter, as I have begun and
continued it, without compliment, upon the
score of being without, if not above any,

My dearest Brother,

Your most Affectionate Brother,

and most Faithful Humble Servant,

ROBERT BOYLE.

To the READER.

*The author having with the following dis-
course sent to the publisher a letter,
which contains almost all the particulars,
that would be requisite to be taken
notice of in a preface, it is thought fit
to premise, instead of it, the letter it
self, as it was addressed to Mr. P. P.
A. G. F. I. (to favour whose modesty, he
is not now more openly named.)*

S I R,
YOU will perhaps think it strange,
that a person obsequious enough to
those he loves should be able to hold
out so long against the importunity of two such
powerful sollicitors, as my willingness to own a
veneration for the scripture, and my unwilling-
ness to deny you any thing. But if you will give
me leave to acquaint you with the considera-
tions, that have hitherto dissuaded me from the
publication of the papers you press for, you
will, I presume, rather marvel at my resolving
at last to comply with your desires, than that
I have been somewhat long contesting, before
I could take up so opposed a resolution. First
then, the treatise, of which the papers you de-
sire make a part, was written nine or ten years
ago, when my green youth made me very un-
ripe for a task of that nature; whose difficulty
requires, as well as its worth deserves, that
it should be handled by a person, in whom

nature, education, and time have happily
matched a senile maturity of judgment with a
youthful vigour of fancy. Next, the discourse
I have mentioned being written to a private
friend, who put me upon that task, I not only
had a theme of another's choosing imposed
upon me, for which he was pleased to think
me much more fit than I had reason to think
myself, but was by the freedom allowable a-
mong friends tempted to vent and express my
thoughts with more negligence, than were
proper to be made use of in a solemn discourse
intended for publick view. The contrary of
which were yet very requisite for a person, who
though he have, by I know not what unhappy
fate, been cast upon the learning divers langua-
ges, has yet too great a concern for the know-
ledge of things to be a diligent or sollicitous
considerer of words; and so was more fit to
write almost of any thing, than of a style, or
of matters rhetorical. Besides, that my Essay
touching the Scripture having not been all
written in one country, but partly in *England*,
partly in another kingdom, and partly too on
shipboard, it were strange, if in what I writ,
there did not appear much of unevenness, and
if it did not betray the unlesuredness, and relish
of the unfettedness of the wandering author,
who, by thus rambling, was reduced, for want
of a library, to comply with the request of his
friend, who was more desirous to receive from
the author apples and pears growing in his
own

own orchard, than oranges and lemons fetched from foreign parts : whereby I was condemned not to enrich my discourse with what I might have borrowed, of real and valuable, from the eloquent composures of more happy pens. But these, Sir, are not all the detriments, that opposed my obeying you ; for besides these disadvantages, with which the discourse itself was written, that part of it you demand must appear with a peculiar as well as great disadvantage : for in an intire and continued discourse, the several parts, that compose it, do mutually afford light and confirmation to each other. And therefore, though whatsoever I here present you, touching the style of the scripture, had been written altogether in some one place of the discourse, whereof it makes a part ; yet I could not dismember it from the rest, without a great deal of injury, as well to it as to the rest of the treatise. But this is not the worst of my case ; for though I did, in one part of my essay of the scripture, more professedly apply myself to the consideration of its style ; yet, because divers things were interwoven even in the distinct part, which were not so fit for publick view ; and because that in divers of the other parts of my essay I had here and there, frequently enough, occasion to say something of the same theme, I have been obliged, that I might obey you, not only to dismember, but to mangle the treatise you perused, cutting out with a pair of scissars here a whole side, there half, and in another place perhaps, a quarter of one ; as I found, in the other parts of my discourse, longer or shorter passages, that appeared to relate to the style of the scripture, that I might give you at once all those parts of my essay, which seemed to concern that subject. And though I have, here and there, by dictating to an amanuensis, inserted some lines or words, to make the loose papers less incoherent, where I thought it easy to be done ; yet in many others I have only prefixed a short black line to the incoherent passages, if I found they could not be connected with those, whereunto I have joined them, without such circumlocution, as either the narrowness of the paper would not permit, or my present distractions (which you know are not a few,) and the weakness of my eyes, would not allow of. For, to compleat my unfitness to obey you with any thing of accurateness, I must, to obey you at all, do it, both when I have other composures in the press, and when the distemper in my eyes makes me so far from daring to transcribe the papers I send you, that I might alter them, according to the exigency of your design in them, that I durst not so much as read them over, but with another's eyes. To which I must add, that, besides all these disadvantages I have already mentioned, I cannot but foretel, that the following discourse may prove obnoxious to the censures of differing sort of readers, and particularly to those of courtiers, for too neglected, and those of critics, for too spruce a dress. By all which, I presume, you will be easily induced to believe, with me, that I cannot expose the papers you desire so much to their disadvan-

tage and my own, without some exercise of self-denial : since, without needing much foresight, I may well apprehend, that I shall hereby hazard the loss of the most part of whatever little reputation, in this nature, any of my former moral or devout composures may, among favourable readers, have procured me.

BUT, by this time, Sir, I suppose not only, that you have left wondering at my making some difficulty to put the annexed papers into your hands, but that I owe you, and my other friends, an account, why I now consent to a compliance with desires, which such powerful considerations would dissuade my assenting to.

My first inducement then to what I do, is the favourable character, that you and some other very competent judges have been pleased to give me of these papers ; and especially your thereupon pressing their publication upon me as a duty, whereto I stand obliged, to those many readers, whom you would have me think likely to be benefited thereby. For in such cases, where knowing and sober persons think there is a great probability of a discourse's doing good, it is not impossible, but that an unwillingness to have it published may not so much proceed out of modesty, as from some secret pride, almost as unjustifiable, as if a physician should refuse to come abroad upon an urgent occasion, because he has not his best clothes on, or is not carefully dressed. And therefore, when I incline to make, with you, a case of conscience of the matter, I think myself obliged, whatever my private apprehensions may be of the success, to do my duty, and leave events to the wise and sovereign disposer of them. It is not, that I have the vanity to expect, that I should convert obstinate and resolved cavillers, nor much instruct the great clerks ; but since I have not yet met with such a discourse, as I intended mine to be ; and since the greater part of the things I have written in it will not, perhaps, be elsewhere met with ; I hope, that what I have said may not be useless to those, who have considered the subject, I treat of, less attentively than I have done, and may, if not procure a veneration for the scripture in those that are altogether indisposed to it, yet at least increase or confirm it in those, that have already entertained it ; and furnish such devout persons with something to alledge on the scripture's behalf, who are better furnished with affections than with arguments for it. And I the less scruple to allow myself such a hope, because you have been pleased to make, not only to me, but to others, such a mention of the following papers, that after your preference of them to the other pieces of devotion, you have yet seen of mine (without excepting that discourse of *Seraphick Love*, which yet has had the luck to be so favourably entertained by readers of all sorts) I shall confess to you, that as some of them do now appear very much dislocated and mangled, so others were penned with more care, than any other of my writings about matters theological. And indeed I conceived my self obliged,

obliged, in point of gratitude as well as duty, to speak as advantageously as I could of the scripture; because, if I may without vanity make such an acknowledgement, I am sensible I have been benefited by it, and might have been much more so, if I had been as disposed to learn, as the matchless book is qualified to teach. And I confess to you also, that since the physiological writings I have been induced to publish of late, and the sort of studies, to which (for reasons to be told you at a fitter opportunity) I seem, at present, to be wholly addicted to, make many look upon me as a naturalist; and since some persons, as well philosophers as physicians, have either faultily, or at least indiscreetly, given many men occasion to think, that those, that being speculatively studious of nature's mysteries, depart, as I often do, from the vulgar peripatetick philosophy, and especially if they seem to favour that, which explicates the phenomena of nature by atoms, are inclined to atheism, or at least to an unconcernedness for any particular religion: Since, I say, these things are so, I was not unwilling to lay hold of this opportunity, to give a publick testimony, whereby such as do not know me may be satisfied, (for I presume, all that do know me, are so,) that, if I be a naturalist, it is possible to be so without being an atheist, or of kin to it; and that the study of the works of nature has not made me either disbelieve the author of them, or deny his providence, or so much as disesteem his word, which deserves our respect upon several accounts, and especially that of its being the grand instrument of conveying to us the truths and mysteries of the Christian religion; my embracing of which I know not why I should be ashamed to own, since I think I can, to a competent and unprepossessed judge, give a rational account of my so doing.

To all this, I might subjoin some apologies, which might perhaps serve to prevent, or withdraw, the censures of some sorts of readers.

For to critics and philologers I could represent, partly, that I have not a little impoverished my discourse, by making use of books, to shun the repetition of what I found obvious already; partly, that when I wrote the essay, of which the ensuing treatise is a piece, I had thoughts of annexing it to annotations, wherein I hoped to illustrate, and by particular instances to exemplify, divers of those things, which should appear to require it, or which else the readers might suspect I have slightly considered, because I seem to make but a transient mention of them; and partly, too, that I ignored not the stricter interpretations given by modern critics to divers texts by me alledged; but that (not having opportunity to criticize) I was content to use them in their received, or obvious sense; and have sometimes employed them but by way of allusion, or as arguments *ad hominem* (wherein some of my readers are like to acquiesce, though I do not) and sometimes rather used them to express, than prove my thoughts. And, in-

deed, in these popular discourses, which are not written for, nor to be examined as regular disputations, men use not so much to look whether every thing be a strict truth, as whether it be proper to persuade, or impress the truths they would inculcate; and especially in composures of the nature of this of mine, men have been rarely censured for being sometimes even indulgent to the exigences of their themes. Those, that require more of method than they will here find, may be advertised, that much of this scribble being designed to serve particular acquaintances of mine, it was fit it should insist on those points they were concerned in; and that (consequently) much of the seeming desultoriness of my method, and frequency of my rambling excursions, have been but intentional and charitable digressions out of my way, to bring some wandering friends into theirs, and may closely enough pursue my intentions, even when they seem most to deviate from my theme. And as for the longer excursions, which either you, or other judicious friends, would needs have me leave here and there, I have, for the ease of my perusers, annexed to them some marks, whereby they may be taken notice of, to be digressions; that as I submit to their judgment, who think they may be useful to some readers, so I may comply with my own unwillingness to let them be troublesome to others; who by this means have an opportunity to pass by, if they please, such, as they shall not expect to find themselves, (either upon their own score, or that of their acquaintances) concerned in. To those of the wits, who happening to be disregards of the scripture, may find themselves upon that account used here with any shew of slighting or asperity, I may add to what I have already said in the papers themselves, that it hath been, but as we pinch, and cast cold water on the faces of persons in a swoon, to bring them out of it to themselves again; I having done it with as harmless intentions, as those of the angel (mentioned in the *Acts*) when he struck *Peter* on the side, ^{Acts xii.} not to hurt him, but to awake him, lead him ^{7,} the way out of the prison he was bound in, and rescue from imminent death. And if that will not satisfy some of the least judicious, or the most desperate, (for others I expect to find better affected or more moderate) I am willing to leave the intelligent and pious to judge between us; assuring those, that are so much more jealous of their own honour than of God's, that as I writ to reclaim them, not to deprive them of the repute of wits, or share it with them, so I shall not overmuch deplore the being by them denied a title, to which I have as little pretension as right. And (to dispatch) I might add, that orators may not unjustly bear with some rudenesses in the style of a person, that professes not rhetorick, and writes of a subject, that needs few of her ornaments, and rejects many as indecencies misbecoming its majesty: and that severer divines may safely pardon some smoothness in a discourse, written chiefly for gentlemen, who would scarce be fond of truth in every dress, by a gentleman, who feared it might misbecome a person of his youth and

and quality studiously to decline a fashionable style. And if any divine would censure me for intruding upon his profession, and handling my subject less skilfully than he would have done; I will not urge, that to write well on this subject is a task, which he that shall try, will perhaps find far less easy than one would imagine; but I shall rather tell him, that I hope I may obtain his pardon, by assuring him, that I shall be as little angry to be rectified in my mistakes, as to be shown the way when I am out of it, and as little troubled to have this discourse, that but skirmishes with laziness and prophaneness, surpassed by another on the same subject, as to see another embracer of the same quarrel come in with a fresh regiment, to assist me against a formidable enemy, in a conflict I were engaged in but with a troop, or bring cannon against a fortress I had but sakers to batter with. Yes, I shall be glad, if my dim short-lived match but serve to light another's brighter torch; and shall think it a happiness to have contributed, though but thus occasionally, towards the elucidation, or splendour of the scripture. And consonantly to this temper, I would beseech any reader, that may so much want learning as to need such a request, not to measure what can be said in the defence and celebration of the scripture's style, by what hath in the following discourse been traced by the callow pen of a travelling layman. For I profess ingenuously, that there can as little be an unwelcomer as an unjust compliment placed upon me, than to mistake any thing that I am able to say, and much less what I have said, for the best that can be said upon such a subject. Nor is it my least encouragement to consent to the publication of such incompleat writings, that the considerations already intimated will probably keep my readers from doing the scripture and their own judgment so great an injury.

But I see I have so far transgressed the bounds of a letter, that if I add any thing more of apology, it must be for having been so prolix already. Wherefore there scarce remains any thing for me, but to mind you, that since your persuasions have so much contributed to my exposing the following tract, in-

compleat as it is, your own credit is somewhat concerned in it as well as mine. And therefore I hope you will have a care, that there be no faults of the printer added to those of the author, which do so little need additional blemishes; and especially that there pass no mistakes of the punctuation. For in such compositions as this, if the stops be omitted, or misplaced, it does not only lessen the gracefulness of what is said, but oftentimes quite spoil the sense. And if by this care of yours (which your affection, both for the subject, and the writer makes me confident of) and by the authority of your approbation, I find these imperfect considerations to be so favourably received as to deserve another edition; it will perhaps invite me to put them forth enlarged, and recruited with what I may meet with pertinent to this subject in such other papers of mine concerning the scripture, as I had not yet the conveniency to get into mine own hands and look over. However, though I pretend not here to answer all objections against the style of the scripture; yet as I hope, I have been so happy as to answer some of them, and weaken most of the rest; so if others, that are more able, will but employ themselves as earnestly in so useful a work, there is great hope, that some answering this objection, another that, and a third another, they may at length be all of them satisfactorily replied to. And in the mean time I shall think my labour richly recompensed, if they either procure or establish a veneration for the scripture in any of my readers; or do at least encourage those, that are qualified for a far more prosperous making such an attempt, to undertake it, by showing those of them that know me, what were easy for them to do, whilst they see what has been done even by me; whom sure they will not think to be half so much an orator, as I hope so uneasy a proof of his obedience will make you think him.

Sir, Your Affectionate Friend

and humble Servant,

ROBERT BOYLE



CONSIDERATIONS

TOUCHING THE

STYLE *of the* HOLY SCRIPTURES.

THES E things, dear *Theophilus*, being thus dispatched, I suppose we may now seasonably proceed to consider the style of the scripture: a subject, that will as well require as deserve some time and much attention; in regard that divers witty men, who freely acknowledge the authority of the scripture, take exceptions at its style, and by those and their own reputation divert many from studying, or so much as perusing, those sacred writings; thereby at once giving men injurious and irreverent thoughts of it, and diverting them from allowing the scripture the best way of justifying itself, and disabusing them. Than which scarce any thing can be more prejudicial to a book, that needs but to be sufficiently understood to be highly venerated; the writings these men criminate, and would keep others from reading, being like that honey, which *Saul's* rash adjuration withheld the Israelites from eating, which being tasted, not only gratified the taste, but enlightned the eyes.

1 Sam. xiv.
ver. 27,
29.

Now these allegations against the scripture we are to examine being but too various, it will be requisite for us to consider the style of it, not in the stricter acceptation, wherein an author's style is wont to signify the choice and disposition of his words, but in that larger sense, wherein the word style comprehends not only the phraseology, the tropes and figures made use of by a writer, but his method, his lofty or humbler character (as orators speak) his pathetic or languid, his close or incoherent way of writing; and in a word, almost all the whole manner of an author's expressing himself.

WHEREFORE, though the title of an essay prefixed to this treatise will, I presume, invite you to expect from me rather some loose considerations than any full and methodical discourse concerning the style of the scripture; yet I hope you will not think it strange, if so comprehensive a theme make this part of the essay disproportionate to the others; especially since the nature of your commands, and that of my design, oblige me to interweave some other things with those that more directly regard the style of the scripture, and particularly to lay hold on all opportunities I can discreetly take, to invite you to study much, and highly to esteem a book, which there is no danger you can too much study, or esteem too highly.

It has been a common saying among the ancients, that even *Jupiter* could not please all. But by the objections I meet with against the

scripture, I find, that the true God himself is not free from the imputation of his audacious creatures, who impiously presume to quarrel as well with his revelations as his providence, and express no more reverence to what he hath dictated than to what he doth. For not now to mention what is by atheists and antiscipiturists alledged to overthrow the truth and authority of the scripture, (because it is not here, but elsewhere, that we are to deal with that sort of men) even by some of those, that acknowledge both, (for with such only we have now to reason,) there are I know not how many faults found with the style of the scripture. For some of them are pleased to say, that book is too obscure; others, that it is immethodical; others, that it is contradictory to itself; others, that the neighbouring parts of it are incoherent; others, that it is unadorned; others, that it is flat and unaffecting; others, that it abounds with things, that are either trival or impertinent, and also with useless repetitions. And indeed so many and so various are the faults and imperfections imputed by these men to the scripture, that my wonder at them would be almost as great as is my trouble, if I did not consider, how much it is the interest of the great adversary of mankind, and especially of (that choicest part of it) the church, to depreciate composures, that if duly revered would prove so destructive to his kingdom and designs; and if I did not also remember, that (such is the querulous and exceptious nature of men) it was *Cicero* himself that observed, *Vitari non posse reprehensionem, nisi nihil scribendo*. But as poets and astronomers have fancied, among the celestial lights, that adorn the firmament, bears, bulls, goats, dogs, scorpions, and other beasts; so our adversaries impute I know not what imaginary deformities to a book, ennobled by its author with many celestial lights, fit to instruct the world, and discover to them the ways of truth and blessedness. Although, I say, this be so, yet since the misrepresentation made by these men of the bible is not inferior to that made by poets and cosmographers of the firmament; I hope you will be as little deterred by the most disparaging imputations from studying the scripture, as pilots are by the name of *bear* given to the most northern constellation, from having their eyes upon the pole-star, and steering their courses by it.

AND since you will easily believe, that a person so averse from wrangling as I is not like to make the disputing with these censures of the

the scripture-style, any further his design, than as the invalidating their objections conduces to the reputation of that sacred book; I presume you will not think it at all impertinent, if oftentimes I intermix with those things, that more directly regard such objections, other things, that seem to tend rather to celebrate than vindicate the scripture. For in so doing, I hope I shall not alone considerably, though not perhaps so directly, strengthen my answers, by shewing that we justly ascribe to the scripture qualities quite opposite to the imperfections imputed to it; but I shall perfectly comply with my main design, which I here declare, once for all, is but to engage you to study and value the scripture, and therefore obliges me to answer objections only so far forth, as they may look like arguments to dissuade you from prizing and studying it. And because I find not, that the objections to be considered have any great coherence with, or dependence on each other, I shall not scruple to mention them, and my reflections on them, in no other order, than that wherein they shall chance to occur to my thoughts whilst I am writing.

Of the considerations then, that I am to lay before you, there are three or four, which are of a more general nature; and therefore being such as may each of them be pertinently employed against several of the exceptions taken at the scripture's style, it will not be inconvenient to mention them before the rest.

AND, in the first place, it should be considered, that those cavillers at the style of the scripture, that you, and I have hitherto met with, do (for want of skill in the original) especially in the Hebrew, judge of it by the translations, wherein alone they read it. Now scarce any but a linguist will imagine, how much a book may lose of its elegance, by being read in another tongue than that it was written in; especially if the languages, from which, and into which, the version is made, be so very differing, as are those of the eastern and these western parts of the world. But of this I foresee an occasion of saying something hereafter; yet at present I must observe to you, that the style of the scripture is much more disadvantaged, than that of other books, by being judged of by translations. For the religious and just veneration, that the interpreters of the bible have had for that sacred book, has made them, in most places, render the Hebrew and Greek passages so scrupulously word for word, that for fear of not keeping close enough to the sense, they usually care not how much they lose of the eloquence of the passages they translate. So that, whereas in those versions of other books, that are made by good linguists, the interpreters are wont to take the liberty to recede from the author's words, and also substitute other phrases instead of his, that they may express his meaning, without injuring his reputation; in translating the Old Testament, interpreters have not put Hebrew phrases into Latin or English phrases, but only into Latin or English words; and have too often besides, by not sufficiently understanding, or at least consider-

ing, the various significations of words, particles, and tenses in the holy tongue, made many things appear less coherent, or less rational, or less considerable, which, by a more free and skilful rendering of the original, would not be blemished by any appearance of such imperfection. And though this fault of interpreters be pardonable enough in them, as carrying much of its excuse in its cause; yet it cannot but much derogate from the scripture, to appear with peculiar disadvantages, besides those many, that are common to almost all books, by being translated.

FOR whereas the figures of rhetoric are wont, by orators, to be reduced to two comprehensive sorts; and one of those does so depend upon the sound and placing of the words (whence the Greek rhetoricians call such figures *ῥήματα λέξεως*) that, if they be altered, though the sense be retained, the figure may vanish; this sort of figures, I say, which comprizes those that orators call *Epanados*, *Antanaclasis*, and a multitude of others, are wont to be lost in such literal translations as are ours of the bible, as I could easily show by many instances, if I thought it requisite.

BESIDES, there are in Hebrew, as in other languages, certain appropriated graces, and a peculiar emphasis belonging to some expressions, which must necessarily be impaired by any translation, and are but too often quite lost in those, that adhere too scrupulously to the words of the original. And, as in a lovely face, though a painter may well enough express the cheeks, and the nose, and lips; yet there is often something of splendour and vivacity in the eyes, which no pencil can reach to equal: so, in some choice composures, though a skilful interpreter may happily enough render into his own language a great part of what he translates, yet there may well be some shining passages, some sparkling and emphatical expressions, that he cannot possibly represent to the life. And this consideration is more applicable to the bible and its translations, than to other books, for two particular reasons.

FOR first, it is more difficult to translate the Hebrew of the Old Testament, than if that book were written in Syriack, or Arabick, or some such other eastern language. Not that the holy tongue is much more difficult to be learned than others; but because in the other learned tongues, we know there are commonly variety of books extant, whereby we may learn the various significations of the words and phrases; whereas the pure Hebrew being unhappily lost, except so much of it as remains in the Old Testament, out of whose books alone we can but very imperfectly frame a dictionary and a language, there are many words, especially the *ἀπαξ λεγόμενα*, and those that occur but seldom, of which we know but that one signification, or those few acceptions, wherein we find it used in those texts, that we think we clearly understand. Whereas, if we consider the nature of the primitive tongue, whose words being not numerous, are most of them equivocal enough, and do many of them

them abound with strangely different meanings; and if we consider too, how likely it is, that the numerous conquests of *David*, and the wisdom, prosperity, fleets, and various commerces of his son *Solomon*, did both enrich and spread the Hebrew language, it cannot but seem very probable, that the same word or phrase may have had divers others significations, than interpreters have taken notice of, or we are now aware of: since we find in the Chaldee, Syriack, Arabick, and other eastern tongues, that the Hebrew words and phrases (a little varied, according to the nature of those dialects) have other, and oftentimes, very different significations, besides those, that the modern interpreters of the bible have ascribed to them. I say, the modern, because the ancient versions before, or not long after our Saviour's time, and especially that which we vulgarly call the Septuagint's, do frequently favour our conjecture, by rendering Hebrew words and phrases to senses very distant from those more received significations in our texts; when there appears no other so probable reason of their so rendering them, as their believing them capable of significations differing enough from those, to which our later interpreters have thought fit to confine themselves. The use, that I would make of this consideration, may easily be conjectured, namely, that it is probable, that many of those texts, whose expressions, as they are rendered in our translations, seem flat, or improper, or incoherent with the context, would appear much otherwise, if we were acquainted with all the significations of words and phrases, that were known in the times, when the Hebrew language flourished, and the sacred books were written; it being very likely, that among those various significations, some one or other would afford a better sense, and a more significant and sinewy expression, than we meet with in our translations; and perhaps would make such passages, as seem flat or uncouth, appear eloquent and emphatical. Whilst I am writing this, our English tongue presents to my thoughts an example, which may seem to illustrate much of the foregoing consideration: and it is this; that though, as one would easily believe, there are but a few forms of speaking, which relate to the birth of infants, yet there are five or six expressions concerning that one affair, wherein very peculiar and unwonted notions belong to the words and phrases: for, if I say, that such a woman has looked every hour these ten days; that yesterday she cried out; that she had a quick and easy labour; that last night she was brought-to-bed; that now she lies-in; and, that it is fit we should remember the lady in the straw: if, I say, I make use of any or all of these expressions, an Englishman would readily understand me; but if I should literally, and word for word, translate them, I say, not into Greek or Hebrew, but into the languages of our neighbour-nations, French or Italian, men would not understand what I mean. And if a discourse, wherein they were employed, were translated by an interpreter only acquainted with the genuine

and more obvious signification of the English word, it would, in such passages, appear very disadvantageously, and perhaps be thought impertinent, or non-sensical, to a French or Italian reader.

BUT this is not all; for I consider in the second place, that not only we have lost divers of the significations of many of the Hebrew words and phrases, but that we have also lost the means of acquainting ourselves with a multitude of particulars relating to the topography, history, rites, opinions, fashions, customs, &c. of the antient Jews and neighbouring nations, without the knowledge of which we cannot, in the perusing of books of such antiquity, as those of the Old Testament, and written by and (principally) for Jews; we cannot, I say, but lose very much of that esteem, delight, and relish, with which we should read very many passages, if we discerned the references and allusions, that are made in them to those stories, proverbs, opinions, &c. to which such passages may well be supposed to relate. And this conjecture will not, I presume, appear irrational, if you but consider, how many of the handsomest passages in *Juvenal*, *Perfius*, *Martial*, and divers other Latin writers, (not to mention *Hesiod*, *Museus*, or other antienter Greeks) are lost to such readers, as are unacquainted with the Roman customs, government, and story; nay, or are not sufficiently informed of a great many particular circumstances, relating to the condition of those times, and of divers particular persons pointed at in those poems. And therefore it is, that the latter critics have been fain to write comments, or at least notes, upon every page, and in some pages upon almost every line of those books, to enable the reader to discern the eloquence, and relish the wit of the author. And if such dilucidations be necessary to make us value writings, that treat of familiar and secular affairs, and were written in an European language, and in times and countries much nearer to ours; how much do you think we must lose of the elegancy of the book of *Job*, the Psalms of *David*, the Song of *Solomon*, and other sacred compositions, which not only treat oftentimes of sublime and supernatural mysteries, but were written in very remote regions so many ages ago, amidst circumstances, to most of which we cannot but be great strangers? And thus much for my first general consideration.

My second is this, That we should carefully distinguish betwixt what the scripture itself says, and what is only said in the scripture. For we must not look upon the bible as an oration of God to men, or as a body of laws, like our English statute book, wherein it is the legislator, that all the way speaks to the people; but as a collection of compositions of very differing sorts, and written at very distant times; and of such compositions, that though the holy men of God (as *St. Peter* calls them) were acted by the Holy Spirit, who both excited and assisted them in penning the scripture, yet there are many others, besides the author and the penmen, introduced speaking there. For besides

the books of *Joshua, Judges, Samuel, Kings, Chronicles*, the four evangelists, the *Acts of the Apostles*, and other parts of scripture that are evidently historical, and wont to be so called; there are, in the other books, many passages, that deserve the same name, and many others, wherein, though they be not meer narratives of things done, many sayings and expressions are recorded, that either belong not to the author of the scripture, or must be looked upon as such, wherein his secretaries personate others. So that, in a considerable part of the scripture, not only prophets, and kings, and priests being introduced speaking, but soldiers, shepherds, and women, and such other sorts of persons, from whom witty or eloquent things are not (especially when they speak *ex tempore*) to be expected, it would be very injurious to impute to the scripture any want of eloquence, that may be noted in the expressions of others, than its author. For though, not only in romances, but in many of those that pass for true histories, the supposed speakers may be observed to talk as well as the historian; yet that is, but either because the men so introduced were ambassadors, orators, generals, or other eminent men for parts, as well as employments; or because the historian does, as it often happens, give himself the liberty to make speeches for them, and does not set down indeed what they said, but what he thought fit that such persons, on such occasions, should have said. Whereas the pen-men of the scripture, as one of them truly professes, having not followed cunningly devised fables in what they have written, have faithfully set down the sayings, as well as actions, they record, without making them rather congruous to the conditions of the speakers, than to the laws of truth.

NOR is it only the style of very many passages of scripture, that may be justified by our second consideration; but, with the same distinction well applied, we may silence some of their malicious cavils, who accuse the scripture of teaching vice by the ungodly sayings and examples, that are here and there to be met with in it. But, as the Apostle said, that *they are not all Israel, that are of Israel*; so we may say, that is not scripture, that is in the scripture: for many wicked persons, and their perverter Satan, are there introduced, whose sayings the Holy Ghost doth not adopt, but barely registers; nor does the scripture affirm, that what they said was true, but that it is true they said it. And if I had not reduced some of those cavillers to confessions, that they never did themselves read those pieces of the bible, at some of whose passages they cavil, I should much more admire than I do, to find them fatter, as confidently as they do all they hear cited from it, upon the enditer of it; as if the devil's speeches were not recorded there, and as if it were requisite to make a history divinely inspired, that all the blasphemies and crimes it registers should be so too. As for the ills recorded in the scripture, besides that wicked persons were necessary to exercise God's children, and illustrate his providence; and, besides the allegations commonly made on that subject, we may consider,

that there being many things to be declined, as well as practised, 'twas fit we should be taught as well what to avoid, as what to imitate; and the known rocks and shelves do as well guide the seamen, as the pole-star. Now, as we could not be armed against the tempter's methods, if we ignored them, so could we never safer nor better learn them, than in his book, who can alone discover the wiles, and fathom the *depths* Rev. ii. of Satan, and track him through all his windings, and (otherwise untraceable) labyrinths; and in that book, where the antidote is exhibited with the poison, and either mens defeat or victory may teach us, at others costs, and without our hazard, the true art of what warfare we are all so highly concerned in. And, as chymists observe in the book of nature, that those simples, that wear the figure or resemblance (by them termed signature) of a distemper'd part, are medicinal for that part of that infirmity, whose signature they bear; so, in God's other book, the vicious persons there mentioned still prove, under some notion, or upon some score or other, antidotal against the vices notorious in them, being (to present it you also in a scripture simile) like the brazen serpent in the wilderness, set up to cure the poison infused by those they resemble. *Whatsoever* Rom. xv. things were written afore-time, says the Apostle, were written for our instruction. And, to make further use of our former comparison, those, to whom the scripture gives the names of lions, wolves, foxes, and other brutes, by God's assistance, prove to his saints as instructive beasts, as doth the northern bear unto the wandering pilot. And, as antiently God fed his servant *Elias*, sometimes by an angel, sometimes by a woman, and sometimes too by ravens, so doth he make all persons in the bible, whether good, or bad, or indifferent, supply his servants with that instruction, which is the aliment of virtue, and of souls, and makes them and their examples contribute to the verification of that passage of *St. Paul*, wherein he says, that *all things co-operate for good to them that love God.* Rom. viii. 28.

My third consideration is this: That the several books of the bible were written chiefly and primarily to those, to whom they were first addressed, and to their contemporaries; and that yet the bible not being written for one age of people only, but for the whole people of God, consisting of persons of all ages, nations, sexes, complexions and conditions, it was fit it should be written in such a way, as that none of all these might be quite excluded from the advantages designed them in it. Therefore were these sacred books so wisely, as well as graciously, temper'd, that their variety so comprehends the several abilities and dispositions of men, that (as some pictures seem to have their eyes directly fix'd on every one that looks on them, from what part soever of the room he eyes them) there is scarce any frame of spirit a man can be of, or any condition he can be in, to which some passage of scripture is not as patly applicable, as if it were meant for him, or said to him as *Nathan* once did to *David*, *Thou art the man.* What has been thus

Rom. ix. 6.

thus observed touching God's design in the contrivance of the scripture, may assist us to defend the style of a great multitude of its texts, and particularly of divers of those, which belong to the five following kinds.

AND first, the several books, that make up the canon of the Scripture, being primarily designed for their use, that lived in the times wherein they were divulged, it need be no wonder, if each of them contain many things, that principally concern the persons that then lived, and be accordingly written in such a way, that many of its passages allude, and otherwise relate to particular times, places, persons, customs, opinions, stories, &c. which, by our formerly-mentioned want of a good account of such remote ages and regions, cannot afford us that instruction and satisfaction, that those, to whom such books were immediately addressed, might easily derive from the perusal of them.

NEXT, as some portions of scripture were principally designed for ages very long since past, so some other parts of it, especially those that are yet prophetick, may probably respect future times, much more than ours: and our posterity may admire what we cannot now relish, because we do not yet understand it. Moreover, there being many portions of scripture, as almost the whole four last books of *Moses*, wherein God is introduced as either immediately, or mediately giving laws to his people, or his worshippers, I suppose it will not be thought necessary, that such parts of scripture should be eloquently written, and that the supreme legislator of the world, who reckons the greatest kings amongst his subjects, should, in giving laws, tie himself to those of rhetoric; the scrupulous observation of which would much derogate from those two qualities, so considerable in laws, clearness and majesty.

BESIDES, there being a sort of men, of which I hope the number will daily increase, who have such a desire, as *St. Peter* tells us the angels themselves cherish, to look into the mysteries of religion, and are qualified with elevated and comprehensive intellects, to apprehend them in some measure; it is not unfit, that to exercise such mens abilities, and to reward their industry, there should be some abstruse texts of scripture fitted to the capacities of such speculative wits, and above the reach of vulgar apprehensions.

AND, on the other side, the omniscient author of the scripture foreseeing, that it would follow from the condition of mankind, that the greatest part of the members of the church would be no great clerks, and many of them very weak or illiterate, it was but suitable to his goodness, that a great many other passages of the books designed for them, as well as others, should be written in such a plain and familiar way, as may besit such readers, and let them see, that they were not forgotten, or overlooked by him, who truly says, by the prophet, that *all souls are his*. And yet in many, even of these texts, which seem chiefly to have been designed to teach the simple, scholars themselves may find much to learn. For not only

there are some passages, that contain milk for babes, and others, that exhibit strong meat for riper stomachs, but oftentimes (as cows afford both milk and beef) the same texts, that babes may suck milk from, strong men may find strong meat in: the scripture itself in some sense fulfilling the promise made us in it, that *Habenti dabitur* (to him that hath shall be given) and being like a fire, that serves most men but to warm, and dry themselves, and dress their meat, but serves the skilful chymist to draw quintessences and make extracts.

I DOUBT not but you are acquainted as well as I with divers querulous readers, who very boldly find fault with this variety, wherein God hath thought fit to exhibit his truth, and declare his will in holy writ, and presume to censure some texts as too mysterious, very many as too plain. But these exceptions at the oeconomy of the scripture do commonly proceed from their pride, that make them; for that vice, inclining them to fancy, that the bible either was or ought to have been written purposely for them, prompts them to make exceptions suitable to such a presumption; and, whilst they look upon their own abilities as the measure of all discourses, to call all that transcends their apprehensions, dark, and all that equals it not, trivial. They will be always finding fault with the Holy Ghost's expressions, both where his condescensions make them clear, and where the sublimity of the matter leaves them obscurer; like bats, whose tender eyes love neither day nor night, and are only pleased with (what is alone proportioned to their weak sight) a twilight, that is both or neither. But as a skilful fowler (and the comparison will be excused by those, that remember that God in scripture is said to be pressed as a cart is pressed that is full of sheaves, and the *Amos xi.* son of man to be as a thief in the night,) according to the differing natures of his game, so contrives and appropriates his stratagems, that some he catches with light, (as larks with day-nets;) some with baits, (as pigeons with peas;) some with frights, (as black-birds with a sparrow-hawk or a low-bell;) and some he draws in with company, (as ducks and such like sociable birds with decoy-fowl;) so God knowing that some persons must be wrought upon by reason, others allured by interest, some driven in by terrour, and others again brought in by imitation, hath by a rare and merciful (if I may so call it) suppleness of wisdom so varied the heavenly doctrine into ratiocinations, mysteries, promises, threats and examples, that there is not any sort of people, that in the scripture may not find religion represented in that form they are most disposed to receive impressions from; God therein graciously dealing *2 King.* with his children not unlike the prophet, that *iv. 34.* shrunk himself into the proportion of the child he meant to revive. The genius's, the capacities and the dispositions of men are so distinct, and oftentimes so extravagant, that there is scarce a passage of scripture, that is not suitable or appropriate to some of those numberless differences of humour the bible was designed for; and in that unimaginable variety of

1 Pet. i.
12.

Ezek.
xviii. 4.

of occurrences shared amongst such vast multitudes, finds not a proper object. And therefore God (who having created them) best knows the frame of mens spirits, having been pleased to match them with proper texts; I shall not quarrel with his vouchsafing to list mysteries to those, that would be deterred by any other way of expressing them, and to qualify his instruments according to the natures he designs them to work upon, lest he should say to me with the house-holder in the gospel, *Is thine eye evil, because I am good?* And sure it must extremely misbecome us to repine at the greatness of God's condescensions, only upon the score of a knowledge or attainments that we owe to it.

By reflecting upon the three foregoing general considerations, you will, I presume, easily perceive, what it is that is pretended to in what I represent to you in the behalf of the scripture. For you will easily guess, by what I have hitherto told you, I pretend not to prove or assert, that every text of scripture, especially in translations, is embellished with the ornaments of rhetorick, but only to shew these two things; the one, that as there may be drawn from divers things in the scripture it self (without excluding the style) considerable arguments of its having been written or approved by men peculiarly assisted by the spirit of God; so if a man be persuaded either by these intrinsic arguments, (which I may in another paper evince to be no slight ones,) or by any others, of the heavenly origination of the scripture; if, I say, a man be persuaded of this, he ought not in reason by the style of these books to be kept from diligently studying of them, and highly valuing them. The other (which I add as one evincement of the former) is, that not only the scripture is everywhere written with as much eloquence as the chief author (whose omniscience qualified him to judge best in the case) thought fit and expedient, as we now have the sacred books, especially in their originals, very many passages of them are so far from being destitute of what even our western nations count eloquence, that they deserve to be admired for it. And, *Theophilus*, if you please to keep in your eye what I have now told you concerning my scope in writing, and to bear in your memory the three general considerations I have premised, I shall need hereafter, as often as I have occasion to mention them, only to point at them; and thereby shall excuse you and my self from the unwelcome trouble of many times repeating the same things.

To proceed then to the more particular objections against the scripture, the first I shall consider is, that it is obscure. And this I find alleged by two sort of men to two differing purposes; some endeavouring by it to disgrace the bible, and others only making the pretended darkness of many of its passages an excuse for their not studying it.

To the first sort of objectors I answer, that it is little less than inevitable, that many passages of the scripture should seem obscure to us, and

that it is but fit, that divers others should be so too.

For first, the objectors, as I formerly observed, reading the bible but in translations, are destitute of those helps to understand the sense of many passages, that may be afforded by skill in the original languages. Besides, that even to those, that have taken pains to understand the original tongues, the genuine sense of divers words and phrases is denied by the injury of time, through which (as was already noted) a great part of the Hebrew and Chaldean tongues have been lost.

2dly, MANY texts appear obscure to those, that live in these latter times, only because that by reason of the perishing of those writings and other monuments of antiquity, that were contemporary to the books of the old testament, we cannot be sufficiently acquainted with the history, the laws and customs of the *Jews*, and other nations mentioned in the scripture; so that it need be no wonder if divers passages of the books of *Genesis*, *Josuah*, *Judges*, *Samuel*, the *Kings*, *Hester*, and other historical books of the scripture, as also of the four last books of *Moses*, are obscure to us; and yet might be very intelligible to those, in whose times they were written, and for whose use they were principally designed. As although *Lucius Florus* would in many places appear very obscure to such readers, as know nothing of the Roman affairs, but by the account given of them in his writing, (whence divers late criticks have been invited to illustrate him out of other Latin authors) yet questionless to the Roman readers, that lived in his time, or not very long after, his book was easy enough to be understood. How much the want of other historians, contemporary to the penmen of the old testament, may make things seem obscure, that might by such stories be easily cleared up, we may observe from divers passages of the new testament, which can scarce be well understood without an account of *Herod's* family, and the changes that happened about our Saviour's time in *Judæa*, which was sometimes all of it governed by *Herod* the great, that massacred the children of *Bethlehem*, and sometimes was governed by *Pilate* and other Roman magistrates; and sometimes was so divided, that it was as to some parts only governed by *Herod's* descendants under various titles; the want of the knowledge of which, and of the several princes that bore the name of *Herod*, does much puzzle many readers, that are strangers to *Josephus*. And it seems somewhat strange to many, that Christ should in Luke xxi. 21, 22. *St. Luke* admonish his hearers to fly out of *Jerusalem* and *Judæa*, and not resort thither from the neighbouring countries, when they should see *Jerusalem* encompassed with armies, since those armies would probably hinder the counselled retirement, (at least as to the city.) Whereas he that finds in the story, that the Roman forces under *Gratus* did on a sudden, and (as good authors tell us) without any manifest cause, withdraw from the siege of *Jerusalem*, and then return to it again, and (under *Titus*) carry

carry the town by force; he that shall read also in *Euseb. lib. 3. cap. 5.* that the Christians of *Jerusalem* did (divinely admonished) make use of the opportunity presented them to quit all of them the city, and retire to *Pella* on the other side of *Jordan*; he, I say, that shall read and take notice of all this, will not only clearly understand the reasonableness of our Saviour's warning, but admire the prophetic spirit by which he could give it. And as it is difficult to collect out of the old testament alone the history of those times, wherein it was written; so it is not to be expected, that out of those books we should be able to collect and comprehend, either complete ideas of the Israelitish government, civil and ecclesiastical, or the true state of their several sects, opinions and affairs in matters of religion: and yet without the knowledge of those it cannot be, but that many texts will seem obscure to us, which were not at all so to them, that were coetaneous to the pen-men of those books. The labours of some modern critics, that have put themselves to the trouble of making a thorow search into the writings of those Jewish Rabbies, that lived about our Saviour's and his Apostles times, have, by the help of the rabbinical learning, already cleared up divers texts, which before were dark, because they related to particular sects, customs, sayings, or opinions amongst the then Jews, whose knowledge, the writers of the new testament do not teach, but suppose. And I doubt not, but higher and valuable attainments in that kind of learning (how worthless soever I should think it, if it were not conducive to the illustration of the scripture) will, ere it be very long, disperse that obscurity, which yet dwells upon divers other texts, and will shew the groundlessness of all our cavils at them, as well as that of many of our too fierce contentions about them. I shall add, that I dare almost presume to question, whether even our famousst critics have not left divers Mosaical texts in the dark; if not clouded them by their comments, merely for want of knowing the religion of the antient Zabians, in opposition of whose magical worship and superstitions, I am apt to think divers ceremonies of the ritual law of the Jews to have been instituted. And yet of those Zabiists (or צביות and צביות as the Hebrews and Arabians express the name) I find a deep and general silence in classic authors, except (the Rabbi's oracle) *Maimonides*, out of whom our great antiquary (Mr. *Selden*) both in familiar discourse, and in his excellent tract of the Syrian deities, gave me first a hint, which by lighting on another author of those parts, I have since had the luck to improve sufficiently, to make me fear, that they, who are strangers to the Zabians rites and creed, will scarce give us the clearest account the theme is capable of in divers passages of the Mosaick law. As I am apt to think, that our ignorance or want of taking notice of the persuasions and practices of the Gnosticks, Carpocratians, and the sects allied to theirs, if it do not make us mistake

and misinterpret, doth at least keep us from giving the clearest interpretations, whereof they are capable, to many passages of the New Testament, wherein they are either clearly pointed at, or closely related to.

3. WE may reasonably suppose, that of the texts, that are now difficult unto us, there are divers that are so, but because they were principally intended for the use of those that shall live in after-times, by whom they will questionless be better understood. To the Jews, that lived in and along after *Moses* his time, many of those predictions, both verbal and typical, of the Messias, seemed very dark, which to us Christians are abundantly illustrated by the rising of that sun of righteousness, who was aimed at in them. And though the mysterious temple and city described in *Ezekiel*, as also much of the *Apocalypse*, and divers other prophetick passages of holy writ, do yet seem abstruse to us; yet they will not appear so to those, to whom their completion (the best expositor of dark prophecies) shall have unfolded them. For I observe, that as some divine predictions are clearly expressed, to the intent that those, that are made acquainted with them, may before-hand know what will happen, so others are proposed, not so much that those, to whom they are first addressed, should know the fore-told events, before they do come to pass, as that, when they do come to pass, the same accomplishment, that expounds them, may evince, that the fore-teller of them was able to foresee them, according to that of our Saviour to his disciples, to whom he prophesied the sufferings they should undergo; *These things have I told you, John that when the time shall come, ye may remember that I told you of them.* xxvi. 4.

4. IT was fit, that there should be some obscure passages left in the inspired volume, to keep those from the knowledge of some of those divine mysteries, that are both delightful and useful, though not absolutely necessary, who do not think such knowledge worth studying for. As it was also fit (which I partly noted above,) that there should be some clouded and mysterious texts, to excite and recompence the industry and speculation of elevated wits and religious inquirers.

Lastly, THERE are divers obscure passages in scripture, wherein the difficulty lies in the thing it self that is expressed, not in the scripture's manner of expressing it. For not to mention that obscureness, that is wont to attend prophetick raptures, (of which there are many mentioned in the scripture) there are divers things, that we agree to be knowable by the bare light of nature without revelation, which yet are so uneasy to be satisfactorily understood by our imperfect intellects, that let them be delivered in the clearest expressions men can devise, the notions themselves will yet appear obscure. Thus in natural philosophy it self, the nature of place and time, the origin of motion, and the manner whereby the human soul performs her functions, are things, which no writers delivered so clearly, as not to leave

leave the things somewhat obscure to inquisitive and examining readers. And shall we then wonder, that those texts of scripture, that treat of the nature and decrees of God, and of such sublime mysteries as the trinity, the incarnation, the influence of the spirit upon the soul of man, and such other abstruse things, which it cannot be reasonably expected that human words should keep from being hard to be comprehended by human understanding, should be obscure to us; especially if we suffer our not understanding their full meaning at first to deter us from endeavouring to find it out by further study. I am sorry I can add on this occasion, that divers texts are made to appear more dark, than otherways they would, by the glosses and interpretations of some, that pretend to expound them. For there are divers subtle men, who being persuaded, upon certain metaphysical notions they are fond of, or by the authority of such either churches or persons as they highly reverence, that such or such niceties are either requisite to the explication of this, or that doctrine delivered in scripture, or, at least, deducible from it, will make bold so to interpret dark texts, (and sometimes even clear ones) that they shall seem to hold forth, not only their own sense, but the nice speculations, or deductions of him that quotes them: so that divers texts, which, to a rational and unprepossessed peruser, would appear plain enough, seem to contain inextricable difficulties to those unwary or prejudicate readers, who are not careful to distinguish betwixt the plain sense of the text itself, and those metaphysical subtleties, which witty and interested persons would father upon it; though oftentimes those niceties are either so groundless, that though there needs much wit to devise them, there needs but a little reason to despise them; or so unintelligible, as to tempt a considering man to suspect, that the proposers either mean not what they speak, or understand not what they say. And I could wish these metaphysical quirks, with which several, not only school-men, but other writers, have perplexed the doctrine of predestination, of the trinity, of the operation of the spirit of God upon the will of man, and some other mysteries of Christian religion, did not give advantages against those doctrines to the opposers of them, and perhaps make some men opposers, who otherwise would not have been so. And I fear, that too great an opportunity has been afforded to atheistical wits, by unintelligible fancies, which many have made bold to add to what the scripture has revealed, concerning the eternity and infiniteness of God. For whilst men indiscreetly and unskilfully twist together, as integral parts of the same doctrine, a revealed truth with their own metaphysical speculations about it, though these be too often such as cannot be proved, or perhaps so much as understood; they tempt such examining readers, as are rational enough to discern the groundlessness of one part of the doctrine, to reject the whole for its sake. But I fear I have digressed, for my intention was

only to intimate, that it is not oftentimes so much what the scripture says, as what some men persuade others it says, that makes it seem obscure: and that as to some other passages, that are so indeed, since it is the abstruseness of what is taught in them, that makes them almost inevitably so, it is little less saucy, upon such a score, to find fault with the style of the scripture, than to do so with the author for making us but men.

Thus much being said, by way of answer, to the first sort of objectors of darkness against the scripture, it is easy to foresee, that the second sort of them may endeavour to pervert what has been delivered to apologize for their neglect of the scripture, by alledging, that albeit what has been represented may serve to shew, that the obscurity of the scripture is justifiable; yet the very proving it needful or fit, that it should be obscure, is a plain confession that it is so. Wherefore it is requisite, that I now say something to this sort of objectors also, who are so unfavourable to the scripture and themselves, as that, because they cannot understand all of it, they will not endeavour to learn any thing from it. I have already acknowledged it, and shall not now deny, that (as heaven it self is not all stars) there may be parts of scripture, whose clear expositions shall ennoble and bless the remotest of succeeding ages, that perhaps some mysteries are so obscure, that they are reserved to the illumination and blazes of the last and universal fire.

But here it would be considered in the first place, that those texts, that are so difficult to be understood, are not necessary to be so. In points fundamental and indispensably necessary, the darkness of scripture is no less partial, than that of *Egypt*, which benighted only the enemies, but involved not the people of God: in such articles as these, *If the gospel be hid, 2 Cor. iii. it is hid to them that are lost, in whom the God of this world hath blinded the minds.* At least in relation to such truths as these, we may justly apply that of *Moses*, where he tells *Israel, This commandment, which I command thee Deut. xxx. this day, is not bidden from thee, neither is it far off. But the word is very near unto thee, in thy mouth, and in thy heart, that thou mayest do it.* And surely the bible's being appropriate (as it self tells us) *to enlighten the eyes, and to make wise the simple*; and it being written *for the use of the whole people of God, whereof the greater number are no clerks, things are there expressed with an evidence proportionable to the degree of assent that they exact, and are as far forth intelligible to pious and industrious readers, as they are necessary to be understood by them; and we may not unfitly say of the understanding of those cloudy passages of scripture, what I remember a father said of the sacrament, That not the wanting it, Non privatur sed con-* but the slighting it shall condemn men. It is *temptus* our duty to study them, but it is not (always) *damnatur.* to understand them.

AND as the knowledge of those texts that are obscure, is not necessary, so those others, whose sense is necessary to be understood, are easy enough to be so. And those are as much

more numerous than the others, as more clear. Yes, there are shining passages enough in scripture, to light us the way to heaven, though some unobvious stars of that bright sphere cannot be discerned without the help of a telescope. Since God, then, has been pleased to provide sufficiently for our instruction, what reason have we to repine, if he have in a book, not designed for us alone, provided also for those, that are fitted for higher attainment? especially since, if we be not wanting to ourselves, those passages, that are so obscure as to teach us nothing else, may at least teach us humility.

NOR does it misbecome God's goodness, any more than his wisdom, to have so tempered the canonical books, as therein to leave all sorts of readers an exercise for their industry, and give even the greatest doctors continual inducements to implore his instructions, and depend on him for his irradiations, by leaving, amongst many passages that stoop unto our weakness, some that may make us sensible of it. It should, methinks, be looked upon as the prerogative, not the disparagement, of the scriptures, that the revelation of his truth, vouchsafed us by God in them, is like a river, wherein a lamb may quench his thirst, and which an elephant cannot exhaust. I should think him but an ill-natur'd child, who should be angry to see strong meat provided for his elder brothers, because he himself can yet digest nothing but milk: and as the same child, being grown up to riper years, would be then troubled, that, according to his first envious wish, there were no stronger aliment provided in the family than milk; so when, by the attentive and repeated perusal of the scripture, a child in knowledge shall attain to some higher measure of skill in the scriptures, he will then be well pleased to have his understanding exercised by those most mysterious texts, of which he formerly complained that they surpassed it. However, since there are so many plain passages of scripture, that clearly hold forth, not on'y all that is necessary for us to know, but, I fear, much more than we are careful to learn and practise, the zealous Christian would no more decline feeding on this heavenly food, though all the hard places should still remain such to him, than the Jews would forbear to

Exod. xii. 46. eat the paschal lamb, though not a bone of it were broken. And, in earnest, would not he merit unrelieved beggary, that should refuse the profit of a rich mine, because all those of the world are not yet discovered, nor those of the Indies exhausted?

MOREOVER, the pretended obscureness of the bible is a mistaken discouragement from reading it: for the frequency of reading it still lessens that obscurity; which, like a mist, seems thicker at a distance, than when one enters it, and attempts a passage through it; which, in our case, many pious students have done so prosperously, as to find, by welcome experience, that what, at a distance, deterred them, was not intended to frustrate industry, but punish laziness.

BESIDES that, the scripture being avowedly the best expositor of itself, our ignorance of

those places, whose sense we seek for, makes us often occasionally much knowing, and more perfect in the meaning of all the rest; and makes us too so much more ready in the uses of them, that I cannot but apply to this subject the fable of that dying husbandman, who, by telling his sons of a hidden mass of wealth he had buried in a nameless place of his vineyard, occasioned their so sedulous delving all the ground, and turning up the earth about the roots of the vines, that they found indeed a treasure, though not in gold, in wine: for thus out of hope, by the light of understood scriptures, to penetrate the sense of the obscurer ones, we occasionally so improve our knowledge and readiness in the clearer passages, that our by-acquists do richly recompence our frustrated (or rather unsuccessful) pains; since our particular disappointments hinder not the promotion of our general design, which is a greater proficiency in spiritual knowledge, and therefore ought not to deter us from the duty of those searches, in which not only to discover is happy, but even the unsuccessful attempts are gainful, whatever the event be; the pains being seldom fruitless, but reaching either their end or recompence. And this prompts me to represent to you further, that not only the scripture is instructive upon the same account with other theological writings, but that we may hope to improve our understandings by it upon this score, that it is also the instituted means, as well of knowledge, as of grace, and appointed for our instruction by him, who, as sin came into the world by man's listening to the words of the devil, is pleased to make restoring-grace operate chiefly by our listening to the word of God, whether heard or read. Wherefore those, whom the intuition of this encouragement invites to be diligent perusers of the scripture, do to their unfirm understandings, as the inhabitants of *Gennazareth* did to their sick and weak countrymen, lay them in *Jesus* his way, and consequently in that of recovery. It is of (at least one of) the darkest books of the scripture, that it is said, *Blessed is he that readeth, and they that hear the words of this prophecy.* The eunuch in the *Acts* would (though upon the highway) needs read the Prophet *Isaiab*, and though (as appears by his question to *Philip*) as then he understood not what he read, yet did the Spirit take thence (perhaps a rise, as well as) opportunity to reveal Christ unto him, and both satisfy him of the meaning of that prediction, and acquaint him with the fresh and happy accomplishment of it. And surely this consideration of the bible being one of the conduit-pipes, through which God hath appointed to convey his truths, as well as graces, to his children, should, methinks, both hugely animate to the searching of the scriptures, and equally refresh us in it. For as no instrument is weak in an omnipotent hand, so ought no means to be looked upon as more promising, than that which is like to be prospered by grace, as it is devised by omniscience. We may confidently expect God's blessing upon his own institutions, since we know, that whatsoever

1. John v. *ever we ask according to the will of God, he will give it us*; and we can scarce ask any thing more agreeable to the will of God, than the competent understanding of that book, wherein his will is contained.

THE difficulty ought not to deter us from the duty of searching the scriptures, the difficultest commands of God being a warrant to a believer's confidence of being enabled acceptably (though not exactly) to obey them; which St. Peter seems to have known well in the theory, though he failed in the practice, when to be enabled to walk upon the sea, he desires only, that our Saviour would please to command him to come to him upon the water. The bible is indeed, amongst books, what the diamond is amongst stones, the preciouslest, and the sparklingest, the most apt to scatter light, and yet the solidest, and the most proper to make impressions. But were it as unsuitable to its end, as it is the contrary, I should remember, that our Saviour could successively employ even clay and spittle to illuminate blind eyes: and though I thought the bible to be, on other accounts, no more than equal to other books of morality and devotion, God's designation would make me study it more hopefully, by minding me of that of the Syrian leper, when he would needs have *Abana* and *Parpar*, rivers of *Damascus*, likely to be as medicinal for his disease as *Jordan*; and vainly fancied, that God's appointment could not put a difference betwixt things that knew no other.

I KNOW, that because of the intermixture of some obscurer texts of scripture with the clear ones, there are divers well-meaning, and even devout persons, that leave the study of it for that of other books of religion, which, by leaving out all such difficult matters, seem to promise more of instruction. But, notwithstanding this, I shall not much scruple to affirm, that as the moon, for all those darker parts we call her spots, gives us a much greater light than the stars, that seem all luminous; so will the scripture; for all its obscurer passages, afford the Christian and Divine more light than the brightest human authors.

To dispatch, since the scripture is both a naturally proper, and an instituted instrument, to convey revealed knowledge to the studies of it; and, in it, many clear passages may instruct ordinary capacities; and its darker ones may either recompense more inquisitive wits, or humble them: I see not, why the obscurity of a small part of it should deter any sort of pious persons from the perusal of the whole. And, as the word of God is termed a *light*, so hath it this property of what it is called, that both the plainest rusticks may, if they will not wilfully shut their eyes, by the benefit of its light, direct their steps, and the deepest philosophers, may be exercised, if not posed and dazzled, with its abstruser mysteries. For thus, in the scripture, the ignorant may learn all requisite knowledge, and the most knowing may learn to discern their ignorance.

The second OBJECTION.

To proceed now to the second objection a-

gainst the style of scripture: the seemingly disjointed method of that book is by many much cavilled at; to which, were the supposal a truth, I might reply, that the book of grace doth but therein resemble the book of nature; wherein the stars, (however astronomers have been pleased to form their constellations) are not more nicely or methodically placed, than the passages of scripture, that where there's nothing but choice flowers, in what order soever you find them, they will make a good posy: that it became not the majesty of God to suffer himself to be fettered to human laws of method, which, devised only for your own narrow and low conceptions, would sometimes be improper for, and injurious to his, who may well say (as he doth in the Prophet) that his thoughts are so far from being ours, that, *As the heavens are higher than the earth, so are his thoughts higher than our thoughts*: that, as a mixture of amber-grease and musk is more redolent than the single ingredients; and as, in compound medicines, (as mithridate and treacle) the mixture gives the electuary a higher virtue than the sever'd drugs possessed; so, oftentimes in morality and divinity, a complication of precept and example, of rhetoric and mystery, may operate better than their distinction would. And sure we should judge that man a very captious creature, that should take exception at a proffer'd sum, only because the half-crowns, shillings, and sixpences, were not sorted in distinct heaps, but huddled into one. This, I say, with much more, might be represented, were the scripture-series as destitute of method, as pretended. But the truth is, that the method, though it be not pedantically nice, is proper and excellent; (if the goodness of a method be to be judged less by the order of the sections, than its being in order to the author's end) and never swerved from, but upon sufficient ground, or for some mysterious purpose; the laws of order in the scripture being rarely declined, but, as the laws of nature are in the world, for man's instruction. The historical dislocations have their particular reasons, and, for the most part, are accounted for by judicious expositors: and as for the frequent (and sometimes long) digressions, excepted against in the epistles of St. Paul, were he a bare human writer, I should possibly attribute his frequent excursions to his fulness upon all subjects, not his want of skill to prosecute any one; and compare his pen to those generous horses, who, though never so well managed, will ever be jetting out on this or that side of the path, not out of undisciplinens, but purely out of mettle. But, looking upon St. Paul under another notion, I shall rather choose to tell you, that as rivers are said to run to the sea, though oftentimes the interposition of hard or rising grounds, or other obstacles, force them to such winding meanders, that they seem to retreat from the ocean they tend to; which nevertheless, with increased streams, they afterwards bend again their intermitted course to, having watered and fertilized, by their passage, the grounds

Matth. xi. 28.

John ix. 6.

2 Kings v. 12.

Psal. cix. 105. Prov. vi. 23.

Isa. lv. 8.

grounds, through which they seemed to wander; so our Apostle, though he direct his course to his main scope, may not only without declining it, but in order to it, (for in some cases the wisdom of the proverb will inform us, that the longest way about, is the nearest way home,) seem for a while to abandon it, by fetching a compass to answer some obvious, or anticipate some tacit objection; and afterwards more prosperously resume his former considerations, now strengthened by the defeat of the interposing scruples, having by the by happily illustrated and enriched those subjects, which his incidental excursions led him occasionally to handle. I must add, that in St. Paul's, as in the rest of the inspired writings, the meanness of heeding the Holy Ghost's way of writing makes the method appear to us at a very great disadvantage. For in the historical parts of scripture, when the order of time is interrupted, those *προόδους-ερα προλήψεις* and *επιάνοδοι*, and such dislocations, are used oftentimes only to comply with the connexion of the matter; and either dispatch all that belongs to the same long narrative at once, or else to join passages allied in some other circumstance, though sever'd in that of time; and sometimes too things are inserted, which do not readily seem pertinent to the series of the discourse, but are extremely so to some scope of the author, and afford much light and excellent hints to the reader. Sometimes the coherence, where it appears defective, may be very well made out, by rendering Hebrew verbs (and some Greek aorists) in a preterpluperfect sense instead of a perfect; or by some such other grammatical variation of the words, as all, that understand Hebrew well, know to be allowed by the propriety of that tongue, which ignores divers moods and tenses, &c. of our western languages. Sometimes that, which seems incoherent to a discourse, serves really to prevent a foreseen (though perhaps not always obvious) probability of the misapplication of it; and so must not be judged impertinent to a doctrine, which it hinders from being either scrupled at, or abused. Sometimes the prophets in the midst of the mention of particular mercies promised to, or judgments denounced against the people of God, fall out into pathological excursions relating to the Messias, which seem extremely abrupt and incoherent with the rest to them, that consider not how seasonable the mention of Christ may be, both in that of the mercies of God, of which he is the foundation and pinnacle, the ground and consummation, (and the promise made of him, taught the faithful to reason thus with his Apostle,

Rom. viii. *He that spared not his own Son, but delivered*
32. *him up for us all, how shall he not, with him,*
also freely forgive us all things? and with the threats of the judgments of God, in which he

John. xiii. was his people's grand consolation. Sometimes
13. *ὁ διδάσκαλος*, the teacher, that bishop of our
2 Pet. xi. souls, who was in the supreme degree of per-
25. fection, which St. Paul required of a bishop,
1 Tim. iii. *διδασκτικός*, both fit and forward to teach,
2. takes a rise from any invitation, either of a word, expression, or theme, though belonging

to his own first subject, to give further instructions, by digressing a little to that occasional and intervening theme; which, however it related to his matter, suited very well with his merciful inclinations to instruct dim mortals. Sometimes, nay oftentimes, the inspired discourses seem to say things, not only incoherent, but contradictory; (as is very remarkable in divers of St. Paul's epistles, where he seems to praise and dispraise the same persons,) whereas addressing themselves to mixt assemblies, wherein (as Noah and Ham in the ark, and the tares and the wheat in *agro Dominico*) there were both good and bad men, hereticks, especially Gnosticks, and orthodox Christians; they only so wisely dispensed and tempered their discourse, that both these sorts of persons might find something, in what was in general terms delivered, to appropriate to themselves in particular; which application was necessarily left to their own consciences to make. Sometimes the order is in scripture much disturbed, or injured, by the omission or misplacing of a parenthesis. For there not being any in the Hebrew copies, nor (as it is thought) in the original Greek ones, the publishers of the several editions of the bible have placed parentheses as they have judged most convenient; some including in them what others leave out of them; and some making long ones, where others make none at all; and perhaps none of them having been so happy, as to leave no room for alterations, that may deserve the title of corrections and amendments. And sometimes too, the seeming immethodicalness of the new testament (not to determine any thing of the antiquity, which is certainly great, and the authority of the accents, and partition of the old testament, because amongst very able criticks *ad huc sub judice lis est*) is due to the inconvenient distinction of chapters and verses now in use: which though it be a very great help to the memory, and be some other ways serviceable; yet being of no greater antiquity than its contriver *Stephanus*, and being (though now of general use) but of private authority, and by him drawn up in haste; it will be perhaps no slander to that industrious promoter of heavenly learning, to say, he hath sometimes sever'd matters, that should have been left united, and united others, which more conveniently he might have sever'd; and that his lucky attempt ought not to lay any restraint upon the other learned men, from making use of the same liberty he took in altering the former partitions, (for of them I speak, not of the punctuation) of the new testament, in altering his alterations, to the best advantage of the sense or method. The analytical works of some (I wish I could say many) judicious expositors and divines upon the scripture may sufficiently manifest its being generally reducible enough to a perspicuous order; and that it conforms to the known laws of method, where its diviner one doth not transcend them. And it were not impossible for me to give divers instances to manifest, that as the north-star, though it be less luminous than many others,

others, yet, by reason of its position, doth better guide the pilot, than even the moon herself: so there are some texts in scripture, which, though less conspicuous in themselves, are, by reason of their relation to a context, more instructive than other more radiant passages; to which these would be much inferior, if they were not as well considerable for their being there, as such.

The third OBJECTION.

ALLIED to their objection, who find fault with the scripture for being immethodical, is theirs, who would fain persuade us, that it is seldom coherent, and scarce any where discursive. And I have observed, with trouble, that even some pious readers are easily tempted to look upon the bible as barely a repository of sentences and clauses, where divine truths lie huddled, and not ranged, and are too ready to apply to its texts the title *Nero* gave *Seneca's* style, of *arena sine calce*. Whereas an intelligent and attentive peruser may clearly enough discern, both that the prophets and apostles do make frequent deductions and inferences, and that their arguments, though not cast into mood and figure, are oftentimes as cogent as theirs, that use to make syllogisms in *Barbara*. I frequently entertain myself with both those authors, and yet methinks, *St. Paul* reasons as solidly, and as acutely, as *Aristotle*: and certainly according to *David's* logick, (*He that planted the ear, shall he not bear? He that framed the eye, shall he not see? He that teacheth man knowledge, shall he not know?*) the first and grand author of reason should as well know how to manage and disclose that faculty, as they that possess it but by participation, and glister so but with some few condescending beams, vouchsafed by that bright sun, who is indeed the *father of lights, from which each good and perfect gift descends*. But on this occasion, to point at a few particulars, I consider,

Psal. xciv.
7, 10.

Jam. i. 17.

1. THAT some ratiocinations of scriptures remain undiscerned or misunderstood, because of our unacquaintedness with the figurative, and (oftentimes) abrupt way of arguing, usual amongst the Eastern people, who in their arguments used to leave much to the discretion and collection of those they dealt with; and discoursed at a wide distance from the logical forms of our European schools, as to persons versed in their writings cannot but be notorious.

2. THAT the seeming incoherency of many ratiocinations proceeds purely from the misrendering of the original particles, especially of the Hebrew conjunction copulative *Vau*, or *Vaf*, (as it is diversly pronounced by the Jews, of whom I shall here advertise you once for all, that they have confessed to me, they differ in pronouncing Hebrew, not only from the Christians, but exceedingly from one another) for there is hardly any of those particles, that hath not, besides the obvious various significations, of which, if that were skilfully and freely in every text taken up, that would

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there afford the best sense, the scripture would, I am confident, appear much more coherent and argumentative than translations or expofitors are wont to make it: and though I did but consider, how many thousand times the particle *Vaf*, is used in the scripture, and that it doth not only (though it do primarily) signify *AND*, but hath also (I speak within compass) four or five and twenty other significations (as *that, but, or, so, when, therefore, yet, then, because, now, as, though, &c.*) and that the sense only gives it this great diversity of acceptations; I cannot but think, that if we always allowed our selves an equal freedom in rendering it, where the motive (which is the exigency or conveniency of the sense) is the same; the dextrous use and rendering of that one particle would make no small number of texts both better understood, and more esteemed.

3. THAT sometimes (especially in *Solomon's* and *St. Paul's* writings) in many passages so penned as to contain (like *Seneca's*) a tacit kind of dialogue, that is unskilfully by readers, and even interpreters, taken for an argument or an assertion, which is indeed an objection: and that such a mistake must mightily discompose the contexture of a discourse, even a raw logician need not to be told.

4. THAT the omission or misplacing of parentheses (which the Hebrew text altogether wanting, interpreters have supplied and used at their own discretion) makes the scripture oftentimes appear less discursive, as well as (what we elsewhere complain of) less methodical. And the like may be said of the points of interrogation. For whether it be true or no what the critics esteem, that in the original Greek copies of the new testament there were no such points, (as indeed I have found them wanting in the ancientest manuscripts I have seen) it is certain, that in our modern copies, both Greek and translated, the authors of several editions have variously placed them, as themselves thought fit: and though, instead of the interrogative point, the Hebrews make use of their interrogative *He*; yet that the sense of the words, and a certain supposed modulation, do oftentimes make an interrogation, where that *He* is wanting, an Hebrician can scarcely ignore, no more than a logician, that the interrogation is not always supplied to the best advantage of the scripture's logick.

5. THAT the apostles and other inspired discoursers in the bible divers times use arguments, not to convince opposers, but to confirm believers. For the persons they reason with, being such, oftentimes, as esteem them teachers sent from God, upon whose score all they teach exacts belief, they may without irrationality use arguments to confirm in their doctrine men already acquiescing in the principles of it, and persuaded of their integrity, sufficiency, and authority, that it would be improper to urge against a refractory disbeliever, that is convinced of none of these. And as masters often use, in instructing their scholars, arguments, they would forbear to insist on

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against

against a professed antagonist; so the apostles dealing with those, that thought them inspired teachers, and fully instructed in the mysteries of scripture, and the designed dispensations of God, might justly draw inferences, not to be urged against an infidel, from a doctrine first delivered by themselves, or from a text or passage, wherein those, they reasoned with, justly supposed they might know more of the mind and counsel of God than other men; and would teach nothing as such, that was not so.

6. THAT arguments exquisite, and (as artists term them) apodictical, had been oftentimes less proper in discourses, which being address'd to popular auditories, required rather popular arguments; which the inspired discoursers employ, but as likely to be better understood, and more prevalent than those, which are so logical, that they require logicians to relish them. Where teaching and persuading is the design, not only the native cogency of a ratiocination is to be considered, but its proportion to their spirits it is address'd to, and its aptitude to work upon them. For as a spider will catch flies better than a hawk can; as a cat is more fit to destroy mice than a grey-hound, though this be stronger and swifter; and as the crowing of a cock will (according to famous naturalists) sooner fright a lion than the bellowing of a bull, though the latter be much the more terrifying noise, and proceed from the more formidable animal: so oftentimes weaker and popular arguments succeed better with a resembling auditory, than the irrefragable syllogisms.

7. THAT divers scripture-arguments do not logically and cogently prove the thing they would persuade, merely because they were meant only for what logicians call *argumenta ad hominem*; (reasonings designed not so properly to demonstrate the opinion they contend for, irrelatively and abstractedly considered, as to convince, of the truth of that opinion, the persons they are address'd to) and consequently the inspired discoursers arguing *è concessis*, from principles conceded and confessed by those they reason with, though the principles should be unsolid, the ratiocination is not. Thus there are divers texts of the old testament applied to Christ in the new, which though they did not now inevitably conclude against the present Jews, were without any illogicalness employed against their ancestors; because then the relation of those passages to the Messias was so acknowledged, that there needed but the pertinent applications made of them in the new testament; whereas the refractoriness of the succeeding Jews hath taught them to devise so many sophistical evasions to elude the texts we speak of, that they now dispute, not only the application of them, but the explication too. St. *Jude* argues with the rodomonts of his time, out of the story of the arch-angels and the devil's contest about the body of *Moses*: and though perhaps that story be (like the Jewish book, whence it seems not improbable it was taken) somewhat apocryphal; yet as long as they revered it, it was not irrational in him to urge

them with it, and employ it to the redargution of their insolence. And, although as there be nothing less solid and more fickle than the wind, yet the skilful pilot diligently observes it, and makes it drive on his ship more forcibly, than the powerfulest and best contrived engines in the world could: so though there be scarce any thing more groundless and unstable than popular opinions and persuasions, yet a wise teacher neglects them not, and may sometimes make such use of them, as to draw thence arguments more operative than the accuratest syllogisms logick could devise. And indeed the most convincing proofs of assertions being ever afforded by the mediums, wherein both parties agree, not only *Socrates* in *Plato's* dialogues, but dextrous discoursers generally, have often elected the drawing of inferences from the opinions and concessions of those they dealt with, as the most persuasive and successful way of arguing; to all which I shall add,

8. THAT another thing, which very generally keeps men from discerning the reasonableness and true sense) of scripture texts, is, the shiness of divines to let the context and the speaker's scope regulate their choice, amongst all the various, though not equally obvious, significations of ambiguous words and phrases. It is not, that (as far as I have observed) men almost of all religions are not wont to make bold with (and perhaps for a need to strain or wrest) phrases and words of scripture, when the giving them less usual notions may fit them to serve their turns: but the mischief is, that they decline the commonest acceptations, but to make the texts they quit them in, symphonize with their tenents, not with their neighbouring texts. It were methinks impartialler, if the frequenter sense of an expression were to be waded (as oftentimes it must) for one less current, to do this to make the scripture coherent, or discursive: and then, for our opinions, rather to conform them to the sense of the scripture, than wrest the words of scripture to them. But perhaps this impartiality would silence too many of our clamorous controversies (by shewing some to be groundless, and others undeterminable) to be likely to take place in the heated spirits of men; some of whom, I fear, whilst their feuds and fierceness last, would be willing to have the texts of scripture loose stones, which they may more easily throw at their adversaries, than built up into a structure, wherein they must lose that convenience, (it being difficult to pluck stones out of a building) though reason herself were the architect.

BUT to leave these eager disputants to their animosities, we shall again repeat, that the bible loses much by not being considered as a system. For though many other books are comparable to cloth, in which by a small pattern we may safely judge of the whole piece; yet the bible is like a fair suit of arras, of which, though a shread may assure you of the fineness of the colours, and richness of the stuff, yet the hangings never appear to their true

true advantage, but when they are displayed to their full dimensions, and seen together.

THESE things, *Theophilus*, among many others, may be represented on the behalf of the scripture, against those, who will needs censure it as a collection, not to say a heap of inmethodical and incoherent passages. But lest you should suspect me of partiality, I should ingenuously confess to you, that there are some things in the oeconomy of scripture, that do somewhat distress my reason to find a satisfactory account of; and that there are very few things, wherein my curiosity is more concerned, and would more welcome a resolution in. But when I remember, how many things I once thought incoherent, in which I now think I discern a close (though mystick) connection; when I reflect on the author and the ends of the scripture; and when I allow my self to imagine how exquisite a symmetry (though as yet undiscerned by me) omniscience doth, and after-ages (probably) will discover in the scripture's method, in spite of those seeming discomposures that now puzzle me: when I think upon all this, I say, I think it just to check my forward thoughts, that would either presume to know all the reclusé ends of omniscience, or peremptorily judge of the fitness of means to ends unknown; and am reduced to think that oeconomy the wisest, that is chosen by a wisdom so boundless, that it can at once survey all expedients, and so unbiassed, that it hath no interest to chuse any, but for its being fittest. I shall annex, that I think those must derogate hugely from the scripture, who only consider the sense of the particular sections, or even books of it: for I conceive, that (as in a lovely face, though the eye, the nose, the lips, and the other parts singly looked on may beget delight and deserve praise, yet the whole face must necessarily lose much by not being seen altogether; so) though the sever'd leaves and portions of scripture do irrelatively, and in themselves, sufficiently betray and evidence their own heavenly extraction; yet he, that shall attentively survey that whole body of canonical writings we now call the bible, and shall judiciously in their system compare and confer them to each other, may discern, upon the whole matter, so admirable a contexture and disposition, as may manifest that book to be the work of the same wisdom, that so accurately composéd the book of nature, and so divinely contrived this vast fabrick of the world. The books of scripture illustrate and expound each other; *Genesis* and the *Apocalypse* are in some things reciprocal commentaries; (as in trigonometry the distantest side and angle use best to help us to the knowledge one of the other :) and as in the mariners compass, the needle's extremity, though it seem to point purposely but at the north, doth yet at the same time discover both east and west, as distant as they are from it, and from each other; so do some texts of scripture guide us to the intelligence of others, from which they are widely distant in the

bible, and seem so in the sense. It is as high as pious a satisfaction to observe, how the sacred pen-men supply each other's omissions, (as is very observable in the four Evangelists mention of the genealogy of Christ,) according to God's degrees and seasons in dispensing the knowledge of his truths and mysteries in the several ages of the church; (to which he at first vouchsafed *but a light shining in a dark* 2 Pet. i. place until the day dawn, and to which these 19. mutual irradiations and secret references persuade, that all these reputed authors had their pens guided by an omniscient hand, and were but the several secretaries of the same enditer) and to find in writers severed by so many ages, and regions, a harmony, whose dissonances serve but to manifest the sincerity and unconfiringness of the writers. And truly for my part, I am professedly enough an impartialist, not to stick to confess to you, *Theophilus*, that I read the bible and the learnedest expositors on it, with somewhat particular aims and dispositions. For besides, that I come not to them with a croud of articles, which I am there resolved to find or make arguments to defend, with the overthrow of all antagonists, esteeming it less safe to carry my opinions to the scriptures than to take them up there: besides this, I say, though I neglect not those clear passages or arguments, that may establish the doctrine of that church I most adhere to; yet am I much less busied, and concerned to collect those subtle glosses or inferences, that can but enable me to serve one subdivision of Christians against another, than heedfully to make such observations, as may solidly justify to my own thoughts, and improve in them, a reverence for the scripture it self, and Christianity in general; such observations as may disclose to me in the bible, and the grand articles clearly delivered in it, a majesty and an excellency becoming God himself, and transcending any other author; and such observations (to dispatch) as may unveil to me in the scripture, and what it treats of, that *πολυποίκιλος* ἡ *σοφία* Ep. iii. 10. *τῆ* Θεοῦ, *manifest wisdom of God*, which even the angels learn by the church. These are, I confess, the things (as to speculative divinity) that I gladly meet with, and take the heedfullest notice of, in the writings of divines, of whatsoever religion, that owns the scripture; (for in this I am almost equally gratified by the abler expositors of all dissenting sects:) for I can scarce think any pains mispent, that brings me in solid evidences of that great truth, that the scripture is the word of God, which is indeed the grand fundamental; all other articles generally thought so being, if truths, better deducible from this one, than this from any of them. And I use the scripture, not as an arsenal, to be resorted to only for arms and weapons to defend this party, or defeat its enemies, but as a matchless temple, where I delight to be, to contemplate the beauty, the symmetry, and the magnificence of the structure, and to increase my awe, and excite my devotion to the Deity there preached and adored.

The fourth OBJECTION,

Of texts
seemingly
impertinent or use-
less.

THE apostle of the Gentiles teaching us, that the whole scripture (for so I should rather english the Πᾶσα γραφή, because there follows) is θεόπνευστος & divinely inspired, and is profitable for doctrine, for conviction, for correction, for instruction in righteousness; that the man of 2 Tim. iii. 15, 16. God may be perfect, thoroughly furnished unto all good works: and the Apostle of the circumcision assuring us, that, Prophecy came not in old time, by the will of man, but holy men of God spake as they were moved by the Holy Ghost; we are not to believe, that so divine an inditer, by secretaries, most of them conspicuous by the gifts of prophecy or miracles, would solemnly publish to the world, and for his church, any thing, that ought indeed to be accounted impertinent or useless. And yet of these qualities, some persons, more bold than learned and considerate, are pleased to impeach many passages of scripture. But truly that God, who was so precisely exact, in the dimensions, proportions, and all other circumstances of the ancient tabernacle, though it were but a typical and temporary structure, ought to be supposed at least as careful to let nothing superfluous intrude into those volumes: which being consigned to the church, for the perpetual use and instruction of it, must contain nothing uncondusive to those designs; the least text in it being as contributory to the completing of the bible, as every loop or pin was to the perfection of the tabernacle. God, by so great a condescension to the weakness of our capacities and memories, as the withholding from the canon so many writings of Solomon, and so many of the oracles and miracles of our Saviour; and by so strangely preserving the whole scripture, (for the books pretended to be lost, though written by never so holy men, are either in our bibles extant under other names, or cannot be demonstrated to have ever been canonical, that is, entrusted with the church as the infallible rule of faith and life) does, methinks, abundantly evince his design of inchoasing nothing there, that hath no tendency to his people's instruction. Were not my discourse confined by my occasions, and the fear of distressing your patience to somewhat narrow limits, I could easily by several instances of texts, seemingly useless, shew, how much men have been mistaken in imagining them such. Many passages, that at the first or second reading I could find nor guess no uses of, at the third or fourth I have discovered so pregnant in them, that I almost equally admired the richness of those texts, and my not discerning it sooner. A superficial and cursory perusal presents us many things as trivial or superfluous, which a perspicacious reflection discloses to be mysterious. And of so precious a quality is the knowledge of scripture, that no one part of it ought to be esteemed useless, if it may but felicitate or improve the understanding of any other; divine truths being of that worth, that the knowledge and acquit of a few of them as much out-values a greater knowledge of other things, as a jeweller's skill

and stock is preferred before a mason's. And I consider here, that as the bible was not written for any other particular time or people, but for the whole church militant diffused through all nations and ages; as many passages (as those opposed to the Zabians magical rites) have at first been necessary for the Jews, which lose the degree (at least) of that quality for us. For there are many others very useful, which will not perhaps be found so these many ages; being possibly reserved, by the prophetic spirit that indited them, (and whose omniscience comprizes and unites in one prospect all times, and all events) to quell some future foreseen heresy, which will not perhaps be born till we be dead; or resolve some yet unformed doubt, or confound some error, that hath not yet a name: so that all the parts of the scripture are useful in some ages, and some in all. We read in the gospel, that at the first institution of the eucharist, it was expressly said to the disciples concerning the sacramental wine, Drink ye all of it, whereas upon the exhibition of the bread the particle *all* is omitted. This difference, it is like, the primitive Christians marvelled at, and discerning no reason for it, might be tempted to think the passage useless or superfluous: but we that live in an age, wherein the cup is denied to much the greater part of the communicants, are invited not only to absolve the recording of this particularity, but to admire it. The ceremonial law, with all its mystick rites (which, like the manger of the shepherds, holds forth wrapped in his swathing-cloaths the infant Jesus,) to many, that bestow the reading on it, seems scarce worth it: yet what use the Apostles made of it with the Jews; and how necessary the knowledge of it is yet to us, in our controversies with them, he, that is any thing versed in them, cannot ignore. And let me tell you, *Theophilus*, that those fundamental controversies are both more necessary and more worthy a wise man's study, than most of those comparatively trifling ones, that at present so miserably (not to say so causelessly) distract Christendom. How many passages of the prophets by lazy readers are thought to have no use, which, as the star did the wise men, lead the attentive considerers to Christ; and so loudly and harmoniously, together with *Moses's* typick shades, utter those words of the Baptist's, *Behold the lamb of God that taketh away the sins of the world!* that I meet with numerous passages in the new testament, to which I cannot but apply what *St. Matthew* notes upon his narrative of our Saviour's apprehension: *All this was done, that the scriptures of the prophets might be fulfilled;* or rather now all this was so done, that they were fulfilled; for so oftentimes the context commands us to render the *ὅτι* in these citations, and which recall to my mind the history of the transfiguration; for as there the Apostles at first saw *Moses and Elias talking with Jesus*, but at the second view (when the cloud was withdrawn, and he had spoken to them) saw none but *Jesus only*; so such passages, as I am speaking of,

Mat. xxvi.

27.

Mark xiv.

23.

Luke ii.

Mat. i.

John i. 22.

Mat. xxvi.

56.

Mat. xvii.

3, 5.

of, in the law, the prophets, and the gospel, at first survey appear very distinct things, but upon a second inspection, and the access of more light from an attentive collation of things, they do all, as it were, vanish into
 Joh. i. 55. Christ; of whom (to use an Apostle's terms) Moses in the law and the prophets did write: and at whom those types, and those predictions pointed. Those instances of the old testament, of the confused or dislocated mention of known pedigrees and stories, were possibly useless, and even troublesome to the ancient Jews; but serve us extremely to silence the cavils of the modern ones, when they would invalidate the new testament's authority; because in St. Stephen's narrative, and some of the Evangelist's genealogies, the Holy Ghost is pleased to employ, in the new testament, that obscure strain he had oftner used in the old: (and sure as insultingly as the Jews use to urge against us objections of that nature, I could readily retaliate, and repay them in the same coin, were there no common enemy, that might be advantaged by our quarrel, and employ either's arguments against both.) And as there are divers prophetic passages in the Revelation, which we know as little the use, as meaning of, which yet doubtless our posterity will not find barren, when once the accomplishment shall have proved the expositor of those predictions, whose event will (if it do nothing else) attest the omniscience of their inspirer: so possibly, of many Mosack constitutions, whereof we Christians find excellent uses, moit of the old Jews scarce knew any; at least my conversation with our modern Rabbies shows me, that they, whilst they obstinately decline referring them to the Messias, can scarce make any more of the inspired and mysterious laws of Moses, (except those that relate to the Zabian superstition, with which too moit of their doctors are as unacquainted as ours) than the Egyptians, or Gymnosoplits, could of their sacrifices and other ritual devotions.

It is not, that I think all the books, that constitute the bible, of equal necessity or equal usefulness, because they are of equal extraction; or that I esteem the church would lose as much in the prophecy of Nabum, as that of Isaiab; or in the book of Ruth, as in the epistle to the Romans, or the gospel of John, (as the fixed stars themselves, though of the same heaven, are not all of the same magnitude and lustre.) But I esteem all the constituent books of scripture necessary to the canon of it; as two eyes, two ears, and the rest of the members are all necessary to the body; without divers of which it may be, but not be so perfect; and which are all of great, though not of equal usefulness. And perhaps it might without too hyperbole be said further, that as amongst the stars, that shine in the firmament, though there be a disparity of greatness compared one to another, yet they are all of them lucid and celestial bodies, and the least of them far vaster than any thing on earth; so of the two testaments, that compose the bible, though there may be some disparity in relation to themselves, yet are they both

heavenly and instructive volumes, and inestimably out-valuing any the earth affords, or human pens ever traced. And I must add, that as mineralists observe, that rich mines are wont to lie hid in those grounds, whose surface bears no fruit-trees, (too much maligned by the arsenical and resembling fumes) nor is well stored with useful plants or verdure; (as if God would endear those ill-favoured lands by giving them great portions:) so divers passages of holy writ, which appear barren and unpromising to our first survey, and hold not obviously forth instructions or promises, being by a sedulous artist searched into, (and the original word ἐρευνᾶν used in that text of Search the Scriptures does properly enough John 7. signify the searching for hid treasure) afford, ^{39.} out of their penetrated bowels, rich and precious mysteries of divinity.

The Fifth OBJECTION.

THE next thing imputed to the scripture is, that it contains many things trivial or impertinent; and it is not impossible, but that some things may seem so, though they are not: of this sort are disjointed speeches, and abrupt transitions observed in many of our Saviour's discourses; in which also we sometimes read him to have answered, without being asked the question, (though that be otherwise fallable by a critick,) and sometimes to have answered to a quite other question than that he was asked. But this is not to be thought an absurdity, but an excellency in the replies of Christ; who possessing the prerogative of discerning hearts, did preach after that rate; his oratory took a shorter way than ours can follow it in: he prosecuted his design by altering his discourses; and wisely measured the fitness of his heavenly sermons, by their relation to his end, not his theme. For as he knew his hearers thoughts, he address himself to them; and reaching them in their earliest formation, and, as it were, their first cradle, before they had leisure to pass into the tongue, he not more convinced his auditory by answering their thoughts, than by thus manifesting that he knew them. Of his so much undervalued parables, some, if not moit, do (like those oysters that besides the meat they afford us, contain pearls) not only include excellent moralities, but comprize important prophecies. The parable of the pregnant grain of mustard-seed, that so suddenly grew to so large a plant, was a (now fulfilled) prediction of the admirably swift progress of the gospel; which from despicable beginnings, soon prospered to a height, that rendered it almost as fit an object for wonder as for faith. That other parable of the treacherous husband-men clearly foretold Christ's death by the Jews malice, and their destruction for it. And I despair not to see unheeded prophecies disclosed in others of them, especially being informed that there is a critick, (Monsieur A. B.) now at work upon a design of manifesting many otherwise interpreted passages of the new testament to be prophecies; of whom no less than the famous of the modern Rabbies, Me-

nasse Ben-Israel, (one time I made him a visit at his own house in *Amsterdam*) gave me this character, that he took him for the ablest person of the Christians. Those historical circumstances quarrelled with, in Christ's parables, are like the feathers, that wing our arrows, which though they pierce not like the head, but seem slight things, and of a differing matter from the rest, are yet requisite to make the shaft to pierce; and do both convey it to, and penetrate the mark. But nothing is thought more impertinent in the scripture than the frequent repetitions. But the learned need not to be told, that many things seem to the ignorant, bare repetitions, which yet ever bring along with them some light, or some accession; in that comparable to the stars, which, as like as they seem to vulgar gazers, are by the skilful astrologer taught to contain, under that colour and figure common to them all, very peculiar and distinct influences. I here also consider, that in all languages there are some customary geminations and expressions, which, though to strangers they appear superfluous, if not absurd, to the natives, and in the propriety of that speech, are not only current, but oftentimes emphatical. I find withal, that there is scarce any of these seeming impertinencies, of which a learned and judicious expositor cannot assign a pertinent cause or reason; and I consider too, that the books of scripture being indited, not all at once, but at very several and distant times, (according to the known saying, that *Nunquam satis docetur, quod nunquam satis dicitur*) the repetition of the same sins and errors required that of the same menaces and dissuasions; whose frequent enforcing, serving both to attest and convince the sinner's obstinacy, was not a bare repeating, but such a redoubling as we are fain to use, to drive in a nail to the head; (and the words of the wife are, in the wife man's words, *As nails fastned by the masters of assemblies*) where though in all the renewed strokes the busy hammer gives, the act be still the same, yet is no blow superfluous; the number of them serving to compleat their operation. They that in perusing books have the learning and skill to strip them, of what cratory or stealth hath dressed and disguised them in, will easily discern most of them to be but varied repetitions: which for my part I find differing from those of scripture, but in that the latter do in the same words generally comprize new matters, whereas the former usually present us stale matter in new words. And I consider further, that our own sad experience showing us, that there is no single text of scripture, that subtler hereticks sophistry cannot plausibly enough elude; the Holy Ghost foreseeing this from the beginning, hath mercifully and wisely provided, that the fundamental truths of faith and manners should be held forth in so many places, and in so much variety of expressions, that one or other of them must unavoidably intercept those evasions, and escape those misconstructions, that sophistry may put upon the rest. Which providence a-

lone hath preserved many articles from the attempts of hereticks; making them both blush to question, and despair to disprove a truth attested by more than two or three witnesses; and giving orthodox believers the satisfaction of having their anchor tied to a *threefold cord, which is not easily broken*. Most of the bible's repetitions (or inculcation rather) teach us something or other untaught before; and, as in *Pharaoh's* vision, though both the ears and the kine signified the same thing, yet *Joseph's* interpretation shows, that neither was superfluous; even those few, that teach us nothing else, teach us at least the importance (or some other attribute,) of those repeated points we were taught before. And I scruple not to compare the expressions of the scripture to a rose, where though so many leaves nearly resemble each other, there's not one of them, but contributes to the beauty and perfection of the flower.

The sixth OBJECTION.

I AM not unacquainted with the קרי *Keri*, Of contradictions and the כתיב *Cethib*; nor the תקון ספרים presumed *Tikkum Sophrim* in the old testament: nor yet with the *Variae Lectiones* (especially those of the Eastern and Western Jews, as they are called) taken notice of by modern criticks in the Hebrew text of the old, as well as in the Greek of the new testament. I am not neither altogether a stranger to the difficulties to be met with, in making good the citations we find made of divers texts of the former of those sacred instruments in the latter: in which they seem not unfrequently to differ much from what we find extant in the ancient testament, as to the words, and sometimes too as to the sense. These things, I say, though by some much urged against the scripture, I am not ignorant of. But I think it not fit to consider them in this place; not only, because those, that are much better qualified for such a work than I, have done it already; but because these objections relating rather to the truth or the authority, than to the style of the scripture, the nature of my present task does not oblige me to examine them. Especially, since I have already said something of them, and may say more, in what I write on the behalf of the Christian religion. And it is upon these grounds, *Theophilus*, that I also decline at present the consideration of what is wont to be objected, as if there were a great many self-contradictions to be met with in the scripture. Only I shall in the mean time invite you to take notice with me, that it is not oftentimes so much the various aspects of the texts, as the divers prepossessions and interests of the expositors, that make books seem replenished with interfering passages and contradictions. For if once the theme treated of do highly concern men's interests, let the book be as clear as it can, subtle and engaged persons on both sides, perusing it with forestalled judgments of biased passions, will be sure to wrest many passages to countenance their prejudices, and serve their ends, though they make the texts never so fiercely fall out with one another, to reconcile them to their partial glosses. Of this I might produce an eminent instance in *Aristotle's*

*A*stle's physical writings, alledged by so many dissenting sects of school-men to countenance their jarring opinions; the injured *Stagyrite* (employed as second by every one that quotes him) being by every sect brought to fight with its antagonists, and by them all to give battle to himself. Thus do the dissenting sects of Mahometans quarrel as well about the sense of their Alcoran, as we do about that of our Bible; and make the one as much a nose of wax, as the Romish catholicks say we make the other. Which brings unto my mind, that not only the *δυσόητα τινα*, the *some things hard to be understood* in St. Paul's epistles, but also the *λοιπὰ γράφαι*, the *other scriptures* are by St. Peter said to be by the *unlearned and unstable wrested to their own destruction*. When a sober author finds an impartial reader, who takes his words in their genuinely obvious acception, wherever the context doth not manifestly force another on them, (in which then the reader acquiesces) the writer is easily understood. But when nimble and forestalled wits peruse an author, not to sit down with his sense, but to make him speak theirs, (whether it be his own or no;) and giving themselves the pains and leisure of considering all the possible acceptions of a word or phrase, and the liberty of pitching upon that which best serves their present turn, allow themselves to conclude; that because it may signify so and so elsewhere, therefore it does so here: an author must be much warier than *Homer* and *Virgil*, whom *Eudocia* and *Alexander Ross* have made evangelists, to keep his words from being tortured into a confession of what was never in his thoughts. And a very pregnant instance of this truth we may observe in the law of our land, whose very end being to prevent or abolish strifes; and which being written so punctually and expressly, and in so peculiar and barbarous a style (clogged with supernumerary repetitions) that nothing but their being conducive to so good an end could make it supportable; is yet by mens concerned wits so misconstrued and perverted, that not only in private mens cases, we see the judges so puzzled, that suits oftentimes out-last lustres; but the prince's party and the subject's kill, and execute one another; and (as charity tempts me to presume) think they may do so by the law, and do so for the law. In this belief, that we often impute to the scripture our own faults and deficiencies, the instances of those anti-scripturists, I have conversed with, have very much confirmed me: though I have still esteemed, that the best as well as the shortest way, is not to wrangle with them about every nicety, where the defeat of their objections gives us no victory over their incredulity, and by but evidencing the scripture's not being either false or absurd, can serve but to justify our reverence to them, not to impart it; but by solidly asserting the divine origination of the scripture, reduce men to ascribe their scruples to the true cause; and persuade us to the temper of the Apostles, who, when Christ had uttered a hard saying, which so unsettled many of his disciples, that they deserted him upon it;

though (their gross misapprehensions of numerous other much less obscure passages will easily persuade us) they relished it not aright, yet would by no means forsake him for their master, because, says their spokesman, *Peter, thou hast the words of eternal life, and we believe, and are sure, that thou art the Christ, the Son of the living God*: teaching us, with one grand and comprehensive truth, to silence particular scruples. And one thing would not be unworthy our objectors considering; that the truth and authority of the scriptures, and consequently their not being contradictory to themselves, hath (as we may elsewhere have occasion to manifest more at large) been immemorably believed by the learnedest men in the world; many of whom may be very reasonably supposed to have examined opinions without any other concern in their inquiries than that of not being deceived; or any other end than that of finding out the truth; and most of whom, though by their sedulousness and their erudition they discovered difficulties in the bible, that our quærists could never have dreamed of; yet did they all conclude the belief of the scriptures grounded on as much reason, as is consistent with a due latitude for the exercise of faith: which possibly needs some dimness or reluctance in the understanding, to be an acceptable virtue of the will; (faith and the twilight seeming to agree in this property, that a mixture of darkness is requisite to both; with too resplendent a light, the one vanishing into knowledge, as the other into day.) And now faith thus casually presents her self in my way, it will, perhaps, not be impertinent to observe, that Christ often deals with new believers, as he is recorded to have done with *Nathaniel*; for as when that guileless *Israelite* had acknowledged him the Messias, upon the bare evidence of his having been discerned by him under the fig-tree, our blessed Saviour tells him, *Because I said unto thee, I saw thee under the fig-tree, believest thou? Thou shalt see greater things than these*; (which in the next verse he proceeds to mention;) so when men once have embraced the persuasion of the scripture's being divinely inspired, that faith is a thing so acceptable to God, that he often discovers to them, to confirm them in their belief, arguments much clearer than those that induced them to it; and convinces them of the reasonableness of having submitted their reason to him that gave it them. And, (as if there were mysteries, in which faith doth more prosperously make way for understanding, than that is set awork to introduce faith,) it happens to them, as it did to the two blind men mentioned in the gospel, in whom our Saviour first required faith, and (having found that, he) then opened their eyes.

The seventh OBJECTION.

FROM the (not long since mentioned) frequent repetitions to be met with in the scripture, and from the unusual method, wherein the author of it has thought fit, that the divine truths and precepts should be extant there, divers

divers have been pleased to take occasion to criminate the bible, as if, its bulk considered, it were but a barren book; wherein instructions are but sparingly scattered, in comparison of what is to be met with in divers other writings, where repetitions are avoided, and more of useful matter is delivered in fewer words. And hence it is (say these objectors) that many persons unquestionably religious chuse rather to study other books of devotion and morality, as containing more full and instructive precepts of good life.

I MIGHT answer this allegation by representing, that the several particulars, whereon the accusation is grounded, having been already examined by me, I need not say any thing distinctly to this accumulative charge. But because I would not only defend my veneration for the scripture, but persuade it, I shall on this occasion offer two or three things to consideration.

ALTHOUGH then the scripture were less replenished with excellent doctrines, and were but, as well as the best of other books, like mines, in the richest of which the golden ore is mingled with store of precious materials, (and needs a laborious separation from them;) yet sure it would, like those mines, deserve to be carefully digged in: and it will become the grateful Christian's zeal to imitate him in the parable, who having found *a treasure hid in a field*, stuck at no price within his power, to purchase the whole field for the treasure's sake.

Mat. xiii.
44.

BUT, God be praised, this is not the case; for it is only our ignorance, our laziness, or our indevotion, that keeps us from discovering, that the scripture is so far from being, as the objectors would have it, a wilderness or a barren soil, that it may be much more fitly compared to that blessed land of promise, which is so often said in scripture to be flowing with milk and honey, things useful and delightful; if not to paradise itself, of which, it is said,

Gen. ii. 9. that there *the Lord God made to grow every tree, that is pleasant to the sight, and good for food; the tree of life also in the midst of the garden.*

And indeed, as the author of it was omniscient, so experience has taught, that he has so much expressed himself to be so in the scripture, that the more knowing its pious studiers have been, the greater store of excellent truths they have met with in it; the scripture being indeed like heaven, where the better our eyes and telescopes are, the more lights we discover. And that this may not appear to be said *gratis*, let us consider, that a book may be instructive as well by teaching its readers speculative truths as practical ones, and that Christians ought as well to know what God would have us think of him and his works, as what he would have them do. Now as it is past question, that there are no speculative truths, of so noble and elevated a nature, as those that have God himself for their object; so there is no book, from whence there is so much to be learned, as there is from the bible, of the nature, and even the thoughts of God, and of those deep mysteries, into which, as I formerly noted from St. Peter,

1 Pet. i.
12.

the angels themselves are greedy of prying. Nay, there is no other book whatsoever, that teaches us any thing at all, concerning divers of these sublime subjects, that may be safely relied on, save in what it is beholden to the scripture for. So that we cannot without an extreme injury look upon that book as barren, which alone contains all those revealed truths, which are of so noble and precious a nature, that we justly prize the compositions of heathen philosophers, and other authors, for being enriched with guesses at some few of them, though much embarrassed by the alloy, whereto the truths, conjecturally delivered, are made liable from the imperfections of writers, always fallible, and, for the most part, in some degree or other, actually erroneous. But of this more perchance elsewhere. Wherefore I shall now add, that whereas those we reason with, are pleased to prefer other books of morality and devotion before the scripture, in reference to good life; they would probably be of another mind, if they duely considered, that to engage men to live well and holily, there is much more requisite, than barely to tell them, that they ought to do so, and how they should do it. For since to lead a life truly virtuous requires in many cases, that we deny and overcome our natural appetites and inclinations, and requires also constancy in a course, that is confessedly wont to be attended with many hardships and dangers; it is not sufficient, to engage a man to a good life, to give him precepts of it; which do not so much (what is yet the main thing in this case) make men willing to conform to such precepts, as suppose them so. And he, that can do no more, does far less than him, who, besides the rules of good life, presents men the highest, and the most prevalent motives to embrace piety and virtue, and the most powerful dissuatives from all that is wicked; by proposing to us such rewards and punishments, and satisfying us, that we ought, according as we behave ourselves, to expect either the one or the other; as to convince us, that we cannot be either wise or happy, but by being good, nor avoid the greatest of miseries, but by avoiding vice. Now, as we shall see anon, that as to the precepts of good life, the bible is not unfurnished with them; so as to that most operative part of the way of teaching good life, the proposing of the most prevalent motives to good, and the most powerful dissuatives from evil; not only no other book does, but no book not inspired, can perform, in that kind, any thing near so much as the scripture alone. Since we have not the same reason to believe any mere man, as we have to believe God, touching those rewards and punishments, which he reserves after death for those, that conform to, or disobey his laws; these being matters, which (whatever philosophers and other learned men may have thought to the contrary) depend upon his free will, and consequently are not to be explicitly known but by his revelation; which he has not, that appears, vouchsafed us in any other book than the scripture. And therefore it is not to be wondered at, that St. Paul should ascribe

ascribe it to our Saviour Christ, *That he had brought life and immortality to light through the gospel.* And whereas hope is that spur, without which men do scarce ever cheerfully undertake, and resolutely go through things, much less difficult and dangerous than those, which a virtuous course of life is wont to expose men to, St. Peter makes a Christian's highest hope to depend upon a revealed truth, where he gives thanks to God for having, according to his abundant mercy, begot us to a lively hope, by the resurrection of Jesus Christ from the dead. And what influence such a knowledge of God and Christ, as, if we have it at all, we must owe to the scripture, and such hopes and promises, as none but God himself, or those he sends, can give a wary and intelligent person, may have upon good life, you may guess by that other passage of the same Apostle, where not only he mentions God's having according to his divine power (or efficacy) given unto us all things, that pertain unto life and godliness, through the knowledge of him, that hath called us to glory and virtue, but also immediately after speaks of our being made partakers of the divine nature, and escaping the corruption, that is in the world through lust; by those exceeding great and precious promises, that are given of God unto us. So that although the scripture did not expressly give us such moral documents as ethical writers do, and taught us good life, but by acquainting us with what God has revealed in those writings concerning himself, and by convincingly proposing to us those highest inducements to embrace a good, and shun an evil life, which (though reason may perchance make some weak and confused guesses at them,) revelation only can make examining men confidently depend upon: if, I say, the scripture did no more than thus engage us to resolve upon a good life, leaving us to derive the particular precepts of virtue from the inward dictates of the law of nature, and the exercise of our own reason, (which two together may well teach us almost as much as ethical books are wont to teach, of really and considerably useful) the scripture ought yet to be esteemed a most instructive book in reference to good life. As in effect we see, that the writings of no philosopher or orator ever made any thing near so many persons so virtuous, as the new testament, though but a pocket book, has been able to do; especially in those primitive ages of the church, when those that received that book were less diverted from it, than since they have been by the reading of others. The moon may in clear weather lend a gardener light enough to dig, and manure his orchard, and perhaps to prune his trees; but none will say, that the moon does as much contribute to his labouring to produce fruit as the sun; since this nobler planet not only affords him light to work by, and a comfortable warmth whilst he is working, but animates him by the hopes he cherishes upon the sun's account, that in due season his diligence and toils shall be rewarded. The application is too obvious to need to be insisted on.

BUT though upon the fore-mentioned accounts alone, the scripture would deserve to be looked upon as highly conducive to the practice of piety, and virtue; yet it is far from being true, that it is destitute of such moral documents, which it needs not, to deserve to be looked upon as a book very instructive in reference to good life. For there being two sorts of virtues requisite to an embracer of the gospel, which have been conveniently enough called, for distinction-sake, the one Christian, and the other moral or ethical; I suppose it will not be doubted, but that the rules of those virtues, that are properly Christian, must be sought for in the scripture, that being acknowledged by protestants, to have such a sufficiency as to matters of meer revelation, (which restriction too many do inconsiderately enough leave out) that in matters of that nature, divines often do, and in many cases may, argue negatively, as well as affirmatively from the scripture; which eases us of many things obtruded as duties, merely by its not, either expressly, or by consequence, imposing them upon us. So that as to things of this nature, there is such a fulness in that book, that oftentimes it says much by saying nothing, and not only its expressions but its silences are teaching, like a dial, in which the shadow as well as the light informs us. Nor must we think, that the bible is destitute of the best sort of such precepts, exhortations, and dissuatives, as we prize in ethical books; because they are not expressed and ranged in the bible, as they are wont to be in systematical compositions; for not only there is extant in the scripture, to them that know how to constellate those lights, a very excellent body of moral precepts; but there are likewise scattered the forciblest motives to the several duties, and the most retracting dissuatives from the contrary vices. And truly, it hath long lessened my esteem of our heathen morals, that ethicks being but the doctrine of regulating our passions, and directing our faculties, in order to the attainment of felicity, they have been hitherto handled by those, to whom the nature of the faculties and passions of the mind was but very little known: whereas to the author of the scripture morals, the frame and springs, and faculties of our souls, being intuitively and most perfectly known, the most proper and powerful ways of working on them, cannot be unknown to him: and then certainly, one unacquainted with the trade will be much less likely to mend a watch, that is out of order, than a watch-maker. And indeed, even in reference to that other sort of virtues, which are wont in the more confined sense of the word to be called moral, there are I know not how many excellent notions and directions, relating to them, dispersed up and down in the scripture; though by reason of their not being drawn up by themselves, and of their being mingled with other matters, they are not so readily taken notice of by ordinary readers. Whereas, those studious perusers, that search the scriptures with a due diligence and attention, are not only wont easily enough to descry the moral counsels and prescriptions

over-looked by the other readers; but take notice of many excellent documents, that are plainly enough intimated or hinted there to knowing and diligent perusers, though not clearly and expressly enough to be found of those, that think them not worth seeing.

WHEREFORE, as to those religious persons mentioned in the last proposed objection, I cannot but think, that by neglecting the scripture for ethcial composures, or even books of devotion, they as well wrong themselves as the scripture; and therefore I shall take leave to think the worse, rather of the practice of the men, than of the book of God. Scarce any thing has given me a favourabler character of *Luther*, than his wish, that all his books of devotion were burnt, when he once perceived, that the people's fondness and over-valuation of them produced a neglect of the study of the bible; to which you shall find, *Theophilus*, that the best of that nature being compared, are but (not to draw to our present purpose that of *Seneca* to his mother; *Paribus intervallis omnia divina ad omnibus humanis distant*) like the stars compared to the sun, whose emanations confer on them their lustre, but whose presence drowns it. For though I deny not books of devotion a due degree of praise and usefulness, yet I refuse them the superlative degree of either; and since the writers of the best of that kind of composures, either steal their best things from, or acknowledge that they borrowed them of the bible; I would not have Christians neglect the fountain for the streams, and unwisely, as well as unthankfully, elect to read God's word, rather in any book than his own; in which, to encourage us to study the precepts of a virtuous and holy life, we have such peculiar and encouraging invitations.—Saint *Paul* seems to make it the (end and the) result of the several usefulnesses he attributes to the scripture, *That it can make the man of God perfect, thoroughly furnished unto all good works; and is able*, (as he speaks a little higher) *Ἐπισημαίνει ἡμᾶς, to make us wise unto salvation*. There are indeed many excellent instructions given to us in other books; but they giving us directions, only towards the attainment of the advantages, conveniences, and ornaments of life; the ignorance of them only makes us miss those particular ends, whereto they give addressees, or whereof they facilitate our pursuits; but the knowledge, whose acquist, or neglect, imports endless joys or torments, we need seek only from the scripture: a Christian to understand the duty of his faith and life, heeding to understand no other book than the bible; though indeed to understand the bible well, it is ordinarily requisite, that a pretty number of other books be understood. Christians then have reason to study most that book, which understood, all others are needless to salvation, and which ignored, they are insufficient. If Saint *Peter's* vision had been a reality, he would scarce, hungry as he was, have ranged abroad to hunt in this desert or that forest for game, when he had a vessel let down to him from heaven, containing in it's self all manner

of four-footed beasts, and other objects of appetite, attended with a commanding invitation from heaven, *Rise, Peter, kill, and Eat*. So when God sends us from heaven in one volume, as at least virtual, collection of all those divine truths and holy precepts, others scatteringly and sparingly glean out of human books; the Christians cannot but prize a book so comprehensive, which by making it safe for him to ignore others, by so merited an *Autonomasia*, wears the title of *the book*, (for so the bible signifies in Greek, as the Hebrews call it *Mikra*, which by excellence signifies *what's to be read*.)—There are precepts enough of virtue, and motives enough to conform to them, held forth in the bible, if the contents of that divine book were believed and considered as they ought to be. It is a mistake to think, that a large system of ethicks, dissected according to the nice prescriptions of logick, and methodically replenished with definitions, divisions, distinctions, and syllogisms, is requisite or sufficient to make men virtuous. Too many of our moralists write, as if they thought virtue could be taught as easily, and much in the same way, as grammar; and leaving our rational motives to virtue, and determents from vice, with other things, that have a genuine influence on the minds and manners of men, they fall to wrangle about the titles and precedences of the parts of ethical philosophy, and things extrinsecal enough to vice and virtue; they spend more time in asserting their method, than the prerogatives of virtue above vice; they seem more solicitous, how to order their chapters than their readers actions; and are more industrious to impress their doctrine on our memories than our affections, and teach us better to dispute of our passions than with them. Whereas, as the condition of a monarch, who is possessed but of one kingdom or province, is preferable to that of a geographer, though he be able to discourse theoretically of the dimensions, situation, and motion, or stability of the whole terrestrial globe; to carve it into zones, climates and parallels, to enumerate the various names and etymologies of its various regions, and give an account of the extent, the confines, the figure, the divisions, &c. of all the dominions and provinces of it: so the actual possession of one virtue is preferable to the bare speculative knowledge of them all. Their master *Aristotle* hath herein been more plain, and less pedantick; who (by favour of his interpreters) hath not been nice in the method of his ethicks. And indeed, but little theory is essentially requisite to the being virtuous, provided it be duly understood, and cordially put in practice; reason and discretion sufficing, analogically, to extend and apply it to the particular occurrences of life; (which otherwise being so near infinite, as to be indefinite, are not so easily specifiable in rules :) as the view of the single pole-star directs the heedful pilot, in almost all the various courses of navigation. And the systems of moralists may (in this particular) not unfitly be compared to heaven, where there

Seneca de
Conf. ad
Helviam,
cap. 9.

2 Tim.
iii. 17.

Ver. 15.

Acts x. 11,
12, 13.

*Mikra,
Lectio.*

there are luminaries and stars obvious to all eyes, that diffuse beams sufficient to light us in most ways; and as I, that, with modern astronomers, by an excellent telescope, have beheld perhaps near a hundred stars in the *Pleades*, where common eyes see but six; and have often discerned in the milky-way, and other pale parts of the firmament, numberless little stars generally unseen, receive yet from heaven no more light useful to travel by, than other men enjoy: so there are certain grand principles and maxims in the ethicks, which both are generally conspicuous, and generally afford men much light and much direction; but the numerous little notions, (admit them truths) suggested by scholarship to ethical writers, and by them to us, though the speculation be not unpleasant, afford us very little peculiar light to guide our actions by. When I remember those ancient heroes, that have ennobled secular, and are ennobled by sacred story, and whose examples suggested the precepts of virtue, before there were any written ones to conform to; I am tempted to say, that virtue was scarce ever better practised, than whilst men had not yet talked of the definition of it: (as many an alchymist begs with rare notions of the nature of gold, which fills the coffers of merchants, that never saw mine nor furnace.) The grand precepts of morality are fruitful seeds, which, industriously cultivated, will bring forth fruits still affording other seeds. And as for the motives to pious, and dissuasions from sinful practices, though out of the many voluminous books of morality, there may be divers collected, not extant in the bible; yet may a dextrous reader find in that heavenly book many more invitations to virtue, and determents from vice, than most men are aware of; and some of them of an importance, that renders one of them as much more considerable than many ordinary ones, as one fair pearl out of a jeweller's shop out-values a score of those little pearls, that druggists sell by the ounce, or doth comprize many inferior inducements, (which wise men judge not of by tale, but value) as a piece doth twenty shillings. And though human authors do often in their parenetical treatises allow themselves to be lavish in ornaments, to expatiate into amplifications, and to drain common-places; yet whilst they want an intimate admission, all these are too often unable to reform, I say not those that read them, but even those that write them: whereas the experience of the primitive and heroical ages of the church does gloriously manifest, that the inducements and dissuaves held forth in the bible, though destitute of those embellishments and advantages, where they are conscientiously entertained, and seriously pondered, are sufficient to raise virtue to a pitch philosophy durst scarcely aim at. Nor indeed is the number great of pertinent and rational incitements, or determents, relating to virtue; and in discourses, that have them for theme, how far soever the bows may extend, yet generally the knot lies in a little compass: and the analyser, that shall crack many of those composures, having sever'd the shells, shall find their kernels

to be much alike. What this writer compares to one thing, that writer likens to another; those ungrateful persons to God, that one resembles to swine, who eat the acorns without ever looking up to the tree they fall from; another compares to cattle, that drink of the streams, without considering what fountain they flow from; these but present us several dresses of virtue and vice, where though the novelty and variety of habit serve to engage attention in all, and want not influence (at least) upon easy and flexible natures, yet in considerate and discerning persons, they alter not much the notion, under which the qualities themselves are entertained. Nor will such be apt to quarrel with the author of the scripture; because the motives and dissuaves extant there are many of them old and known, or frequently repeated; the efficacy of them being so too. Were it not strange, a physician should decline exhibiting of mithridate, because it was a known medicine, and famous for its cures many ages since? Doth bread less nourish us, or is it less used, because it was (as men suppose) contemporary to *Adam*, and the most common food of all nations in all ages? And (as to the repetition of the same allegation and inducements, as often as men's condition returned to need them) the paucity of ponderous considerations in the ethicks often necessitating either (disguised perhaps, yet) repetitions of the same, or the substitution of those, that must be much inferior to be new; such persons as little admire, that reiterated employment of the same truths, as they would to see a soldier use a sword, though he, and legions many ages before him, have constantly made most use of that weapon; or a general encourage his engaging soldiers by representing to them honour, duty, spoil, necessity, and those other known topicks used by himself at the head of his army, as often as he had occasion to lead it on to fight. To all this I am invited by this occasion to subjoin, that upon the score of God's being both an omniscient spirit and the supreme law-giver to the whole creation, the same truths, counsels, exhortations, dissuaves, &c. oftentimes have, and always ought to have, another-guests efficacy and prevalence on a Christian reader, when he finds them in the scripture, than if he should meet with the same in the books of heathen moralists, though learned and eloquent. And certainly, those, that with such reverence read the writings of those great wits of antiquity, that have made the greatest discoveries of truth, because they believe them to have been endowed with very illuminated intellects, ought to pay them, and a book published by an omniscient enditer, a reverence somewhat proportionate to the disparity of their authors, since men (as *Elibu* speaks in *Job*) are but of yesterday, and know little or nothing. A wary person reads the wisest authors, with a reflection, that they may deceive him by being themselves deceived; and undergoes a double labour, the one in investigating the meaning, and the other in examining the truth of what they deliver: but in the bible, we are eased of the

the latter of these troubles; for if we find the sense of a text of scripture, we cannot miss a truth, being never deceived by that book, but when we deceive our selves by presuming we understand it, when indeed we do not. I am otherwise affected to find the vanity of the world proclaimed and depreciated by him, that enjoyed all the delights and glories of it, than when I meet with the same truth from some beggarly Cynick, that never was admitted to taste those luscious and bewitching pleasures, and needs no great philosophy to despise a world, he judges of by the scant share the narrowness of his condition allows him of the joys of it, and of which (consequently) his criminations should as little move, as a blindman's of a black-moor; whom though he may (perchance) truly style ugly, yet he were of a somewhat easy faith, that should think her so, barely upon the testimony of so incompetent a witness. Thus when God himself is pleased to reveal, what is vice or virtue, sublime or despicable, truth or falsehood, happiness or misery, I have another-guise acquiescence in his decisions, than in the same met with in an human author, who having necessarily frailties and passions, is both obnoxious to mistake, and capable to deceive. And therefore it is no wonder, that the slighting of God's dictates should receive an aggravation upon the score of their being his; as our Saviour gave the precedency of the Ninivites converted by *Jonah* to them, that repented not at his preaching, because he was a greater than *Jonah*. And therefore, though I have formerly been no very negligent peruser of books of morality; yet knowing, that they have a power but to persuade, not to command, and that the penalties of sin or death are not inseparably annexed to the disobedience of their prescriptions, I confess, I often find my self but faintly wrought on by them. For I must acknowledge, that frequently assuming the liberty of questioning the reasonableness of what human writers, (whether philosophers or fathers) are pleased to impose upon us; I find those specious and boasted allegations, the apothegms of the sages, the placits of the philosophers, the examples of eminent persons, the pretty similies, quaint allegories, and quick sentences of fine wits; I find all these topicks I say, such two-edged weapons, that they are as well applicable to the service of falsehood, as of truth, and may by ready wits be brought equally to countenance contrary assertions. And really, most moralists, except in those few duties, that nature herself hath fore-taught us, to a man, whose restless curiosity leads his enquiries to all times and nations, will appear little other than fencers with wit, (I mean those that have any;) for each of these popular topicks is such an unsolid or uncertain foundation, that one man can build a little on it, that an equally able antagonist may not with as specious probability overthrow; and I fear, most of us have but too often found our corruptions sophisters enough to elude any such thing, that pressed that as a duty, which they had no mind we should perform. But when I find any thing

Mat. xiii.
42.

enjoined in the scripture, my consciousness to its being imposed by that *father of spirits*,^{9.} Heb. xii. (who has both right to enact laws, which must be therefore just, because he enacts them, and power to punish the transgression of them, with no less than eternal death;) I then leave roving, and see where to cast anchor. I think it my part without disputing them to obey his orders, and acquiesce more in that imperious *ὁ θεὸς ἔφη*, *Thus saith the Lord*, than in a whole dialogue of *Plato*, or an epistle of *Seneca*. I therefore love to build my ethicks (as well as my creed) upon the rock, and esteeming nothing but the true, proper, and strict sense of the scripture, (and what is convincingly deducible from it) to be indispensably obligatory, either as (in matters of mere revelation) to faith or practice; it is no wonder, if I study God's will most in that book, wherein alone I think it revealed; and, truly, finding in my self no motive more justly prevalent to obedience, than his right to exact it that requires it, few men are more ready than I, in distinguishing what indeed God says from what man would make him say. And if I allow my self such liberty to discern the text from the gloss, in the writings of our vulgar interpreters, (of most of whose comments, for reasons prosecuted into another paper, I am no great idolater) and even of the fathers of the church; I hope I shall not need to tell *Theophilus*, that in all other moralists I like the freedom to like or disapprove, as upon examination my impartiallest reason relishes them, or that I frequently fear their harangues will hardly pass for demonstrations, with those wary testers, that like not to be cheated, so much as into virtue, but chuse to act as rational or Christians, as well in relation to the inducements, as to the nature of what they do.

AMONGST the thirteen articles of the Jewish creed, one acknowledges the very expressions of the law (or pentateuch) to have been inspired by God. That saying of the Rabbins is not altogether so hyperbolic, as a perfunctory reader would imagine, that upon each title of the law whole mountains (of doctrine) hang. I shall not mention, as any proof of this, the strange mysteries they fancy in the strange accenting of the ten commandments in the original, since their soberer doctors have in free discourse confessed to me, that it is as much a riddle to them as us. Nor shall I insist upon the Jews reducing the whole law to 613 precepts, affirmative and negative, according to the number of the letters of the decalogue; thereby insinuating, that all the laws, that regulate man's duty, are virtually or reductively comprized there. Although this Rabbinical notion, (not to call it whimsy,) be in such request among them, and so known to those, that are any thing conversant in Jewish authors, that I have sometimes suspected, that the conceit entertained by so many Christian divines, that all the precepts, that relate to any part of the whole duty of man, are but just consequences deducible from the decalogue, had its rise thence. But I shall not, as I said, ground my opinion of the pregnant instructive-

instructiveness of the scripture, upon such questionable, not to say altogether proof-les, conceits. That which may better persuade a considering man, is, that besides those more resplendent and obvious truths, wherewith the scriptures do evidently abound, there are many instructions exhibited, many truths asserted, many errors confuted, and many mysteries hinted, in the very expressions of holy writ, to an inquisitive and concerned peruser, which a heedless vulgar reader is not wont to take notice of. God, who in the scripture is said to *cover himself with light as with a garment*, justifies that expression in the scripture, where (as the first words, that he is recorded to have ever spoken, were *אור יהי אור* Yehi-or, *Let there be light*) the very words and phrases, that cloath the sense, are not alone emphatical, but oftentimes mysterious. The Apostle assures us, *whatsoever things were written, even in the old testament, were written for our learning*; but yet, besides those many particular sentences of the bible, that are not destitute of instructions, there are some so pregnant with them, that we may easily find this difference betwixt them and human writings, that those first mentioned contain more matter than words, and the other more words than matter. Nay, many of the very flowers of rhetorick growing there have (like the marygold, that in hot countries points at the sun) a virtue of hinting the usefulest and the sublimest truths; the bible being in this like the tree of life, (flourishing in the *New Jerusalem*) which not only afforded seasonable fruit, but of which the very *leaves were for the healing of the nations*. As for those, who have in this and the last age made bold to depreciate the old testament, by pretending, that to Christians the view is sufficient; I am at present apt to think, that the doctrine of the gospel, together with the light of nature, (which it excludes not) but rather supposes, contains all those duties, which are absolutely necessary to be perform'd by all Christians, in order to salvation. And that consequently, many divines, both Catholics and Reformed, do inconsiderately enough press many things enacted in the old testament, as laws properly so call'd, which are not now, upon the score of their being there enacted, obligatory to us Christians, nor perhaps ever were to any, but the Jews, and some kind of Jewish profelytes. But I think withal, that though it be hard to shew, that any thing is a necessary duty to Christians, in the sense above declared, if it cannot be shewn to be so, either by the new testament, or the light of nature: yet not only there are many particulars relating to such duties, of which the old testament may excellently assist us to give ourselves a more distinct and explicite instruction, than is easy to be collected from the new; but of the mysteries of our religion, there are many things deliver'd more expressly, or more fully, in some passages of the old testament, than in any of the gospel, as I could easily evidence, if I thought it requisite. So that the use of it is very great, as to the *credenda* in divinity, though not perhaps absolutely necessary as to

V O L. II.

the *agenda*. But I consider further, that both the matters and the expressions made use of in the old testament are so very frequently, and, almost upon all occasions, related to in the new, (as if the wisdom of God were like rivers and seas, that affect to flow in the same channels themselves had made before) that there is scarce a page of the latter, to the better understanding of which the study of the former is not either absolutely necessary, or at least highly useful. Should God be pleased to instruct us, as he did *Jonas*, by the shadow of a weed, it were our duty to acquiesce: how much more then, when he vouchsafes to speak to us in almost as glorious a manner as he did to *Moses*; in a scripture, that hath such resemblances to the sanctuary, which contained the law of God, exhibited the mercy-seat, (the type of Christ) and wherein the two golden cherubims, like the two precious and harmonious testaments, looked towards one another, and both towards that mercy-seat, that typified the Messias? We should therefore, not only with acquiescence, but gratitude, look upon God's having appointed the scripture to be the light, in which his spirit regularly shines upon his church; since the luminary is as well refulgent, as the choice of it his, whose blessing can prosper any means of grace, as without his blessing no means of grace can prosper.

AND, *Theophilus*, since among those, that are so far mistaken, as to postpone the study of the bible to that of some applauded books of morality and devotion, there are not wanting divers persons, otherwise eminently religious; I hope you will easily excuse me, if, for fear their example should prove a temptation to you, and add to the discouragements you must expect from the darkness of some texts, and the opposition, that will be given you, especially at first, by the grand enemy to the author and design of the scripture; I venture to superadd to all that I have said already, concerning these mens practice, that it is not only a commendable, but a much more improving custom, than it is by many thought, to read daily and orderly some set portion or chapters of the bible; and, not to desist from that practice, though (as *Naaman* dipped himself six times in *Jordan*, without being cured) we should not perceive a sudden and sensible benefit accruing from it. For in diseases (bodily or spiritual) though the mouth be out of taste, and cannot relish what is taken in, yet wholesome aliments must be eaten, and do effectively nourish and strenghten, though they be then insipid, (perhaps bitter) to the distempered palate. We must, with the eunuch, read divers texts we understand not, when we read them; and though, at first, we be not able to penetrate the senses of some portions of God's word, we must at least make our faculties as hospitable to it as we can; and make our memories admit, and embrace it, till our understandings be grown up to do the like: it becoming the disciples of our Saviour, herein to imitate his holy mother, of whom it is written, that *they* (the blessed virgin and her husband) *understood not the sayings, which he*

H h

Speake unto them, ————— but his mother
 kept all these sayings in her heart; and to
 think it may very well be, that, as our Sa-
 viour said to Peter, *What I do, thou knowest
 not now, but thou shalt know hereafter*: so,
 by the welcome he disposes you to give his
 word into your memory, he says to you, *What I
 say, thou knowest not now; but thou shalt know
 hereafter*: and the apostle's motive to hospita-
 lity, *Be not forgetful to entertain strangers,
 for thereby some have entertained angels un-
 awares*, will, without being overstretched, take
 in the texts of scripture we are unacquainted
 with. For we may easily in them, entertain
 with Abraham and Lot, greater guests than we
 are aware of; and who, when their true con-
 dition appears, may recompence our entertain-
 ment of them, by showering blessings on us,
 and rescuing us from the company and destiny
 of the wicked. And sure, if the Pagans laid
 up, with awful reverence, those dark and
 squinting oracles, that came (at least many of
 them) from the prince of darkness, and father
 of lyes; we should blush to refuse attentive
 perusals, and lodging in our memories, to
 those *λόγια ζῶντα*, those *lively oracles*, those
λόγια τῷ Θεῷ, *oracles of God*, who is the father
 of lights, and an essential truth that cannot
 lye. And the most ænigmatical texts we meet
 with, which seem meant purposely to pose us,
 we may make useful admonitors of our weak-
 nesses, and take for welcome opportunities,
 to evince how great a reverence we pay God's
 word, upon the single score of its being so.
 Nor let those disturbances, with which the
 devil seldom fails to obstruct or discourage our
 first progress in a study so ruinous to his mali-
 cious ends upon us, deter us; for these are
 commonly but the throws and strugglings of
 Christ new-formed in us; or else like those
 horrid fits and outcries, which preceded the e-
 jection of that unclean spirit mentioned in the
 first of *Mark*; such parting ceremonies being
 not unusual to the dislodging devil; who when
 he finds himself upon the point of being ex-
 pelled, *hath great wrath, because he knoweth
 he hath but a short time. And though the God
 of peace, however he will bruise Satan under
 your feet shortly*, should for a while try us even
 with desertion in the study of the scripture;
 let us not, for all that desert so improving a
 study, but resolutely persevere in the constant
 and faithful use of the means of grace: as the
 moon, when she suffers an eclipse, forsakes not
 her orb or motion, but, by continuing her un-
 retarded course, regains the irradiations she
 was deprived of. We find the word of God
 compared to seed, (that deathless seed, by
 which Saint Peter saith, we are *born again*)
 and that, we know, may seem, for a long time,
 as well dead as buried in the ground, and yet
 afterwards spring and grow up into a plentiful
 harvest. Nor must our proficiency any more
 dispense with us from the being conversant
 with the scripture, than our frailties: *I will
 never, (saith the Psalmist) forget thy precepts,
 for with them thou hast quickened me.* And in-
 deed, the word of God is not to be used like
 active physick, taken once, that it may not be
 taken again; but 'tis compared to food, which
 indeed it is, of the soul; in which sense it may
 be literally enough said, *That man liveth not
 by bread alone, but by every word that proceedeth
 out of the mouth of God.* Now as our having
 fed never so well and heartily on excellent and
 nutritive meats yesterday, will not keep us
 from needing to eat again to-day, or to-morrow,
 and so daily, as long as we continue in these
 ruinous cottages of clay; so in spiritual refec-
 tions with full, without repeated meals, the
 soul will scarcely thrive. And as, generally,
 the more healthy and lusty men are, the fre-
 quenter and stronger appetites they have; so
 the best Christians, and (witness David) the
 greatest proficient in scripture-knowledge, have
 the keenest stomachs to this food of souls; and
 the vigorousst piety, by a desuetude and neg-
 lect of it, is subject to faint and pine away. Nor
 have we just cause to repine at an engage-
 ment to assiduity in the scriptures; for there
 are not near so many things, that will require,
 as there are that will deserve and recompence
 a serious study in a book, where both the strict
 sense and the circumstances, and expressions
 that cloath it, are richly instructive: like that
 aromatical fruit, of which, not only the ker-
 nel is a nutmeg, but the very involving skin
 is mace. This inexhausted fulness occasioned
 that panegyric precept of the Rabbies concern-
 ing the law; *הפוך כה יהפוך כה ארי כולי כה*
*Turn it over, and again turn it over, for all is
 in it: concurrently to which, the Jew, that
 translates the Arabian apothegms into Hebrew,
 thus pronounces; There proceedeth not a true
 sentence out of the mouths of this world's wise
 men, that is not intimated in our law.*

The usefulness of divers texts is such, that
 we should not only have them in our possession,
 but in a readiness; and as David, distressed by
 his mortal enemies, took Goliath's sword from
 near the ephod, to wear it whithersoever he
 went; so Christians, persecuted by ghostly ene-
 mies, should be diligent, not only to have an
 armory well furnished with spiritual weapons,
 but to wear this *sword of the spirit* always
 by their sides, to ward and thrust with, upon
 all occasions; without needing to depend
 upon any such thing as concordances, which
 often cannot be come by, and oftner, not
 soon enough to keep us from being foiled by
 the father, or the champion of lyes. But now,
 to engage us to grow ready scripturists, it is
 not only true, that as the texts of the bible
 interchange light with one another, and every
 new degree of scripture-knowledge is not
 only an acquit of so much, but an instrument
 to acquire more; so is that book a theme so
 comprehensive and so fertile, that the last hour
 of a Christian's longest and industriousest life
 will still leave undiscovered mysteries in it:
 this, I say, is not only true, but it is also true,
 that the doctrines of it are of that importance,
 and find that opposition in our depraved na-
 ture, that even those truths, that require but
 few perusals to be understood, require many
 to be duly impressed; our preposterously
 partial memories, being rarely like quick-
 silver, wherein nothing will sink but (that
 pre-

pretiouslest of metals) gold; for that alone is heavier than the mercury. *The word of Christ* must not be as a passenger, or sparingly entertained in our minds, but must dwell there, and that richly: and the word, which St. *James* pronounces *able to save our souls*, he describes as a graff, which must not only be closely embraced by that, wherein it is to fructify, but must continue there, to bring the stock and graff to (if I may so speak) congregate. And indeed we are so indisposed to admit, and so obnoxious to deface, religious impressions, that we need, during our whole life, be conversant with the precepts of leading it piously.—But it is scarce more faulty in, than incident to, the froward nature of man, to be ever quarrelling with God's method of prosecuting his intentions; and, (as if he were wiser than his Maker) to criminate his conduct in his dispensations. Even that excellent person, the gloriouslest of virgins, and of mothers, whom all ages must deservedly call *Blessed*, incurred her divine son's reprehension, for an intimated offer to alter his purposed method in disclosing himself. But God is too just to himself, and too merciful to us, to degrade (as it were) his omniscience so far, as to suffer himself to be swayed against the dictates of it, by such purblind and perverse tutors as we; his goodness concerns him too much in our instruction, to suffer him to let our fancies indite his word. To attain his own ends, he makes choice of his own means and instruments, without needing our purblind eyes in the election; and what with unfathomable wisdom he hath been pleased to contrive for man's instruction with a gracious, though often mis-understood constancy, he persists in. He knows, that many, who are disposed to cavil at the present contrivance or style of scripture, would be apt to take exceptions at any other: for some thing or other it must necessarily be; and the unimaginable diversity of humours, judgments and prepossessions is such, that as these now say, why thus, and not so? others would, in case of alteration, be as ready to ask, why so, and not thus? It is questionable, whether the Israelites were greater murmurers at *Pharoah* in *Egypt*, or at *Moses* in the desert: and the children complained of by their companions in the market-place have had either posterity or predecessors in all ages; which have been still of the disposition of those Jews, who imputed the more than prophets rigidity of virtue to the great enemy of that lovely quality; and the greater than *Solomon's* condescensions to the vices he designed them to destroy. But the great physician of mankind is too compassionate and wise, to let his distracted patients prescribe their own course of physick, or, to decline our fond and peevish cavils, shuffle or discompose those mysterious and profound contrivances; whose wisdom engages the attention, and exacts the wonders of those heavenly unclogged spirits, that are scarce more advantaged over us by their native abilities, than by the means they have of improving them. And therefore, our Saviour refused to descend from the cross, though they,

whose malice served to fix them there, (the Mat. chief priests and scribes themselves) declared, that on those terms they would believe on him. And though we are (but too) apt to fancy, that we should be won to our duty, if it were taught or pressed in such or such a way; yet we may be pleased to remember, that it was one in hell, that would needs have another means than the scripture, of having sinners preached to; and one in heaven, that referring them to the scripture, declared, *That if men heard not Moses and the prophets, neither would they be persuaded, though one rose from the dead, to preach to them.*

If I address what I write, not to so intelligent a person as *Theophilus*, but to promiscuous readers, I should add, to what I have said of the several exceptions against the scripture, a cordial advice to all, whose parts and leisure give them not a just hope of being able solidly to vindicate it either to themselves or others, to decline as much as they discreetly can, the listening to objectors or objections, of what sort, or under what disguise soever, against that heavenly book; especially, if proposed by plausible and insinuating wits. For it not being necessary, (nor indeed possible) for every private Christian, to know the opinions and reasons of all dissenters about the scripture, (no more than for every traveller to be a geographer;) nor requisite to the knowledge of the way to heaven, to know all those, in which they that miss it, wander; (as to learn the way from *Dover* to *London*, I need not learn those that lead not thither;) it is not prudent to run a very probable hazard of disquieting one's faith, and a not improbable one of subverting it, only to gratify a needless curiosity; an itch, which we are delighted to have scattered, but which is exasperated by being so. And frequently, though your design seem innocent, (as only to hear without believing, and please your self with something of wit and novelty;) yet those conversations rarely enough prove harmless; and (as too frequent and sad experience proclaims) generally either abate a degree of your faith, or qualify some ardor of your love, or lessen your reverence for that matchless book, or put some strange and disquieting scruples into your thoughts, which it is much easier to confute than to silence. Wherefore, as in infectious times, when the plague reigns, physicians use more strictly to forbid the smaller excesses and inordinancies of diet, and the use of meats of ill digestion, or apt to breed any distemper; because every petty fever becomes, through the malignity of the air, apt to turn into the plague: so now, that anti-scripturism grows so rife, and spreads so fast, I hope it will not appear unseasonable to advise those, that tender the safety and serenity of their faith, to be more than ordinarily shy of being too venturous of any books, or company, that may derogate from their veneration of the scripture; because by the predominant and contagious profaneness of the times, the least injurious opinions harboured of it, are prone to degenerate into irreligion. But I fear, you'll think I preach.

The

Luke i. 48. call *Blessed*, incurred her divine son's reprehension, for an intimated offer to alter his purposed method in disclosing himself. But God is too just to himself, and too merciful to us, to degrade (as it were) his omniscience so far, as to suffer himself to be swayed against the dictates of it, by such purblind and perverse tutors as we; his goodness concerns him too much in our instruction, to suffer him to let our fancies indite his word. To attain his own ends, he makes choice of his own means and instruments, without needing our purblind eyes in the election; and what with unfathomable wisdom he hath been pleased to contrive for man's instruction with a gracious, though often mis-understood constancy, he persists in. He knows, that many, who are disposed to cavil at the present contrivance or style of scripture, would be apt to take exceptions at any other: for some thing or other it must necessarily be; and the unimaginable diversity of humours, judgments and prepossessions is such, that as these now say, why thus, and not so? others would, in case of alteration, be as ready to ask, why so, and not thus? It is questionable, whether the Israelites were greater murmurers at *Pharoah* in *Egypt*, or at *Moses* in the desert: and the children complained of by their companions in the market-place have had either posterity or predecessors in all ages; which have been still of the disposition of those Jews, who imputed the more than prophets rigidity of virtue to the great enemy of that lovely quality; and the greater than *Solomon's* condescensions to the vices he designed them to destroy. But the great physician of mankind is too compassionate and wise, to let his distracted patients prescribe their own course of physick, or, to decline our fond and peevish cavils, shuffle or discompose those mysterious and profound contrivances; whose wisdom engages the attention, and exacts the wonders of those heavenly unclogged spirits, that are scarce more advantaged over us by their native abilities, than by the means they have of improving them. And therefore, our Saviour refused to descend from the cross, though they,

Mat. xi. 16, 17, 18, 19.

1 Pet. i. 12.

The eighth and last OBJECTION.

AND NOW, *Theophilus*, 'I am arrived at that part of this discourse, wherein it will be fit to examine the grand objection against the style of the scripture, which, though a philosopher would not look upon it as the most considerable, is yet most urged by many of its witty adversaries; especially such as are wont to exercise and gratify their fancy more than their reason: the objection itself is this: 'That the scripture is so unadorned with flowers of rhetoric, and so destitute of eloquence, that it is flat, and proves commonly inefficacious upon intelligent readers. Inasmuch that divers great wits and great persons, especially statesmen, do either despise it, or neglect to study it.' And truly, the story is famous of that cardinal, (who flourished in the last age) that said, that once indeed he had read the bible, but if he were to do so again, it would lose him all his Latinity. And amongst those great orators, (as they thought themselves) who lived in the same age and country that he did, the complaint was ordinary, that the reading of the bible untaught them to the purity of the Roman language, and corrupted their Ciceronian style. And I remember no obscure prince, (though he shall here be nameless, because for other qualities I honour him) in no obscure company, disputed with me one day an opinion about the style of the scripture, to which the cardinal's scorn was a compliment. I wish these saucy expressions were but outlandish, and could not cross those seas, that environ *England*; (which is not so happily sever'd from the world's vices, as from its continent,) this profane judging so boldly that book, men shall be judged by, being, if not a native, yet at least a free denizen of *England*. For not only it was one, that I am sorry I can call our countryman, who is recorded to have solemnly preferred one of the odes of *Pindarus*, before all the psalms of *David*; but I could easily add divers resembling instances, that I have myself been troubled to meet with, were it not that I somewhat doubt, whether this kind of profane sayings be not as well fitter as worthier to be forgotten than remembered, and to be suppressed than divulged: for (not to mention, that the recording of such enormities puts an ill compliment upon mankind) the satisfaction some men's curiosities receive by such relations, will scarce account for the temptation it gives others to imitate what they find some have dared. For there are some sins, whose grand deterring is a kind of persuasion, that they are too horrid to have been committed; and some wise legislators thought it better against certain crimes, to use the silence of the laws, than their threats. I shall therefore, without any further mention of scandalous particularities, take it for granted, that there have been, and are but too many witty disrespecters of the scripture. But as for the accusation itself, which they are alledged to countenance, many defences might be here made against it,

if divers considerations pertinent to that purpose, among others, did not belong to some of those ensuing parts of my discourse, wherein it is not the style of the scripture, but other themes, that are principally and directly treated of. Yet that you may be assisted to refer hither such parts of the following discourse, as are applicable to the matter under consideration, I shall here take notice to you, that my answers to the objection above proposed may for the most part be reduced to these five heads of argument.

FIRST, That as to divers parts of the scripture, it was not requisite, that they should be adorned with rhetorical embellishments.

NEXT, That the bible seems to have much less eloquence than indeed it has, to those that read it only in translations, especially the vulgar Latin version.

THIRDLY, That by reason of the differing notions several sorts of men, especially of distant nations and climates, have of eloquence; many passages, that are thought uneloquent by us, may appear excellently expressed to another part of mankind.

FOURTHLY, That there are in the scripture a multitude of those texts, wherein the author thought fit to employ the ornaments of language, conspicuously adorned with such as agree even with our notions of eloquence.

AND lastly, That it is very far from being consonant to experience, that the style of the scripture does make it unoperative upon the generality of its readers, if they be not faultily indisposed to receive impressions from it.

As to the first of these, having already above declared, that there are many parts of scripture, wherein it would have been improper to affect eloquence; I am willing to suppose, that you have not yet forgot what has been formerly said; and therefore, I am unwilling to detain you on this first consideration. Yet I cannot but on this occasion take notice to you, that we allow all sorts of people expressions proper and fitted to their several professions and themes. How many of us can dwell on lawyers, physicians, and chymists books; though oftentimes written in terms as harsh and as uncourtly, as if those rudenesses were their design? And yet we can neglect and scorn the scripture, because in some passages we there find the mysteries, and other matters of religion, delivered in a proper and theological style. I remember *Machiavel*, in the dedication of his famous *Prince*, after he had (not causelessly) acknowledged to *Lorenzo de Medici*, (to whom this book is addressed) that he had not stuffed it with lofty language, or big words, nor adorned it with any of those inveigling outward ornaments, usual to other authors in their writings; gives this account of the plainness of his style, [*Perche io ho voluto, o chè veruna cosa la honori (la mia opera) o che solamente la verità della materia, & la gravità del soggetto la faccia grata*] that he thought fit, either that nothing at all should recommend his work, or that only the truth of the discourse and the dignity of the subject should make it acceptable, and exact its welcome. If a mere states-

man,

man, writing to a prince, upon a mere civil theme, could reasonably talk thus; with how much more reason may God expect a welcoming entertainment for the least adorned parts of a book, of which the truth is a direct emanation from the essential and supreme Truth, and of which the contents concern no less than man's eternal happiness or misery? And if our nice Italian criticks themselves cannot, by the plainness of *Machiavel's* style, nor the forbidding of his writings by the inquisition, be deterred from as assiduous as prohibited a study of his books; what excuse will they one day have, that now make the unaffected style of scripture the sole excuse of their despising, (or at least neglecting) that divine book?

The second answer to the eighth objection.

SECONDLY, As to the disadvantage the scripture receives by its not being read by those I now reason with, in its originals; though I have said something to it already, yet I must now resume it into consideration, and represent, that it is no wonder they reverence not the bible's style, as they ought, whilst they judge of that of an Hebrew book by their vulgar translation; which (though sometimes causelessly enough censured by divers protestant divines, that would find it no easy task to make a better, yet) certainly is in many places strangely harsh and barbarous; and by a partial and unlucky affectation of literality, misseeth the propriety both of the Hebrew speech, and of the Latin. And to adhere to the original words commonly injures its eloquence, and oftentimes sense; rendering excellent expressions in such ungraceful ones, as would probably fright readers from it, if it could not very well spare fine language. So that to our present theme we may not ill apply that notable saying of *Mirandula*; *Hebræi bibunt fontes, Græci rivus, Latini paludes.* The old French rhiming translation of *Virgil* makes not the *Æneids* much more eloquent than *Hopkins* and *Sternbold* have made the psalms: which sure being written by a person, who (setting aside his inspiration) was both a traveller, a courtier, and a poet, must at least be allowed to contain polished and fashionable expressions in their own language, how coarsely soever they have been mis-rendered in ours. What opinion the eastern world hath of the sweet-finger of *Israel*, may appear, both by other hyperbolical fictions they believe of him, (whom, with *Moses*, *Jesus* and *Mahomet*, they reckon amongst the four great prophets) and by what *Kessæus*, (the famed Mahometan writer of the lives of the fathers) relates concerning him; *That when David sang the praises of God, the hills, and birds, and beasts therein accompanied him.* Which gross literal interpretation of figurative expressions in the psalms, and of his pathetic invitations to the inanimate creatures to join with him in celebrating their common Creator, he seems to have borrowed from the Alcoran it self; where *Mahomet* brings God in saying, 'We reduced the mountains to comply with him, who should join with him in praises morning and evening; the birds also flock to him; and these are obsequious to him.' And though the new testament be not written in Hebrew,

yet its writers being Hebrews have chiefly conformed themselves to the style of the translators of the old testament, (which whether or no it constitute what criticks of late so dispute of under the name of *Lingua*, or *Dialectus Hellenistica*, I pretend not to define) and that of the apocryphal authors and other Jews writing in the same language; who (except perhaps *Josephus* and *Philo*) wrote rather, if I may so speak, an Hebrew than an Attick Greek; or at least, in a dialect, which (by reason of their frequent references to the septuagint's version,) abounds, if not with Hebraisms, with expressions obvious in Hebrew writings, and unfrequent in Greek ones, and so relishes much of the Hebraick style: of which, as well in the new as the old testament, those we reason with, being strangers to that primitive tongue, must be incompetent judges; there being in the idiotisms of all languages peculiar graces, which (like those most subtil spirits, which exhale in pouring essences out of one vessel into another) are lost in most (especially if literal) translations; and the holy tongue being that, which God himself made choice of to dignify with his expressions, having divers whose penetrancy is as little transfusable into any other as the sun's dazzling brightness, or the water of a diamond can be undetractingly painted; and having divers words and phrases, whose pithiness and copiousness none in derived (or other) languages can match. Some of the Hebrew conjugations, as those called *Hipbil* and *Hitpaël*, give significations to verbs, which the want of answerable conjugations in western languages makes us unable to fill or equal without paraphrases, which are very rarely so comprehensive as the original words. And (to hint this upon the by) the ignorance, or not considering of this one grammatical truth, hath kept men from fully understanding divers passages of the new testament, wherein the Greek tongue's want of those conjugations hath made active, or intransitive verbs, be used in a transitive or reciprocal signification. How impertinently men's ignorance of its originals may make them censure the scripture, I had once occasion to take notice of, by finding a famous commentator accusing *St. Paul* of impropriety of speech, in the beginning of that, which is commonly thought to be his first epistle to the Thessalonians, but by the learned *Grotius* (in his paradoxes *De Antichristo*.) not improbably esteemed to be his second: for whereas instead of the Greek words ἀφ' ἑμῶν 2 Thef. i. ἐξήχηται ὁ λόγος τοῦ κυρίου, which our have rightly Englished, *from you sounded out the word*; he found in his translation, *a vobis diffamatus est sermo*; not knowing *Paul* to have written in Greek, he would needs correct him, for having written *Diffamatus est* instead of *Divulgatus est*.

Kessæus, pag. 99. See Psal. cxiv. 4. Psal. xix.

Surat. 3. Vide H. Hotting. 62. and 63.

THIRDLY, we may yet further consider, that as to many passages of scripture, accused of not appearing eloquent to *European* judges, it might be justly represented, that the eastern eloquence differs widely from the western. In those purer climates, where learning, that is here but a denizon, was a native, the most cherished

cherished and admired composures of their wits, if judged by western rules of oratory, will be judged destitute of it. Their dark and involved sentences; their figurative and parabolical discourses; their abrupt and maimed way of expressing themselves, which often leaves much place to guesses at the sense; and their neglect of connecting transitions, which often leaves us at a loss for the method and coherency of what they write; are qualities, that our rhetoricians do not more generally dislike, than their practice; yet being perhaps little less disparity in our opinions than in our ways of writing; for their pens, (as if it were a presage of the different changes the Jews and Greeks have made in point of religion) move from the right hand towards the left; ours (therein imitated by those of the Ethiopians) from the left towards the right; so that we think they write backwards, and they, that we do. Of this difference of the notions, that the eastern and western colonies of the sons of *Adam* have harboured concerning eloquence, I shall need to mention but one instance, that one is so remarkable; and that is the Alkoran. How much the Mahometan world boasts the eloquence of that book, can scarce be unknown to those, that have (though but a little) busied their curiosity in that sort of inquiries. The ablest Arabian expositors, and other authors, tell us, that all the wit and art of men and dæmons would be unable to hinder that book from being matchless. *Mahomet* himself was so proud of it, that in some passages in it he defies its opposers to equal one surrat or section of it, and seems to make its peerlessness an argument of its not being barely of human authority. And the Saracens, depressed with their religion's being destitute of attesting miracles, will not scruple to reply, that though there were no other * miracle to manifest the excellency of their religion above that taught by the prophets, yet the Alkoran it self were sufficient, as being a lasting miracle that transcends all other miracles. How charming its eloquence may be in its original, I confess my self too unskilful in the Arabick tongue, to be a competent judge; my other studies and distractions having made me forget most of the little knowledge I had once acquired of that flourishing language. But though the Alkoran have stolen too much from the bible, not to contain divers excellent things, (which is one inducement to me to cite it the oftener;) yet certainly, not only the ancient Latin version of it, made by order of the abbot *Petrus Cluniacensis*, and published in the last age, by the procurement of *Bibliander*, (and of which this is the grand critick *Scaliger's* exclamation, *Deum immortalem, quam inepta est vulgaris illa, quam habemus, interpretatio!*) would scarce by our European orators be thought so much as of kin to eloquent: but the recent translations I have seen of it in French, and (as to divers of it, in) Latin, elaborated by great scholars, and accurate Arabicians, by making it very conformable to its eastern original, have

not so rendered it, but that persons, that judge of rhetorick by the rules of it current in these western parts of the world, would, instead of extolling it for the superlative, not allow it the positive degree of eloquence; would think the style as destitute of graces, as the theology of truth; and would possibly as much admire the Saracen admiration, as they do the book. And not only what I have seen of the eminent East-Indians, is strangely incongruous to our notions of eloquence; but what I have perused of the famous *Literati* (as they call the learned men) of *China*, though written with great care by the authors, and (as it seems) translated with no less by the knowing interpreters, would, to an ordinary European orator, appear rather ridiculous than eloquent. But to content ourselves with the examples we formerly selected out of the less remote parts of the East; since *Mahomet*, whose eloquence (almost as prosperous as his sword) was able to bring credit and proselytes even to such a religion as his; since *Moses*, that so celebrated legislator, bred up in the refining court, and all the famed wisdom of the Egyptians; since *Solomon*, who had such incommunicable advantages to improve himself, and whose wisdom (esteemed capable to have governed more kingdoms than his had subjects) the western world hath for so many ages admired, and the eastern only not idolized; and since the prophet *Daniel*, whose promising youth was not only cultivated by the instructions of the Chaldean sages, but enjoyed the diviner tutorage of God's spirit, and whose matchless abilities preferred him, from a captive, to be the chief as well of the Chaldean wise men, as the Median princes: since these applauded writers, I say, whom the eastern nations so much and so justly admired, by many of our Latinists are not thought good writers, because of our differing notions of eloquence; nay, if amongst Europeans themselves, *Cicero* hath found many censurers, and a book hath been published to prove, that *Tully* was not eloquent; may not we rationally enough suppose, that the Grecian and Roman style, amongst the eastern writers, may not be much better relished than theirs is amongst us; and that consequently, in those parts of the scripture, whose eloquence is not obvious to us Europeans, the pretended want of eloquence may be but a differing and eastern kind of it? Specially, if we consider, that the ancientest writers in prose, now extant amongst us, were scarce contemporary to the latest writers of the old testament; and yet that eloquence, the dress of our thoughts, like the dress of our bodies, differs not only in several regions, but in several ages. And oftentimes in that, as in attire, what was lately fashionable, is now ridiculous; and what now makes a man look like a courtier, may within these few lustres make him look like an antick: though how purely it is the mode, that makes such things appear handsome or deformed, may be readily collected from the vicissitudes observable in

Beidavi,
Ahme-
dibn, E-
dris, and
others.

Surat. x.
S. 11. and
S. 17.

J. Scaliger Epist.
362. apud
Theod.
Hackspan
in libro
cui titulus,
Fides & Leges
Mohamed.
dis. pag. 2.

* ——— *Est nihil præter solum Alkoranum (adduxisset) satis hoc foret ad eximiam excellentiam supra reliqua, quæ prophetæ adduxerunt: nam ille miraculum est, quod in secula durat præ omnibus aliis miraculis.* H. Hotting Hist. Orient. pagina circiter 360.

modes;

modes; men by intervals relapsing into obsolete fashions. That there are great changes in that mode of writing men commonly mistake for eloquence, I shall produce no less illustrious a witness than *Seneca*, who in his hundred and fourteenth epistle, (to omit other passages in his works) not only proves it at large, but shows, that in some ages, even the faulty ways of expression, conspired in by the wits of those times, have passed for eloquence. The scripture style then, though it were not eloquent now, may have excellently suited the genius of those times its several books were written in; and have been very proper for those people it was primarily designed to work upon. And if I would presume to be paradoxical in a thing I so little pretend skill in, as eloquence, I might further represent on this occasion, that rhetorick being but an organical or instrumental art, in order chiefly to persuasion, or delight, its rules ought to be estimated by their tendency, and commensurateness to its rules; and consequently, are to be conformed to by a wise-man, but so far forth as he judgeth them seasonable and proper to please or to persuade: which when he sees, he can do better by declining them, than by practising them, (as orators, like hunters, must oftentimes leave the most beaten paths, if they will not lose their game,) he should not scruple to prefer the end to the means; the scope of the artist, to what the schools are pleased to call the scope of the art; and to think it more eligible to speak powerfully, than to speak regularly. And we may hence consider, that it may be somewhat inconsiderate to judge of all eloquence, by the rules of it, that *Cicero's* admirers impose on us; and confound their systems of precepts with the art of rhetorick, as if they were equivalent, or of the same extent. For *Cicero* being reputed (and that deservedly) an eloquent man, and very successful in persuading his thus and thus qualified hearers; divers, whose modesty and despair kept them from aspiring to more than imitation, observing, that *Tully* often made use of such and such a contrivance, and such and such figurative forms of speaking, took the pains to reduce those observations into rules, which being highly applauded by their successors, and by them recruited with some resembling rules drawn from the practice of a few other orators, were afterwards compiled into an art, which as I deny not to be a great help to the imitation of *Tully* and *Demosthenes*, or those others, from whose structure and fashions of speech such institutions have been drawn, so I shall no more take it for a complete system of rhetorick, than any instructions deducible from the journals of *Solomon's* Tarshish fleets, and from the Grecian and Roman sea-voyages, for the true and entire art of navigation. For if other persons, either by an endowment or improvement of nature, can find others equally, or more happy and powerful, or moving, (though never so

A short digression concerning the art of rhetorick.

differing) ways of expressing themselves, they ought as little to be confined by the prescriptions acquiesced in before them; as *Columbus* thought himself obliged to be by the rules or practice of ancient navigators; whose methods and voyages had he not boldly ventured to vary from, and pass beyond, how vast and rich a portion of the world had his conformity left undiscovered! And on this occasion, *Theophilus*, I must mention one thing, that I have observed, which perhaps you will not think either despicable or impertinent; and it is, that though the people of *China* be esteemed the most numerous, the most flourishing, and (very few, if any, excepted) the most civilized nation in the world; though amongst them the greatest part of preferments be attainable by verbal learning; and though they have books in their language (how well written, I know not, having never read any of them) of almost all kind of liberal arts and sciences; yet I find by the late traveller in *China*, that writ the Italian history of that kingdom, and by other authors, that mention their literature, that this populous and ingenious nation, that has been so long settled in a flourishing condition, and more than any other people allows encouragements and recompences to learned men, has not cared to receive rhetorick into the number of their arts and sciences; presuming, as one may guess, that the confining men's expressions to establish rules would not be so like to enable those to express themselves eloquently, that nature has indisposed to do so, as to hinder others from expressing themselves as well, as, were they left to their full liberty, they would do. I will not say, nevertheless, that our strict Ciceronian rules are crutches, that may be helps to weak or lame fancies, but are clogs or burdens to found and active ones; but this I observe, that these Utopian laws of oratory are seldom rigorously imposed by any, that publish other books, that may be examined by them; and that wisemen, as well in the West, as in the East, will not easily lose good thoughts, or good expressions, because they are not reducible to them. And this I the rather press, because I have found but too many so blindly fervile, as to imitate without discretion or reserve in applauded authors, as well the bad as the good; create such artists errors rules of art; and make one man's particular fancies, or perhaps failings, confining laws to others; and convey them as such to their successors, who are afterwards bold to mis-name all unobsequiousness to their incogitancy, presumption: as *Seneca* * tells us of divers imperfections of style, which being familiar to some one, who at that time hath the vogue for eloquence, are upon his score copied by his imitators, and by them taught to others: as, (says he) when *Sallust* flourished, his style made maimed and abrupt sentences, words surprisingly mis-placed, and an obscure brevity pass for ornaments.

And

* — Hæc vitia unus aliquis inducit, sub quo tunc eloquentia est; ceteri imitantur, & alter alteri tradunt. Sic Sallustio vitæ, amputatæ sententiæ & verba ante expectatum cadentia, & obscura brevitatis, fuerit pro cultu. Seneca epist. 14.

And indeed, it is not uneasy for any man to observe the very weeds of cried up rhetoricians cried up for flowers of rhetorick. But having already wandered, perhaps, too far in this digression, I shall now conclude it; and though, since, it is for the scripture, and with its enemies that I am contending, I shall venture to do it, with minding our cardinal, and those that so undervalue the scripture's ways of expression, in comparison of *Tully's*, because his books do so regularly express the rules of eloquence; that it is no marvel they should find *Cicero's* writings to be so conformable to their laws of art, whilst they frame those laws of art out of his writings.

BUT, *Theophilus*, I fear I have detained you too long in a digression, whereinto I slipt but occasionally, which is not so necessary to my present argument, but that I am content you should look upon the paradox as any thing rather than an opinion or reasoning, whereon I lay any great stress.

The fourth
answer to
the eighth
objection.

IN the fourth place then let me represent to you, that there are very few, if any books in the world, that are no more voluminous, in which there is greater plenty of figurative expressions, than in the bible. Though this may seem strange, it is no more than may be made good by more than some hundreds of instances; there being few tropes or figures in rhetorick, of which numerous examples are not collectible out of the expressions of holy writ. I insist not upon this, because a bare catalogue of the rhetorical passages, I could enumerate, would too much swell an essay; and I am informed, that task hath been already prosperously undertaken by abler pens. Wherefore I shall now only say, that the eloquence of the scripture hath been highly celebrated by no small number of persons, highly celebrated for eloquence; and that many, who thought themselves as intelligent in oratory, as those that censure the scripture, have suspected their own eloquence of insufficiency worthily to extol that of the prophet *Esay*; and some of them, (amongst whom I cannot but name that excellent prince of *Mirandula*, whom even the greatest rabbi of this age styles the phoenix of his age) who after having unsatisfiedly travelled thorough all sorts of human volumes, have rested and acquiesced only in these divine ones: which will not a little recommend the scripture, since we may apply to books what an excellent poet says of mistresses;

Menasse
Ben-Israel.

Mr. Waller.
'Tis not that which first we love,
But what dying we approve,

That we express the highest value of. And indeed, the best artists making two parts of oratory; the one, which consists in the embellishments of our conceptions, and the other, that consists in the congruity of them to our design and method, and the suitable accommodation of them to the various circumstances considerable in the matter, the speaker, and the hearers; this latter is peculiarly and inimitably practised in the scripture; and as

much of the former (which is not only less considerable, but is changeable and unagreed of,) as we have newly seen, is made use of, as is requisite to the author's purposes, and to manifest, that delicacy or smoothness never ceases to be the property of his style, but because in some cases it would be incongruous to his design. And where these verbal ornaments are spared, they are not missed; for as there are some bodies so well shaped and fashioned, that any clothes become them much better than the most fine and graceful would do ordinary (much more crooked or mis-shapen) persons; so there are writings, whose matter and structure are such, that the plainest language can scarce mis-become them so, as to hinder them from eclipsing a trifling or ill-matched subject with the sprucest and gaudiest expressions, that can be lavished on it. But the truth is, that this florid eloquence is great in many texts; where it is not at all conspicuous, being hidden in the matter; (as in roses of diamonds, the jewels oftentimes keep us from minding the flower and the enamel;) and appears not great, but because it is not the greatest. Some famous writers have challenged *Demosthenes* and *Cicero* to compare with the prophet *Esay*; in whom they have not only admired that lofty strain, which artists have termed the sublime character, but even that harmonious disposition and sound of words, (I mean in their original) which the French prettily call, *la cadence des periodes*.

WHEREFORE, *Theophilus*, whereas I have formerly acknowledged, that there are some witty men, that speak very disrespectfully of the scripture, I hope, that if you meet with any such, you will consider, that it has among the wits as well celebrators, and admirers, as disregards. And that you may think this desire of mine the more reasonable, be pleased to consider with me, that there are divers things, which ought to lessen the authority of the disparagers of the scripture, in the case under consideration.

FOR first, how few of them, think you, are wont to read it in its originals; and how much a less number is there of those, who both know and duly consider all those particulars represented in the past discourse on the behalf of the scripture style? So that in a great many men of parts, their undervaluation of the scripture proceeds not from their having great wits, but from their not having a competent information of what can be alledged for its justification.

BUT though we should suppose those we speak of not to want information, yet we may well suppose many of them not to be free from vanity and envy; there scarce being any fault so incident to great wits, as the ambition of being thought still more and more so, and the unwillingness, that any composures but their own, or those they have a hand in, should be celebrated; as if all praises were injurious to them, that are given to any other. It need be no great wonder then, if so excellent a book as the scripture have, as well envious, as admirers; and if there be divers, who cavil

cavil at it, and seem to undervalue it, out of a criminal fondness of the over-ambitioned title of a wit, which they hope to acquire by unherding and keeping out of the road, and owning their being able to slight and disgrace that, which so many others reverence and venerate.

BUT thirdly, it is sufficiently notorious, that of the opposers of the scripture there is a great part, whose vanity and envy, though no small faults, are not their greatest crimes; but who live so dissolutely and scandalously, that the suspicion cannot but be obvious, that such decry the scripture for fear of being obliged (at least for meer shame) to live more conformably to it. And that it were no slander to affirm it to be their interest, not their reason, that makes them find fault with a book, that finds so much fault with them; and they who are sensible of the truth of that of our Saviour, where he says, *That many love darkness rather than light, because their deeds are evil; and that he that doth evil, hateth the light, neither cometh to light, lest his deeds should be reproved*; will not be much moved to find conscious malefactors find fault with the statute-book, but will rather look upon these sinners censures of the scripture, as apologies they judge necessary to palliate their sins, or as acts of revenge, for their being exposed in all their deformity to the eyes of the world, and of their own consciences, in the bible; and consequently will be inclined to think, that their irreligious expressions do rather shew what they would have men believe of them, than what they believe of the scripture, by seeming to slight which, they hope to have their vices imputed rather to a superiority of their reason over that of others, than a servitude of their reason to their passions.

John iii.
19, 20.

A long digression against prophaneness, as it relates to the scripture.
Pf. xxxix.
3.

[HERE I thought to pass on to another argument, but (to express my self in David's words) *While I was musing, the fire burned*, and my zeal for the scripture, together with the charity it has taught me to exercise even towards its opposers, suffers me not, with either silence or languid resentments, to see how much that incomparable book loses of the opinion of less discerning men, upon the account of their disrespect, who are (whether deservedly or not) looked upon as wits. And therefore to what I have represented to invalidate the authority of these few persons, otherwise truly witty, that undervalue the scripture, I am obliged to add, that besides them, there is a number of those, that slight the scripture, who are but looked upon as wits, without being such indeed; nay, who, many of them, would not be so much as mistaken for such, but for the boldness they take to own slighting of the scripture, and to abuse the words of it to irreligious senses, and perhaps passing from the impudence of perverting inspired expressions, to deliver obscene thoughts. But to knowing and serious men, this prevaricating with the scripture will neither discredit it, nor much recommend the prophane prevaricator: for a book's being capable of being so mis-used

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is too unavoidable to be a disparagement to it. Nor will any intelligent reader undervalue the charming poems of *Virgil* or of *Ovid*, because, by shuffling and disguising the expressions, some French writers have of late been pleased out of rare pieces to compose whole books of what they call, *Vers Burlesques*, designed by their ridiculousness to make their readers sport: and on the other side, to abuse dismembered words and passages of any author to meanings he never dreamed of, is a thing so easy, that almost any man may have the wit to talk at that prophane rate, that will but allow himself the sauciness to do so. And indeed experience shews, that if this vice itself do not make its practices suspected of the being necessitous of the quality they put it on to be thought masters of, yet at least persons intelligent and pious will not be apt to value any discourse as truly witty, that cannot please the fancy without offending the conscience; and will never admire his plenty, that cannot make an entertainment, without furnishing out the table with unclean meats; and considering persons will scarce think it a demonstration of a man's being a wit, that he will venture to be damned to be thought one. And that which aggravates these mens prophaneness, and leaves them excusable in it, is, that there are few of these fools, (for so the wise-man calls them) that *make a mock of sin; that have said in their hearts, that there is no God*; or that the scripture is not his word; their disrespect to the scripture springing from their vanity, not their incredulity. They affect singularity, for want of any thing else than is singular; and finding in themselves strong desires of conspicuousness, with small abilities to attain it, they are resolved with *Erostratus*, that fired *Diana's* temple; to be talked of for having done so, to acquire that considerableness by their sacrilege, which they must despair of from their parts. And indeed there want not many, who have so little wit, as to cry up all this sort of people for great wits. And as withies, whilst they are sound, grow unregarded trees, but when they once are rotten, shine in the night; so many of these pretenders, whilst they were not very prophane, were (and that justly) esteemed very dull; but now that their parts are absolutely corrupted and perverted, they grow conspicuous, only because they are grown depraved. And I shall make bold to continue the comparison a little further, and observe, that as this rotten wood shines but in the night; so many of these pretenders pass for wits but amongst them, that are not truly so. For persons really knowing can easily distinguish betwixt that, which exacts the title of wit from our judgments, and that which but appears such to our corruptions. And how often the discourse we censure is of the latter sort, they need not be informed, that have observed, how many will talk very acceptably in derogation of religion, whom, upon other subjects, their partiallest friends acknowledge very dull; and who are taken notice of for persons that seldom say any thing well, but what it is ill to say. And questionless, there is no small number

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number of these scorners, whose censures of the scripture's style are little less guilty of presumption than profaneness. I have of late years met with divers such vain pretenders, who blush not to talk of rhetorick more magisterially than *Aristotle* or *Tully* would; and superciliously to deride, in comparison of their own writings, and theirs who write like them, not the bible only, but the most venerated authors of antiquity; and, to use *Asaph's* words; Pf. lxxiii. S. 9. *They speak loftily, they set their mouth against the heavens, and their tongue walketh thorough the earth:* they speak arrogantly and censoriously both of God and men; whilst themselves oftentimes understand no tongue but their mother's; and are strangers enough to rhetorick, not to know the difference betwixt a trope and a figure, betwixt a prosopopœia and a metaphor, or betwixt a climax and a metonymy. Nor is our wonder like to cease, to find these transcendent wits, (as they are pleased to think themselves,) so undervalue the scripture, by considering the rare composures they despise it for; these being commonly no other than some drunken song or paltry epigram, some fawning love-letter, or some such other flashy trifle, that doth much more argue a depressed soul, than an elevated fancy. Some of these gallants by their tavern songs use the muses like anchovies, only to entice men to drink: another with more solemnity and applause makes the muses (what the French call) the confidants of his amours, prostitutes his wit to evince and celebrate the defeat of his reason, and never considering how apt self-love makes us to magnify any thing that magnifies us, is proud to have wit ascribed him by as bribed as incompetent judges of it; and takes it for as high a proof as desirable a fruit of eloquence, to persuade a vain mistress, that she is handsome and adored, to whom it were eloquence indeed to be able to persuade the contrary. Divers of the Jews are wont to mention the names of deceased sinners, with that brand taken out of the *Proverbs*, *May the name of the wicked rot*; but as the filthiest swine after their death are salted, and the gammons made of their flesh are served in, all stuck with bays; so divers, that have lived notorious Epicures, have too often, after their death, not only their names salted (not to say embalmed) with flattering epitaphs, and (I wish, seldom, as flattering) funeral sermons; but have their drunken or lustful rhimes extolled with such eulogies by their surviving resemblers, that not only good Christians, but good poets cannot but grieve and blush, thus to see bays, that should be appropriated to, and crown that heavenly gift called poetry, when mindful of its dignity and extraction, it in-dears to us by our fancies truths, that should have an influence on our affections, (by cloathing excellent thoughts in suitable and winning dresses) prostituted and degraded to make wreaths for those, who have no better title to them, than a few sensual rhimes, where the dictates of *Horace* are as little conformed to, as the example of *David*; and the laws of the art little less violated than those of religion.

It is pleasant to observe, in how many of such copies of verses, the themes appear to have been made to the conceits, not the conceits for the themes; how often the words are not so properly the clothes of the matter, as the matter the stuffing of the words; how frequently sublime nonsense passes for sublime wit; and (though, according to my notion of it, that is indeed true wit, which it is more easy to understand, than it is not to admire it) how commonly confused notions, and abortive or unliked conceptions, are in exotic language, or ambiguous expressions, exposed to the uncertain adoption of the courteous reader; which the writers are emboldened to expect favourable, by finding men once thought (whether deservedly or otherwise) lofty wits, to have so often the luck of parrots, and of those that talk in their sleep, who are not seldom understood by others, when they do not understand themselves. And very much of kin to their verses is their prose. For though I am far from denying, that those, that have store of wit, may express some of it in an address to a great man, or in writing to a mistress; yet as for such prophane persons I am now speaking of, who rather would be thought wits, than are so, it is easy to discern, that very many of their almost as much flattered as flattering letters of love and compliment are but prologues to, and paraphrases of the subscription, (your humble servant.) Though love be universally thought to make the fancy soar, (lovers like ceeded pigeons flying the higher for having been blinded) and though even the wiser observe, that, like war, which is wont as well to raise soldiers of fortune, as to ruin men of fortune, love warms and elevates lesser wits, though it too often infatuates the great ones: yet a witty lady did not scruple to say frequently, that give her but leave to bar half a score words, and she would undertake to spoil all the fine letters of our amorous gallants. I applaud not the severity of this lady, and think her challenge relishes as much of vanity as skill; but yet, to express the sense of these few words, [I desire you should think I can write well, am a civil person, and your humble servant,] being the drift and substance of most of these ceremonial papers; these (oftentimes as tedious as servile) amplificators, with all their empty multiplicity of fine words, do but, like market-people, pay a piece in twenty shillings. In wits not blessed with solid reason and learning, (that is, in most readers) fancy being the predominant faculty, makes them relish those writings most, where fancy unrivalled reigns. And therefore, though I dare not say, that it requires no great parts for those to write high and acceptable compliments, that think nothing fit to be endeavoured in compliments, but to make them acceptable by making them high enough; (flattery and profaneness seeming in such composures what spots are in leopards, blemishes, that make a great part of their beauty) or for a flatterer to persuade those vain persons, that will readily believe a man, even when he doth not believe himself: yet sure it gives much latitude and liberty to a writer, not to be obliged to believe

believe what he says, not say but what he thinks either will be or ought to be believed. And truly, they that exercise their pens on either sort of themes (I mean those that require only new or pleasing fancies, and smooth language, and those that require learning and knowledge pertinently and handsomely expressed) do, I doubt not, find it much less difficult for writers to delight, where they propose themselves no higher end, and scruple at nothing they judge conducive to that inferior one; than to please, where to do so is but a subordinate end, which men allow not themselves, neither the use of all proper means to attain. Nor do I question but such persons find it far more easy to write acceptably on subjects, where they are not tied to speak either reason or truth; than to write well on a theme, where men are confined to write nothing but what they judge useful, and what they can make good, as considering that they may be called to account by men for what they publish, if not by God, both for their own time and that of their readers. And indeed, when I compare the most applauded trifles of these undervaluers of the scripture style, with the celebrating discourses of it extant in the learned writings of St. *Austin*, St. *Hierom*, *Tertullian*, *Laſtanius*, *Chryſoſtom*, *Mirandula*, and others, whose penetrant and powerful arguments defeat not God's enemies, as *Samſon* did the Philistines, with a jaw-bone of an afs, nor as *Shamgar* with an ox-goad, (I mean with blunt and despicable weapons) but as *Elias* did, with fire from heaven; and whose apologetical defences of the spiritual *Jerusalem* are glittering and solid, as the wall of the heavenly *Hierusalem* is described to be of jasper, and the foundations of the wall garnished with all manner of precious stones: when I compare, I say, the composures of our frothy censurers with those of the sacred orators; methinks I discern such a difference betwixt them, as I have observed betwixt those justly admired statues I have seen in the Capitol, and the larger sort of babies that we find in the exchange. For the former, besides their vastness, are so recommended by the worth and permanency of their matter, the excellency of their workmanship, and the nobleness of what they represent, that they are most prized by the best artists, and time is not only unable to consume them, but still increases mens value of them; whereas the latter are little trifles, scarce welcome to any but children in understanding, and admired only for a gaudy effeminate dress, which will quickly either be sullied or worn out; and a fashionableness which within a short while will perhaps be ridiculous. But supposing at length, that the profane aspirer should be so lucky, or so successful, (for happy I cannot think it) as to attain the so criminally courted notedness, yet will he have no great cause to boast the purchase, when he seriously considers, that the devil, who seduces other sinners like men, with current coin or sparkling jewels, (something that either advantages their interests, or delights their senses;) hath enveigled him, like a child, with a

whistle; a trifle that only pleases with a transient and empty sound; and, that fame is a blessing only in relation to the qualities, and the persons that give it, since otherwise the tormented prince of devils himself were as happy as he is miserable; and famousness unattended with endearing causes is a quality so undefirable, that even infamy and folly can confer it; as *Momus* is little less talked of than *Homer*; the unjust *Pilate* is more famous than *Aristides* the just; and *Barabbas* his name is signally recorded in scripture, whereas the penitent thief is left unmentioned. And sure the highest favours, that applause can impart, and the being (though never so loudly) cried up for a wit, will hardly so repair the punishment of prophaneness, but that its wretched sufferer will find but small satisfaction in having his name celebrated in other books, whilst it is blotted out of that of life. And as for those (you know who I mean) that aspiring to posthume glory, endeavour to acquire it by irreligious writings destinated not to see the light, till their authors be gone to the region of darkness; I cannot but admire to see an ambition, that projects beyond the grave, step short of heaven; and cannot but think those wits the greatest fools, who, to tempt praises they shall never hear, provide themselves torments that they shall ever feel. For though prophaneness, by those that are guilty of it, be too often thought but a small sin, because they look upon it but as a verbal one; yet I could easily represent it under another notion, if I would here repeat what I have discoursed, touching indulgence to reputedly small and verbal sin in another paper, from which though I will not now transcribe any thing, yet I cannot but wish it were well considered, how affronting speeches concerning God's word are like to be looked upon in that great day, when (to borrow St. *Jude's* terms) *the Lord shall come with ten thousands of his saints, to execute judgment upon all, and to convince all that are ungodly among them, (not only) of all their ungodly deeds, which they have ungodly committed, (but) also of all their hard speeches, which ungodly sinners have spoken against him.* And indeed these presumed peccadillos, though oftentimes in health and prosperity they appear not to us to blemish much our consciences, yet when in our distresses, or at the approaches of death, God comes, as the prophet speaks, *to search men's hearts as it were with candles, and punish the men that are settled upon their heels, (which whilst a liquor is, it may look clear, and be taken for defecated, but a little agitation of the vessel strait makes it troubled and muddy;)* they appear in a terrifying form. For as paper written upon with juice of lemons may wear white, (the livery of innocence) whilst it is kept from the fire; but being held to it, black lines do presently appear: so out of many consciences, that seem clear in prosperity, the fire of adversity draws out the latent blacknesses, and makes us read things undiscerned there before. And questionless, if, as the scripture informs us, *there are sins, whose cry is able to reach heaven; so loud a* Gen. xviii. 21.
crime

Judg. xv. 15.
Judg. iii. 31.
2 Kings i. 10.

Rev. xxi. 10, 18, 19.

Jude ver. 14, 15.

Zeph. i. 12.

crime as the prophaneness I am now speaking of, is likely to do more than whisper there; especially, since it is much to be feared, that many of these scoffers (as they seem to be called in the scripture) which they bear witness to, by cavilling at it, do *rebel against the light*, and *kick against the pricks* of their own consciences: such a crime, I say, will be so far from whispering in heaven, that it will rather give an alarm, that will rouse up provoked justice; whose inflictions, like stones tumbled down from the towers of an assaulted place, the longer they are in falling on men, the more fatally they oppress them. In which regard perhaps, the feet of our Saviour in the Apocalypse are described to be like unto fine brass, as if they burned or glowed in a furnace; to intimate, that though he be very slow in his march to destroy the wicked, yet he is as sure, when once he pleases to tread them under foot, to crush and consume them. If there be no injury, that more exasperates than contempt, nor no contempt, that more provokes than that, which offends directly and immediately, (the affronters thereby proclaiming, that they are neither ashamed nor afraid of angering) how provoking may we think that crime, which makes God the subject of our derision; and that with so little circuition, as to abuse that word, which he so solemnly declared his mind by to mankind? *Plutarch*, to manifest how much some idolaters did more incense the Deity than some artists, tells us, he should esteem himself less injured by the man, that should doubt or deny, than by him, that should affirm, that there was such a one indeed, but that he was an old fellow, that used, like the poet *Saturn*, to devour his children; and was guilty of those other crimes imputed by the Heathen to their gods. Upon a like account, we may esteem God less provoked by their unbelief, that doubt or reject the scripture, than by their prophaneness, that make so sacrilegiously bold with it; since the latter impute to God the inditing of what they endeavour to make men think fit to have sport made with it. This of prophaneness is so empty and unprofitable a sin, that it scarce gets the practiser any thing but an ill name amongst good men upon earth, and a worse place amongst bad men in hell; by making his enmity to piety so malicious and so disinterested, that he will endeavour to do religion harm, though it be to do himself no good. He is such a volunteer sinner, that he hath neither the wit nor the excuse of declining his conscience in compliment to his senses; and though he ever makes but an ill bargain, that gets in hell to boot, yet those I would reclaim, come far short of the comparative wisdom of their folly, who to gain so considerable (though yet over-purchased) a possession as the whole world, should part with their own souls. And sure a sin, that is injurious to God's glory, and is apt to subvert (what he and good men prize next,) the dearly purchased, immortal, and invaluable souls of men, and to *destroy them for whom Christ died*; will not by being verbal, be protected from being heinous. And to those that

practise it, I shall recommend the latter half of the epistle of *Jude*; which, though it seem properly to relate to the Gnosticks, or Carpocratians of his time, will deserve a trembling attention from those that revive the sins there condemned, in ours; and who would do well, by seasonably considering the fate there threatened to their predecessors, to tremble at their crime. But for fear of losing it, I shall not spend more time in endeavouring to disabuse our scorers; whom I should have left to the quiet enjoyment of their unenvied self-admiration, had not their despising the scripture, upon a presumption of their own matchless wit, (like *Jeroboam*, that forsook that incomparable structure, the temple, where God did so gloriously and peculiarly manifest himself to men, ^{1 Kings} to worship calves of his own making,) engaged ^{xii. 28,} me, in conformity to the wise man's counsel ^{32.} in such cases, to *answer the fool according to his folly, lest he be wise in his own conceit*. For my ^{xxvi. 5.} reproofs are addressed to those called wits, but as they are traducers and undervaluers of the scripture, not as they either pretend to, or enjoy, a quality, which I have the justice to esteem, though not the happiness to possess; and which my value for it, and my charity for men, makes me troubled to see arrogated by many that want it, and by too many, that have prostituted it to gratify other people's pride, or their own lusts. How much happier were it for persons of choice parts to employ them, as *Bezaleel* and *Aboliab* did theirs, in working for the sanctuary; in asserting the embellishing divinity? The structure will not alone deserve the skilfullest hand, but though it reject not goat's hair, and coloured badger's skins, will admit not only purple and fine twined linen, but gold, silver and precious stones; the richest ornaments, that learning and eloquence can grace theology with, being not only merited by that heavenly subject, but being applicable to it, as much to their own advantage as to that of their theme. We see how ambitious men are, to leave a good name behind them, and appear in the habit of virtue to their own after time: witness the artifices and hypocrisy men generally veil or disguise their sins with; and the flattering epitaphs, with which so many vicious persons endeavour to convey themselves to the good opinion of posterity. Now they that write piously, as well as handsomely, have the advantage of getting themselves the reputation as well of virtuous as of able men, and besides that double recompence may expect a third (transcending both) in heaven, where they that (in the true scripture-sense) *be wise, shall shine as the brightness of the firmament, and they that turn many to righteousness, as the stars for ever and ever*. ^{Dan. xii. 4.} It is the general complaint and grief of persons truly zealous, that there are many more wits and grandees now-a-days, who, by perverting God's gifts to the service of idols (of pride or pleasure) of their own setting up, resemble the degenerate Jewish church, of whom God complains by *Hosea*, that *she did not know, that he gave her the corn and wine and oil, and multiplied her silver and her gold, which they prepared for* ^{Hos. ii. 8.}

2 Pet. iii.

3.

Jude ver.
17, 18.

Rev. i. 15.

An appendix to the former digression, inviting one sort of witty men to make amends for the prophaneness of another.

Exod.

xxiii.

3, 4, 5
&c.

for Baal; than that, (by an humble dedication of their choicest abilities to God's service,) imitate holy *David* and his princes; who having consecrated their gold and silver and precious stones, towards the enriching and embellishing of the temple, perfumed that vast offering with this acknowledgment to God; *All things come of thee and thine own have we given thee.* But though now I know divers great persons and great wits amongst us, who very unmindful of that text, *What hast thou that thou didst not receive,* like those ungrateful clouds that obscure the sun that raised them, oppose the glory of that God, who elevated them to that height: yet I do not absolutely despair, that as God hath been pleased to make use of several royal pens for the tracing of his word, and to make a person, learned in all the wisdom of the Egyptians, his first secretary; so he will one day engage both the grandees and the wits to strive to expiate, by their devotion and service to the scripture, the injuries, that irreligious parts and greatness have done it. I will not tell you, *Theophilus*, that an early study of religion would gain to its party most of those many wits, that will be sure to contend for whatever opinion is expressed by the wittiest things they can say. But I will tell you, that a particular consideration, that makes me wish to see witty writers more generally employ their pens on the behalf of religion, is, that the services they do it, endear it to them: for as *Machiavel* smartly observes, and as the love of parents and nurses to children may evince, *La natura de gli huomini è così obligata per li benefici che esse fanno, come per quelli che essi ricevono.* It is natural to men, to be as well engaged by the kindnesses they do, as by those they receive. And for the encouragement of the possessors of great parts, to employ them on religious themes, such as the holy scripture; I shall represent to them, that even that immortality of name, which worldly writers (for the most part) solely aim at, is not by pious writers less found for being last sought: their theme contracts not their fame by a true diminution, but only by comparison to a greater good: their looking upon their own glory but as an accession to God's, not hindering others from praising that wit and eloquence they praise God with; as beauty made it self admirers, though in vestals, and a rare voice may ravish us with a psalm; or as the jewels that adorned it, shone with their wonted lustre on *Aaron's* breast-plate; yes, *as godliness is profitable unto all things, having promise of the life that now is, and of that which is to come; and the hundred fold now in this time,* is very consistent with the eternal life in the world to come: so is it very possible for the same pious writer to have his name written, at once in both those immortal books of life and fame; and, (like the inspired poet, holy *David*) wear as well here a crown of laurel, as hereafter, τὴν ἀμαρῶντινον τῆς δόξης στέφανου, that unfading crown of glory *St. Peter* speaks of. And though we are too generally now-a-days so sinful, that we scarce relish any composition, that endeavours to reclaim us from being so; yet less licentious and more

discerning times, (which may be perhaps, approaching,) will repair the omissions and faultiouness of the present, by an eminent gratitude to the names of those, that have laboured to transmit to others, in the handsomest dress they durst give them, the truths themselves most valued. And I observe, that though *Solomon* himself delivered so many thousand songs and proverbs, and the nature of beasts, birds, reptiles, and fishes, together with the history of plants from the cedar of Lebanon, even to the hyssop that springeth out of the wall; yet those three only treatises, designed peculiarly for the instruction of the church, survive their lost companions. And as anciently the manna, which the Israelites gathered to employ in their domestic uses, lasted not unputrified above a day or two; but that, which they laid up in the sanctuary to perpetuate or secure God's glory, continued whole ages uncorrupted: so the books written to serve our private turns of interest or fame are oftentimes short-lived; when those, consecrated to God's honour, are, for that end's sake, vouchsafed a lastingness and kept from perishing. And those many dull and uneloquent glosses and expositions of the ancient Jews, that the merit of their theme hath preserved for so many ages, may assure us, that the scripture doth often make their names and writings that illustrate it, partakers of its own prerogative of immortality. Not to mention that, (according to that of the Psalmist, *I have more understanding than all my teachers; because, thy testimonies are my meditation*) such an employment of parts doth oftentimes invite God to increase them; as he that had most talents committed to him, for improving them to his Lord's service, was trusted with more of them; and he, who employed some few cups of his wine to entertain our Saviour, had whole vessels of his water turned into better wine. Certainly, transcendent wits, when once they addict themselves to theological compositions, improve and grace most excellently themes so capable of being so improved. They need small time to signalize their pens; for possessing already in a sublime degree all the requisites and appropriates of rare writers, they need but apply that choice knowledge and charming eloquence to divine subjects to handle them to admiration; as *Hiram* successfully used the skill he had learned in Tyre, in the building and adorning of God's temple; and *Jephtha* victoriously employed the military gallantry and art, that had made him considerable in the land of *Tob*, in defending the cause, and defeating the enemies of God. Of this truth the primitive times afford us numerous and noble instances; but especially that stupendous wit *St. Austin*, (whom I dare oppose to any of the wits, that have dared to oppose the scripture,) the productions of whose wit in his unregenerate state, and after his conversion to the catholic faith and piety, oblige me to resemble him to *Aaron's* rod; which (supposing the truth of their opinion, that think it to be the same that *Moses* used) whilst it was employed abroad, did indeed for a while work wonders,

1 Chron. xxix.

ver. 14.

1 Cor. iv. 7.

Nicholo Machiavelli nel libro del Principe, c. 10.

1 Tim. iv. 8.

Mark x. 30.

1 Pet. v. 4.

1 King. iv. 31, 32, 33.

Exod. xvi. ver. 20, 33, 34.

Psal. cxix. 99.

Mat. xxv. 28.

John ii. 10 the tenth verse inclusively.

1 Kings vii. 13, 14.

Judg. xi.

Num. xvii. 4, 8.

that made it much admired; but when once it came to be laid up in the tabernacle, unconfined to the usual laws of other plants, it shot forth and afforded permanent fruit in a night. But, *Theophilus*, to recover my self at length from my over-prolix digression, I must remember, that it was objected, that as well divers great princes and great statesmen, as many great wits, dis-esteem, or at least neglect the scripture. And indeed, though I am sorry it cannot, yet it must not be denied, that notwithstanding all the prerogatives of the bible, there needs not much acquaintance with great men, to shew many of them, that though they deny not God to be the author, deny themselves the blessing of being readers of it, some out of laziness, and others out of pride; both which lurk under the pretext of multiplicity of important avocations. But since, your quality, *Theophilus*, and station in the world, may either make you need to be armed against this temptation, or give you opportunities to assist those that are endangered by it, give me leave, on this occasion, to tell you, that those grandees, that pretend want of leisure for their neglect of the reading of the scripture, must be able to give a rare account of all the portions of their time, to make those pass for a mis-employment of it, that are laid out towards the purchase of a happy eternity; which it is not over-modest for those to expect from God, that grudge him the rent of that time, of which they are but his tenants at will. But to manifest how unlikely this pretence is to pass current; I shall represent, that in the self-same chapter, where God fashions a king fit to govern his own people, he enjoins concerning the book of the law, that *it shall be with him, and he shall read therein, all the days of his life*; which the next verse intimates shall be thereby prolonged. And indeed, it often happens, that as *Samuel's* barren mother for lending one of her children freely unto the Lord, was blest with many others; so the days consecrated to God's service rather improve than impoverish our stock of time. Nay, the king was, (in that place of *Deuteronomy*) not only obliged to read the law, but to write it too: upon which subject, if I mis-remember not, the learnedest of the Rabbies tells us, that the king (as indeed God usually charges eminence of place with eminence of piety) was bound to write it out himself, and that, as king. For though before his ascending the throne, as any other Israelite, he had a transcript of his own writing; yet was there annexed to the acquit of the regal scepter a duty of copying with the same hand that swayed it. To *Joshua* both a general and a judge, who was to wield the swords both of *Africa* and of *Bellona*, to govern one numerous people, and conquer seven; the words of God are very remarkable: *This book of the law shall not depart out of thy mouth, but thou shalt meditate therein day and night, that thou mayest observe to do according to all that is written therein; for then thou shalt make thy way prosperous, and then thou shalt have good success.* *David* was a shepherd, a conqueror, and a king, and had certainly no unfrequent distractions, both before he came to the crown, (whilst he lived a despised younger brother, an envied courtier, a diffident fugitive, and a distrusted captain) and after, whilst he wore, lost, and regained it: but how little the time employed in the study of the scripture prejudiced his secular affairs, his story and successes may attest; and how large a portion of his time that study shared, you may be plentifully informed by himself, and save me the transcribing much of the book of *Psalms*. He gathered bays both on *Parnassus* and in the field of honour; and equally victorious in duels and in battles, his exploits and his conquests were such, as (transcending those in romances almost as much in their strangeness as their truth) needed an infallible historian to exact a belief, their greatness and their number would dissuade. He added to his regal crown of gold two others (of bays and laurel) which his successful sword and numerous pen, making him both a conqueror and a poet, gained him from victory and the muses. And yet for all this greatness and this fame, and that multitude of distractions that still attends them, the (then extant) scripture was so unseveredly his study, and he so duly matched in his practice what the Apostle copies in his precept, *diligence in business, and fervency in spirit*, that it is not easy fittier to resemble him, than to the winged cherubims in the old tabernacle, whom all the gold and jewels, that glittered about them, and all the clouds of incense fumed before them, could never divert from a fixed posture towards the ark of the testimony, that contained the law, and the mercy-seat that represented Christ. And indeed, it is a saying equally ancient and true, that none should know (things better and) better things than princes; for their virtues and their vices participate the eminence and authority of their condition; and by an influential exemplariness, so generally fashion and sway their subjects, that as we find in sacred story, that the Jews served God or *Baal* as their kings did, so profane history tells us, that *Rome* was warlike under *Romulus*, superstitious under *Numa*, and so successively moulded into the dispositions of her several princes; subjects, all the world over, being apt to think imitation a part of the duty of obedience; and being generally but too sensible of the requisite-ness of their being like their prince to the being liked by him. A state, like *Nebuchadnezzar's* mysterious image, should have the head of gold; and the inferior members of a value proportionate to their vicinity to that noblest part. When once I shall see such monarchies and common-wealths no rarities, and see the addictedness of princes to the study of scripture further the ulterior accomplishment of that part of it, which once promised God's people, *that kings should be its nursing fathers, and their queens its nursing mothers*; I shall expect to see the golden age elsewhere than in poets dreams. For I take not absoluteness to be like a plague, whose almost boundless power is confined to do mischief; but I esteem sovereignty little less applicable and effectual to good than ill. *Trajan* and *Constantine* were

Deut. xvii.
18, 19.
1er. 20.

1 Sam. ii.
20, 21.
1er. 18.

Rambam,
or, Rabbi
Moses
Ben-Mai-
mon.

Josh. i. 8.

Rom. xii.

Deut. xxv.
18, 19, 20,
21.

Dan. ii,
31, 32,
&c.

Isa. xlix.
23.

as great and publick blessings, as *Nero* or *Caligula* were mischiefs; and virtue on a throne hath not a much less imperious influence, than crowned vice. And accordingly I shall permit my good wishes for mankind to turn expectations, when I shall generally see sovereignty nobly contend for as great a superiority over each other by their virtues, as they possess over their subjects by their fortune; when I shall see potentates make use of *Mars's* sword but to restrain others from abusing it; and kings affect their resemblance to God, less in his unlimitedness of power, than his employment of it. But, to step back into my way, and leaving princes to fitter monitors, say something to men of either great titles or employments. There is none of these pragmatical persons, that will suffer himself to be so enslaved to his business, but he will allow himself set times, and can daily find leisure for eating, drinking, and other corporal refectations, and frequently for recreations: and certainly, if we valued not our bodies above our souls, we would, in spite of the urgency of secular affairs and employments, reserve and set a part some time to feed our souls with their true food, God's word; else we shall never be able to say of God with holy *Job*,
Psal. cxiii. *I have esteemed the words of his mouth more than my necessary food.* I will not urge, that *Daniel*, whose vast abilities had a resembling theatre, and who surpassed other statesmen as much in the number and weight of the affairs he had to manage, as in the excellent spirit and dexterity, wherewith he managed them, amidst transactions that busied sixscore princes, who loaded him with a weight (of business) capable to have crushed *Atlas*, could yet find leisure to study the prophet *Jeremy*; because it will be perhaps more proper to mention, that even *Machiavel* himself, that secretary and reputed oracle of state, could find time, not only to read, but to write plays, (some of which I have seen in Italian) such as I would not think excellent, though a person, from whom so much might be expected, had not written them. Let us not then think our business or our recreations a sufficient dispensation from an employment, for which, were they inconsistent, they ought both to be declined; since it is both more concerning than the first, and more satisfying than the latter. But that, which is often the true, though seldom the avowed cause of these men's neglect of the scripture, is not their unlearnedness, but their pride; which makes them think it too mean, and trivial an employment for one, that is great and wise enough to counsel and converse with princes; and have a vote or hand in those great enterprizes and transactions, that make such a noise in the world, and are the loud themes of the people's talk and wonder, to amuse themselves to examine the significations of words and phrases. For my part, I am no enemy to the calling of statesmen; I think their profession as requisite as others in a commonwealth; and should think it very injurious to deny them any part of a purchase they pay their care and time for: nor perhaps have I

so little studied the improvements of quiet, as to think my self less obliged than others are to those, whose watchings or protection affords it, or secures it to me. But after all this is said, I love to look upon the world with his eyes, that is justly said to *humble himself* (when he vouchsafes) *to behold the things that are done in heaven and in earth*; and to take measure of the dimensions of things by the scale his word holds forth. Now in the esteem of him, that hath made all things for himself, and of whom his spirit by his prophet truly says, that the nations are as a drop of a bucket, and are counted as the small dust of the balance; nay, that all nations before him (are) as nothing, and they are counted to him less than nothing and vanity; the importantest employments are the study and glory of God. He created this vast fabrick of the world to manifest his wisdom, power, and goodness; and in it created man, that it may have an intelligent spectator, and a resident, whose rational admiration of so divine a structure may accrue to the glory of the omniscient and almighty architect. And as he created the world to manifest some of his attributes, so doth he uphold and govern it to disclose others of them. The revolution of monarchies, the fates of princes, and destinies of nations, are but illustrious instances and proclamations of his providence. The whole earth once perished by water, to signalize his justice on his enemies; and the whole world shall one day perish by fire, to (exercise that former attribute and) evidence his goodness to his children: for whom his faithfulness to his promises will oblige him to build a gloriofer mansion for such glorified residents. The angels, some of whom the visions of *Daniel* represent to us at the helm of kingdoms and of empires, and whose power is so great, that one of them could in one night destroy a force, capable, if divided, to have made half a dozen formidable armies; these glorious spirits, I say, whose nature transcends ours, that the very devil cannot, without the assistance of virtue, despise the objects of our ambition by a superiority of nature only; for all their high prerogatives and employments, think the mysteries unfolded in scripture worthy their bowing as well as desire to look into; think not themselves too eminent to be messengers and heralds, of which fond mortals think themselves too eminent to read; and (being all *ministering spirits sent forth to minister to them who shall be heirs of salvation*;) disdain not to think our instruction worth their concern, whilst we disdain a concern for our own instruction. Nay, the very *Messias*, whose style is *king of kings, and lord of lords*, though he be not recorded to have ever read but once, did yet read the scripture, and think it worthy his expositions and recommending; and well may any think that book worth the reading, that God himself thought worth ending. When *Moses* and *Elias* left their (local, not real) heaven, and appeared in glory to converse with our transfigured Saviour on the mount; their discourse was not of the government of kingdoms, or the raising of armies for subversion of empires; or of those other solemn trifles, which

Job xxiii. 12.

Dan. vi. 3.

Dan. ix. 2.

Isaiah xl. 15, 17.

Dan. x. 13.

2 Kings xix. 35.

μαγεω-
δαι.
1 Pet. i. 12.

Heb. i. 14.

Rev. xvii. 14.
Luke iv. 17. &c.

which heaven places as much beneath men's thoughts as residence; but of (the inspired book's chief theme) *his decease, which he should accomplish at Jerusalem*. And after that St. Paul had been caught up to the third heaven, and had been blest and refined with his ineffable entertainment there; I wonder not to find him profess so resolutely, that he *counteth all things but loss for the excellency of the knowledge of Christ Jesus his lord, in whom faith cometh by hearing, and that hearing, of the word of God*; and who addresseth men to the scriptures, as those which testify of him. And perhaps our Saviour used so frequently to conclude his divine discourses with that just epiphonema, *be that hath ears to hear, let him hear*, but to teach us, that there is no employment of our faculties, that more deserves their utmost attention, than the scrutiny of divine truths. That which is pretended to by this discourse, is to impress this truth, that where God is allowed to be an intelligent and equal valuer of things, a man cannot have so great an employment, as to give him cause to think the study of the scripture a mean one; since, thus saith the Lord, *Let not the wise-man glory in his wisdom, neither let the mighty-man glory in his might; let not the rich man glory in his riches: but let him that glorieth, glory in this, that he understandeth and knoweth me*. For sure, if the knowledge of God be so glorious a thing, the study of that book, whence that knowledge is extracted, and where it is most resplendent, is not a despicable employment. Which sure (to add that upon the by) it is somewhat injuriously thought by those, who are so industrious and proud in profane histories and other political books, to discover (or even guess at) those intrigues, which commonly but tell us, by what crafty arts a knave couzened a fool. Nor (to mention this by the by) even in relation to his own profession, is the scripture unable to recompence the study of a Christian statesman; for to omit the (perhaps too) extolling mention *Machiavel* himself makes of *Moses* amongst the famouslest legislators; the historical part of the bible being indited by an omniscient and unerring spirit, lays clearly open the true and genuine causes of the establishment, flourishing and vicissitudes of the princes and common-wealths it relates the story of. Whereas other histories (for reasons insisted on in other papers) are liable to great suspicions in the judgment of those, that duly ponder the several narratives made often of the same transaction or event by several eye-witnesses; and that the true secret of counsels is so closely locked up, or so artificially disguised, that to have interest enough to discern (what statesmen mind and build on) the truth and mystery of affairs, one must be biassed and engaged enough to be shrewdly tempted to be a partial relator of them. But, *Theophilus*, I perceive I have slipped into too long a digression; which yet I hope you will pardon as the effect of an indiscreet, perhaps, but however a great concern for a person, to whom nature, education, and fortune have been so indulgent, that I cannot but look upon his

Luke ix.
31.

2 Cor. xiii.
2.

Phil. iii. 8.

Rom. x.
17.

John v.
39.

Jer. xix.
23, 24.

The apolo-
gical for and
antagonist
of Roman-
ces.

condition as liable to the temptations, which either parts or employments singly, and much more both together, are wont to expose men to.

You may remember, *Theophilus*, that among the answers, which, I told you, might be made to those, that objected again the scripture, *That it is so unadorned, and so ill furnished with eloquent expressions, that it is wont to prove inefficacious, especially upon intelligent readers*; the fifth and last was this, *That it is very far from being agreeable to experience, that the style of the scripture does make it unoperative upon the generality of its readers, if they be not faultily indisposed to receive impressions from it*.

To make good this reply, I must take notice to you, that that part of the objection, which intimates, that intelligent readers are not wont to be wrought upon by the scripture, has been in great part answered already: for I have lately observed to you, that as it may be granted, that some witty men, who have read the scripture, have, instead of admiring it, quarrelled with it; so it cannot be denied, that many persons as eminent for wit as they, have, upon reading it, entertained a high veneration for it. So that I see not, why the celebrations of those wits, that admire it, may not counter-balance the dis-respects of those, that cavil at it; especially if we consider, that as to most of those, that are looked upon as the witty disregards of the scripture, scarce any thing, so much as the vanity and boldness of owning that they disregard it, makes them (but undeservedly) be looked upon as wits.

BUT to this I shall now add, that whereas the objection speaks of intelligent readers, the greatest part of such have not that quickness, which is wont to make men pass for wits, though they may have other abilities more solid and desirable: and yet that the bible has a great influence upon this latter sort of intelligent readers, I presume you will easily believe, if you consider how many great scholars, not only professed divines, but others, have by their learned comments and other writings, endeavoured either to illustrate, or recommend the scripture; and how much a greater number of understanding and sober men, that never published books, have evinced the scripture's power over them, partly by their sermons and other discourses, publick and private; and partly by endeavouring to conform their lives to the dictates of it. Which last clause I add, because you can scarce make a better estimate of what power the scripture has upon men, than by looking at what it is able to make them part with. For not to anticipate what we shall ere long have occasion to mention, let us but consider, what numbers of intelligent persons almost every age, without excepting our own, (as degenerate as it is) has produced, who have been taught and prevailed with by the scripture, and considerations drawn thence, to renounce all the greatest sinful pleasures, and embrace a course of life, that oftentimes ex-

The fifth
and last
answer to
the last ob-
jection.

poses them to the greatest dangers and very frequently to no small hardships.

AND indeed there is scarce any sort of men, on which the scripture has not had notable influence, as to the reforming and proving many particular persons, belonging to it; and to the giving them an affectionate veneration for the book, whereunto they owed their instruction. The accounts ecclesiastical history gives us of the rate, at which devout persons, both in former and latter ages, would purchase the bible, when it was dangerous and perhaps capital to be found possessed of it, would, if I should here repeat them, much confirm what I say, and might equally create our wonder and our blushes. Those sorts of professed Christians, that seem the most evidently to be liable to temptations to neglect or disregard the scripture, are either those, that do, or would pass for wits, or those that live in courts; the former oftentimes thinking themselves too wise to be taught, especially by a book they think not eloquent, and among the latter there being but too many, whose pleasures are so bewitching, or so dear to them, that they like nothing, that would divert, much less divorce them from their pursuit; or else whose business is so much, and perhaps so important, that they have not leisure enough to learn, or have too much pride to think they need do it. But yet even among those, that have worn crowns either of gold or bays, or (what perhaps some value above both) of myrtle, the bible has not wanted votaries: for not to repeat the names of those, whom I have formerly mentioned to have been as well lovers of the scripture, as favourites of the muses, among the other sort of men, *those that* (to speak in our Saviour's terms) *are gorgeously apparelled, live delicately, and are in kings courts,* there have been divers persons, upon whom the power of the scripture has been almost as conspicuous, as their station among men. I will not mention that devout treasurer of the *Æthiopian* queen, who even upon the high-way (whose length neither deterred nor tired his devotion) could not forbear to read the prophet *Isaiab*, and inquire even of a meer stranger, that passed by alone, and on foot, the meaning of a passage, of whose sense he doubted; nor will I urge any other instances of great men's studiousness of the scripture, afforded us by sacred story. And therefore I shall not press the example of that great and wise *Daniel*, whose matchless parts not only cast upon him the highest employment of the world's monarchy, and disengaged him from the ruins of it; but (what has scarce a precedent amongst the very wisest statesmen) continued him in as much greatness, as ever he possessed under the predecessor, under the successor; and such a successor too, as made his predecessor's carcass the ascent to his throne: I will not, I say, at present urge the examples extant in the sacred records of great men's studiousness of them, because even secular and more recent histories may inform us, that even in courts all men's eyes have not been so dazzled by the glittering vanities, that are wont to abound there, but that some of them have discerned, and

Luke vii.
25.

practically acknowledged the prerogatives of scripture. Though I cannot say, that many kings have been of this number, because there have been but few kings in all, in respect of the numbers, that compose the inferior conditions of men; yet even among these, and in degenerate ages, some have been signally studious of the bible; such was that sixth *Edward*, who imitated the early active piety of *Joash*, without imitating his defection from it, and whose short heavenly life manifested, how soon, even amidst the temptations of courts, grace can ripen men from glory. And such was that learned king, whose having more than per-^{King} functorily studied the scripture, his solid de-^{James} fence of divers of its truths against his misinterpreters have sufficiently proclaimed to the world. Nay, even in those darker times, that preceded the reformation, that excellent Aragonian king, *Alphonfus*, the honour both of his title and his times, in spite of his contemplations and his wars, could, (as himself used to glory) spare time from studies and his distractions, to read the bible forty times with comments and glosses on it; being not, for all his astronomy, so taken up with contemplation of heaven, as to deny himself leisure to study in his book, that made it, the ways of getting thither. Nor shall I forbear to mention here the last pope (*Urban* the eighth) who, when being cardinal, he wanted not the hopes of becoming both temporal and ecclesiastical lord of that proud city, which (as if she were designed to be still, one way or other, the world's mistress) doth still rule little less of the world upon the score of religion, than she did before upon that of arms; in the midst of affairs, perhaps more distracting than busied most potentates, and honours almost as great as are paid to monarchs, could find room in a head crowded with affairs enough to have distressed *Machiavel*, for reflections upon the scripture; some of whose portions I have delighted to read in the handsome paraphrases of his pious muse. Which I scruple not to acknowledge, because that though I did, which I do not, look upon every one, that differs from me, as an enemy; yet I should be apt to think, that they can scarce love virtue enough, that love it not in their very enemies; congruously to which we find that *Hannibal* had statues erected in *Rome* itself; and though I were so uncharitable and so unexperienced as to think a man, that holds an error, can scarce have any good qualities; yet upon such a kind of score as that, which made *David* so angry with him, that took away the poor man's single lamb, the fewer commendable qualities I see in my adversaries, the more scruple I would make to rob them any way of them. Nor hath that very sex, that so often makes diversifements of its employments, been altogether barren in titled votaries to the scripture. Not to mention that Grecian princess, whose profelyted ^{Eudoxia} muse made *Homer* turn evangelist, how con-^{wife to the} versant that excellent mother and resembling ^{Emperor} daughter, *Paula* and *Eustochium*, were in the ^{Theodosius} sacred rolls, is scarce unknown to any, that are not strangers to the writings of *St. Hierome*; for,

for some of whose learned comments on the scripture we are indebted to the charitable importunity of their requests. And even in our times, that so much degenerate from the primitive ones, how eminent a student and happy a proficient in the study of the bible, that glory of princeesses, and the envy of the princes of her time, queen *Elizabeth*, was, her life and reign sufficiently declare. Her sister's predecessor, that matchless lady *Jane*, who had all the good qualities the best patriots could desire in a queen, but an unquestionable title, and in whose sad fate, besides her sex and the graces, that enamour ours of it, her country, philosophy, virtue, and religion, did all sustain a loss, was a conspicuous studier of the inspired books; wherein her prospered sedulousness gave her an understanding much above her age and sex, though not above her virtue. And besides *Eudoxia*, there have been divers other persons of the highest quality of that sex, and even some of those, on whom nature or fortune, or rather beauty or providence had conferred a sovereignty, whom the splendour, the pleasures, nor the avocations of courts could not keep from searching in God's word preservatives against the contagion of their condition. And partly history, and partly even conversation have sometimes with delight made me observe, how some of those celebrated ladies, whose fatal beauties have made so many idolaters, have devoutly turned those fair eyes, that were, and did such wonders, upon those severe writings that depreciate all but the beauty of the soul, from those flattering ascriptions, that deified the body. And it is not to be marvelled at, that such readers as are not infidels, by reading the bible once, should be prevailed with to read it oftener; not only because of the inviting excellency of what it teaches, but because its author does so earnestly in it enjoin the study of it, that scarce any can think the neglect of it no fault, save those that are guilty of it. Nor is their so assiduous perusal of the scripture so much to be marvelled at as commended, in persons of that softer sex, which is perhaps more susceptible than ours of strong impressions of devotion. For sure, if we loved God, I do not say as we ought to love him, but as we can, and do love inferior things, it would hugely endear the scripture to us, that the object of our devotion is the author of that book. When a true flame, though but for a fading object, doth once possess a fervent lover's breast, what a fondness doth his passion for his mistress give him for all things related to her? Her residencies, her walks, her colours, and the least trifles that have belonged to her, exact a kindness that's not due to trifles; though it be but for presenting to his memory its almost only object, and refreshing him with an ideal in the absence of an immediater presence of her. But if the favoured amourist be blest with any lines dignified by that fair hand, (give me leave to talk of lovers in their own language) especially if they be kind as well as hers, how assiduously, and with what raptures do his greedy eyes peruse them, tasting each several

expressions with its own transport; and finding in each line, at each new reading, some new delight or excellency? This welcome letter grows sooner old than stale; and all his too frequent kisses have worn it to tatters, (in which he preserves it, if not worships too, as a relic) with still fresh and still insatiate avidities doth the unwearied lover prize that (too often, either deluding or insignificant) writing, above the noblest raptures of poets, and liberallest patents of princes: and (not to urge the superstitious devotion of our worshippers of relicks) certainly if we had for God but half as much love as we ought, or even pretend to have, we could not but frequently (if not transportedly) entertain our selves with his leaves, which (as parrhelions to the sun) are at once his writings and his picture; both expressing his vast and unmerited love to us, and exhibiting the most approaching or least unressembling idea of our beloved, that the Deity hath framed for mortals to apprehend. It was the devout quarrel of a devout father to some of the choicest composures antiquity hath left us, that he could not find Christ named there; and if, as it is not to be doubted, divers of the devout ladies I was lately speaking of, were of his mind, sure at that rate they are not ordinarily kind to the scripture; where the Prophets and the Apostles, those darker and more clear Evangelists, do so unanimously and assiduously celebrate the Messiah, that when I read and confer them, I sometimes fancy my self present at our Saviour's triumphant entrance into *Jerusalem*, Mat. xxi. 9. xi. Mark where both *those that went before him, and those that followed after him, sung hosannas to the son of David.*—Wherefore, since⁹ even great wits, great princes, and great beauties, have not still by all those temptations, to which these attributes exposed them, been kept from being also great votaries to the scripture, it cannot charitably be doubted, but that in most ages some pious persons have been able to say truly to God in *Jeremy's* terms, *Thy words were found, and I did eat them; and thy word was to me the joy and rejoicing of mine heart.* Jerem. xv. 16. And if the persons I mention have been but few, I can attribute that fewness but to the paucity of wise and good men; and as for persons of other ranks in ecclesiastical stories, the instances are not so rare of the addictedness of God's children to his word, but that we might thence produce them almost in throngs, if we had not nobler inducements to the reading of the inspired volume than example; and if it were not less to be venerated, because so many saints have studied it, as because the study of it made many of those men saints, (I mean not nominal, but real ones;) which we need not much wonder at, whilst such a saint as *Saint Paul* was assures us, that it is all of it divinely inspired, and improveable to all the uses requisite to the entire accomplishment of God's servants. But *Theophilus*, to return to what I was formerly discoursing of, the transforming power the scripture has upon many of its readers; I must subjoin, that though through the goodness of God these be far more numerous than the professed adversaries

faries and contemners of the scripture, yet these make not so great a part of those, that acknowledge the bible, as it were well they did, because both experience and our Saviour's parable have sufficiently taught us, that good seed does not always fall into good ground, and that many intervening accidents may, after it has been sown, make it miscarry and prove fruitless. But when you find (as I fear you may but too often) that the scripture has not upon its readers, and especially upon those that are profane, that power, which I seem to ascribe to it, and which it ought to have; you may be pleased to remember, that I plainly suppose in my fifth answer, that those, to whom the scripture is addressed, must not be culpably indisposed to be wrought upon by it. Which that profane persons are, I presume you will easily grant: for when our Saviour said, that *if any man will do the will of him that sent him, he shall know of the doctrine, whether it be of God, or no*; he clearly intimates, that there is required a disposition as well in the eye of his soul, (if I may so speak) as in the object proposed, to make a man discern the excellency and origination of what is taught, how valuable soever. St. Paul speaking of himself and other penmen and teachers of the scriptures, affirms, that they speak wisdom among them, that are perfect, and (though not this world's wisdom, yet) *the wisdom of God in a mystery, even that hidden one, which God ordained before the world, unto our glory*. But for these scornors, it is no wonder they so fruitlessly read the scripture, without descrying any of this mysterious wisdom, it being a sentence of the scripture it self, *that a scorner seeketh wisdom, and [findeth it] not*, (the expression is odd in the original, but I must not stay to descant upon it;) as the Sodomites could not find the angels, when once they fought them to prostitute and defile them.

BUT besides profane wits, there are too many other readers, who are (more or less) guilty of opposing the reforming and improving influence of the scripture, upon their own hearts; either upon the score of their not sufficiently believing the truths contained in the scripture, or upon that of their not duly pondering them. That unbelief is the fruitful mother of more sins than are wont to be imputed to it, and that many baptized persons are not free from greater degrees of it, than they are suspected of by others, or even by themselves, I could here easily manifest, if I had not professedly discoursed of that subject in another place. And indeed, there needs but a comparing of most men's lives with the promises and threats held forth in the scripture of no less than everlasting joys and endless torments, to make us believe, that there are multitudes of professed Christians, to whom may be applied what the writer to the Hebrews says of the perverse Jews of old, *That what they heard did not profit them, not being mixed with faith in them that heard it*, or (as the Greek will bear) because they were not united by faith to the things they heard. But this is not all, for oftentimes the doctrines of the scripture lose much of their efficacy,

even where they are cordially believed, because they are not sufficiently laid to heart. The disparity of the influences of the bare belief and the due perpenion of a truth is, methinks, conspicuous enough in men's thoughts of death. For though that they shall die is so truly believed, that it cannot seriously be doubted; yet how doth men's inadvertency make them live here, as if they were to do so always? Whereas when once grace, sickness, the sight of a dying friend, or some other tragick spectacle, hath seriously minded them of death, it is amazing to observe, how strange an alteration is produced in their lives by the active and permanent impression of that one obvious and unquestioned truth, that those lives must have a period; and to see how much the sober thoughts of death contribute to fit men for it: it being so imperious an inducement to deny ungodly and worldly lusts, and to live *σωφρο- Tit. ii. 12. νως ἡ δικαιοῦς δὲ εὐσεβῶς ἐν τῷ νῦν αἰῶνι, soberly, 12. righteously, and godly in this present world*, that we must one day leave it; that I admire not much that father's celebrated strictness and austeriety, who tells us, that he fancied always founding in his inward ears, that dreadful alarm of, *Surgite mortui, & venite ad judicium*.

YET notwithstanding the indisposition of many readers to reverence and obey the scripture, and notwithstanding that in divers passages of it, the ornaments of language are (for reasons above specified) purposely declined; yet we find not, but that the scripture, for all these disadvantages, is by the generality of its readers both esteemed and obeyed at another-guise rate, than any other book of ethicks or devotion. And multitudes even of those, whose passions, or interests, will not suffer them to be in some points guided by it, are notwithstanding swayed by it, to forbear or practise divers things, in cases wherein other books would not prevail with them. As Herod, though the Baptist could not persuade him to quit his Herodias, did yet, upon John's preaching, do many other things, and *heard him gladly*.—I was Mark xii. going to say, that we may not unfitly apply to 37. the word of God, what divines have observed of God the word; for as those accidents, that loudliest proclaimed our Saviour's having assumed our human nature and infirmities, were attended with some circumstances, that conspicuously attested his divinity; so in those passages, in which the majesty of the author's style is most veiled and disguised, there is yet some peculiarity that discloses it. But I shall less scruple to tell you, that in divers of those passages, in which the Holy Ghost (who in the Greek fathers wonted expression does often συγκαταβαίνειν ἡμῖν, stoop to our capacity, and, as it were, sink himself down level,) seems most to have vouchsafed a condescension to the style of men; and to have commanded his secretaries, as he once did the prophet *Isaiab*, to *Isa. viii. 1 write, בְּחַרַשׁ אִנֹּשׁ Be-chææt Ênoth, with a man's pen*; in divers of those very places, I say, there is something of so awful, and so peculiarly his, that as the sun, even when he descends into the West, remains still lucider than any of the stars; so the divine inspirer of the

John vii. 27.

1 Cor. ii. 7.

Prov. xiv. 6.

Gen. xix. 5, 11.

Heb. iv. 2.

the scriptures, even when his style seems most to stoop to our capacities, doth yet retain a prerogative above merely human writings. *Known unto God are all his works from the beginning of the world*, says an Apostle; and God, whose attribute is to be *καρδιολογός*, *the knower of hearts*, and whose prerogative it is to *form the spirit of man within him, understandeth our thoughts afar off*. Certainly then, if we consider God as the creator of our souls, and so likeliest to know the frame, and springs, and nature of his own workmanship; we shall make but little difficulty to believe, that in the book written for, and addressed to men, he hath employed very powerful and appropriated means to work upon them. And in effect, there is a strange movingness, and, if the epithet be not too bold, a kind of heavenly magick to be found in some passages of the scripture, which is to be found no where else; and will not easily be better expressed, than in the proper terms of the scripture: *For the word of God*, (says it) *is quick and powerful, and sharper than any two-edged sword, piercing even to the dividing asunder of soul and spirit, and of the joints and marrow, and is a discerner of the thoughts and intents of the heart*. Wherefore, that *Junius*, (as himself relates) was converted from a kind of atheit to a believer, upon the reading the first chapter of *John*; that a Rabbi, by his own confession, was converted from a Jew to a Christian, by the reading of the fifty-third of *Isaiab*; that *St. Austin* was changed from a debauchee into a saint, by that passage of the 13th to the *Romans* and 13th verie; and that another father, whose fear had made him disclaim his faith, burst out publicly into a shower of tears, upon the occasional reading of the 16th verse of the 50th *Psal*; are effects, that I do not so much admire, as I do, that such are produced no oftener. And truly for my own part, the reading of the scripture hath moved me to more, and swayed me more powerfully to all the passions it would infuse, than the wittiest and eloquentest compositions, that are extant in our own and some other languages. Nay, so winning is the majesty of the scripture, that many (like those that fall in love in earnest with the ladies they first courted, but out of, what the French call, gallantry,) who began to read it out of curiosity, have found themselves engaged to continue that exercise out of conscience: and not a few of those, that did at first read the new testament only to learn some unknown language it is translated into, or for some such trivial purpose, have been by the means, that they elected, carried beyond the end that they designed, and met a destiny not ill resembling that of *Zacheus*; who climbing up into a sycamore growing in our Saviour's way, only to look upon him, passed thence to be his proselyte and convert, and to entertain him joyfully both in his house and heart. And though it be true, that the church's testimony be commonly our first, yet it is not always our chief inducement to believe the divinity of Holy Writ; its own native prerogatives heightning that into faith, which the church's authority

left but opinion. To which purpose, I remember a handsome observation of some of the ancients; that the Samaritans, that first believed in Christ upon the woman's report, when afterwards they were blessed with an immediate conversation with himself, they exultingly told the woman, *now we believe, not because of thy saying; for we have heard him our selves, and know that this is indeed the Christ, the Saviour of the world*. For so, divers, that first believe the scripture but upon the church's score, are afterwards by acquaintedness brought to believe the scripture upon its own score; that is, by the discovery of those intrinick excellencies and prerogatives that manifest its heavenly origination.—This sacred book, even where it hath not embellishments of language, doth not want them; being so much recommended by its imperious persuasiveness without them, that it is more ennobled by their needlessness, than it would be, by their affluence. And if to some passages of scripture we must apply that of *St. Paul*, (whereby yet he thought to recommend his ministry to the Corinthians) *That his speech and his preaching was not with the enticing words of man's wisdom, but in ἀνοδείᾳ, ἀνεύματι, καὶ δυνάμει*, we may also remember, that he subjoins as the reason, that moved him to use this plain and unadorned way of teaching his Corinthians, *That their faith might not stand in the wisdom of men, but in the power of God*. And truly the efficacy and operations of the bible, in comparison of those of all other books, duly considered, we may esteem, that as God oftentimes doth in the scripture, what in the scripture he is said to do, draw us with the cords of a man, (passages wreathed with flowers of rhetorick) so is it not unfit, that we should sometimes employ expressions, that carrying away our obedience, our reverence, and our assent in spite of our indispositions to them, might manifest their derivation from him, who is not tied to such means, as men would think necessary, but can compass his ends as well by as without any. Nor can I often consider the instances experience affords us of the efficacy of many texts, (which some that pretend to eloquence accuse of having none) without sometimes calling to mind, how in the book of nature God has veiled in an obscure and homely stone an attractiveness (unvouchsafed to diamonds and rubies) which the stubbornest of metals does obsequiously acknowledge. And as the loadstone not only draws what the sparklingest jewels cannot move, but draws stronglier where armed with iron, than crowned with silver; so the scripture not only is moverger than the glitteringest human styles, but hath oftentimes a potenter influence on men in those passages, that seem quite destitute of ornaments, than in those, where rhetorick is conspicuous.

I SHOULD now, *Theophilus*, immediately pass on to the other things I am to discourse to you of, concerning the scripture, but that the curiosity, wherewith you are wont to take notice of my practices, and to make inquires after my private opinions, makes me imagine you telling me, that I do often read, and do much oftener commend books of devotion,

notwithstanding all the prerogatives I have attributed to the scripture: wherefore to this I shall answer, that I esteem indeed the truths of scripture so important and valuable, that I cannot be troubled to see them presented to us in variety of dresses, that we may the more frequently and the more attentively take notice of them. And though some devout compositions are so unskillfully written, as to be much fitter to express the devotion of the writer, than to excite it in the reader; yet there are others so handsomely and so pathetically penned, that a good man can scarce read them without growing better, and even a bad man must be very much so, without becoming less so by perusing them. Nor do I at all design to disparage books of devotion, when I prefer the scripture to them; that being so noble and matchless a work, that a book may attain to a high degree of excellence, whilst it remains inferior to the scripture, and of whose preheminencies I have already on several occasions named divers to you; and therefore shall at present only recommend to your observation this one advantage of the scripture, even as to those things, that are also to be met with in other books of devotion; That if *the words of the wise be* (as Solomon tells us they are) *like nails fastened by the masters of the assemblies*, the self-same nail must enter less or deeper, according to the strength of the hand that drives it in; and doubtless, any doctrine believed to come from God, in the same terms it is delivered to us, is like to be entertained with a deeper and obsequiouser respect; concurrently whereunto, the Apostle, to set forth the Thessalonians reception of the gospel, says, *That they received it not as the word of men, but (as it is in truth) the word of God.* After which, it is no wonder he could immediately subjoin, that *it did also effectually work in them that believed.* And though it be very true, that the foreignness and obscurity of some texts will require, as well as the teeming richness of others will bear, their being alledged in words much more numerous than those, whose involved or contracted senses they are to display; yet is it also as true, that men do not unfrequently mistake themselves in thinking to deliver the Holy Ghost's conceptions in fitter terms than his own, the proper precise expressions of scripture being oftentimes so pathetic and finewy, that he, that stretches them, enervates them; and paraphrases, though handsome, do as much wrong them, as a mixture of silver, though no ignoble metal, does wrong an ingot of gold. And though some texts, like pearls lose indeed of their beauty, but operate, and are administered more successfully beaten to powder, or with other cordial ingredients made up into a confection; yet divers sacred expressions do like diamonds lose both their sparkling lustre, and engraving faculty, when ground to dust, and lose more in their entireness and form than can be recompensed by any addition. And truly, as to my own particular, no book of devotion doth constantly affect me so powerfully as the bible. And whereas I am of so nice a palate, that in

my esteem compositions of that kind still lose at the second reading; in the inspired volume, familiarity breeds not contempt, but reverence, (and I like a book, acquaintance still endears.) When I first began attentively to read the scripture, and (according to my custom when I read books, whereof I have a promising expectation) to mark in the margin the passages, that seemed to deserve a peculiar notice or reflection, I marked but here and there some verses in a chapter; but when, upon a greater familiarity with the idiotisms, the sense, and the applicableness of scripture, I came to survey it, I then in some places marked the whole chapter, and in most others left much fewer texts than before unfurnished with some mark of reference. And whereas at my entrance I took even the choicest part of the bible to be at best but like some Indian province, wherein though mines and gems were more abundant than in other countries, yet they were but sparingly to be met here and there: after a competent stay, my ensuing perusals presented it me, if not as a royal jewel made up of gold and precious stones, yet (which is gloriously) like Aaron's breast-plate, a sacred jewel, the particular instructions, for which were given by God himself, and which, besides the various number of flaming gems set in fine gold, and placed in a mysterious order, was ennobled by that *Urim and Thummim*, wherein God vouchsafed to reveal himself to mortals, and was adorned with so much cunning work in gold, blue, purple, scarlet, and fine twined linen, that the contrivance and workmanship lent a lustre to the glittering materials, without being obscured by them. This experiment keeps me from wondering to find in the inspired poet's description of the man he attributes a blessedness to, that his *Chaphatz* is in the law Psal. i. 2. *of the Lord, and in his law will he meditate day and night.* For the word other translations render *voluntas & studium*, ours Englishes delight; and indeed the Hebrew *חכמה* will bear both senses, and seems there emphatically to signify a study replenished with so much delight to the devout and intelligent profecutors of it, that, like the hallelujahs of the blessed, it is at once a duty and a pleasure, an exercise and a recompence of piety. And indeed, if God's blessing upon the devout Christian's study of that book do (according to the Psalmist's prayer) *open his eyes to discern the נספלות* Psal. cxix. *Nispaot, hidden wonders* contained in it; he should, in imitation of him that in the same Psalm says of his God, *I rejoice at thy word, as one that findeth great spoil,* Verf. 162. be as satisfied as navigators, that discover unknown countries. And I must confess, that when sometimes, with the Apostles in the mount, I contemplate *Moses* and *Elias* talking with Christ, I mean the law and prophets symphonizing with the gospel, I cannot but (resemblingly transported with a like motive) exclaim with *Peter*, *it is good for me to be here;* and cease to think the Psalmist Mat. xvii. *an hyperbolist, for comparing the transcendent sweetness of God's word to that inferior one of honey, which is like it in nothing more*

Eccles. xiii.
11.

1 Thess.
ii. 13.

more, than in that, of both their suavities, experience gives much advantageous notions than descriptions can.

BUT, *Theophilus*, upon condition you will not call this excursion of your own occasioning a fit of devotion, I will no longer detain you on one subject, but forthwith proceed to discourse of those other things, that I am to consider in the scripture, besides the style. For though this be such as I have been representing

it, yet I hope we shall in our progress find, that it will be far less fit to apply to this matchless book than that of the Heathen poet,

Materiam superabat opus—

than that sacred one of the Psalmist, where he as well says, that *the king's daughter is all glorious within*, as that *her cloathing is of wrought gold*.^{Psal. xlv.}

OCCASIONAL
REFLECTIONS
UPON
SEVERAL SUBJECTS.

Whereto is premised

A DISCOURSE about such kind of
THOUGHTS.

Omnibus rebus, omnibusque sermonibus, aliquid salutare miscendum est. Cum imus per occulta naturæ, cum divina tractamus, vindicandus est à malis suis animus, ac subinde firmandus. Sen. Natural. Quæst. Lib. 2. cap. 59.

To *SOPHRONIA.

My dearest Sister,
YOU receive, in this effect of my obedience, one of the highest proofs I can give you of its greatness. For when you command but things, that tend to your service, the performance is wont to be accompanied with a satisfaction, that suffers me not to find it uneasy. But I confess it was not without reluctance, that I was prevailed with to venture abroad compositions, wherein, even when I publish them, I decline owning them; and which (if our names be discovered) may, I fear, not only hazard the reputation (if it have any) of my pen; but, (where you are less known) bring into question that of your judgment. It was easy for me to represent to you, how unfinished and unpolished the trifles you called for were; especially considering, that the immaturity of some of them would not probably be the chief thing, that would make many think they come forth unseasonably, since they avowedly aim at the persuading and teaching men to improve their thoughts, as well as husband their time, at a season, when both those precious things are

so neglected, or so mis-employed, that the chief use, which too many make of the former, is to devise ways to get rid of the latter. But though, to my unreadiness to publish these very long neglected papers, at the same time when a pre-engagement obliged me to dispatch another treatise of a quite different nature, I added all those other dissuading considerations, that I have mentioned in the preface to the reader; yet what I represented proved as unavailable, as what I had written was incomplete. For, whilst you fancied, that the following reflections (such as they are) had fewer faults, and were like to do more good, than I can presume; your charity for others, and partiality for me, made you so resolute and pressing to have me run a venture, which you are pleased to think but a very small one, that I judged it more excusable to present you green fruit, than, by obstinately refusing what you seemed almost to long for, lose an opportunity of evincing, that your commands can prevail, both where those of others would have been wholly ineffectual, and when they required me to present you (some, if not many,) things, that

* It is the name given to the same lady in the 2d section of the following meditations,

that are so little worthy of you, that perhaps they are scarcely so, even of me.

WONDER not, dear *Sophronia*, that I appear so solicitous to manifest the greatness of my obedience; since that implies an urgency in your commands, that it highly concerns me to have taken notice of. For those, that, having the happiness to converse with you, shall chance to cast their eyes upon the following papers, will probably think, that I shew as little discretion in the address, as I have shewn skill in the writing, of these reflections; when I expose such censurable things to the judgment of a person, that has so piercing a one, and present trifles to one, that deserves the noblest productions of (what she is so great a mistress of) wit, and eloquence. Upon whose account she is wont to persuade piety as handsomely in her discourses, as she expresses it exemplarily in her actions; and might, if her modesty did less confine her pen to excellent letters, both make the wits of our sex envy a writer of hers, and keep our age from envying antiquity for those celebrated ladies, who, by their triumphant eloquence, ennobled the people of *Rome*, and taught their children to sway those rulers of the world.

BUT when I can plead, that not only your commands, but even your importunity engaged me (though not to the address, yet) to the publication of these papers; I may reasonably hope, that among those many considerable persons, to whom your attainments are not unknown, not only my dedication will be excused, but even my book will not be so hastily condemned.

BUT I dare not prosecute so fruitful a subject, for fear of offending your modesty; since that predominant virtue gives you so great an undervaluation for all your other qualities, that it is as much your custom to look even upon small praises as flatteries, as it is your prerogative to keep great ones from being so. And I should therefore have omitted that little itself, which I have said, if, on this occasion, my interest did not as well oblige me, as the known truth warrant me, so to consider your modesty, as not to be altogether injurious to your other excellencies; since the reader's knowledge of these (if he be not a stranger to you) will promise me this advantage, that divers of the criticks themselves will chuse rather to absolve my writings, than condemn your judgment; and that at least the devout, to whom your practice has afforded so many other examples, will be scrupulous to be more

severe to these papers, than a person, in whom, upon the score of her own style, severity were more justifiable than in most readers, (without excepting the eloquent ones;) and will imitate her, in considering, that this book pretends to present them thoughts, rather than words; and in supporting, for the sake of the design, the manner, in which it is prosecuted.

AND certainly, my lady *R*'s approbation is a happiness, which divers sorts of considerations may render as advantageous as welcome to me. For if any of these thoughts do (which yet I can scarce hope) derive it from your justice, that great measure of esteem you do not only merit, but possess, may both assure them of a general one, and much contribute to procure it them. But if all of them owe your approbation (as I fear they do) to your partiality; since that must not be small, to be able to pervert such a judgment, this it self will prove an evidence of the blessing of your affection; which is a felicity, that I know you enough to value above all the praises I can wish of: since applause can make me happy but in other men's opinion, but your friendship can make me so in my own. Yet, apprehend not, sister, that I should here endeavour, by a solemn character of you, to justify what I have been saying; for, though to write a dedicatory epistle, without a panegyrick, be grown of late very unfashionable; yet since it is as much so, to take the praises wont to be profusely given in such letters for measures of any thing but the writer's wit, I must rather reserve the acknowledgments I owe your merit and your favours, to some occasion, where they may not be liable to pass for a tribute paid to custom, not a debt due to you, than draw a needless suspicion upon the sincerity of our friendship, by endeavouring to express my affection and esteem in a dedicatory letter; and by chusing to profess, upon an occasion where custom allows men to say what they do not think, so great and real a truth, as that of my being, far more upon the account of esteem and gratitude, than of nature it self,

My dearest Sister,

Your most affectionate,

and most faithful Servant,

R. B.

AN INTRODUCTORY PREFACE.

WHEN I consider the disadvantages, with which the following trifles come abroad, in an age, that is not only so censorious, but so intelligent, as this of ours; neither the partiality of my friends, nor the favourable reception, that the publick has hitherto vouchsafed to what hath been presented it of mine, is able to give me a confidence, (though they almost create a hope) that these papers will meet with as kind an entertainment, as those of the same hand, that have preceded them. And yet, without being wanting to my self, I cannot but add, that by the help of their suggestions, who have urged the publication of these thoughts, I am not unfurnished with (at least) tolerable excuses for the things, that seem likely to stand in need of any.

I SHALL not much wonder to find it said, that the book is, in general, far short of being an exact and finished piece. For perhaps few readers will be more of that mind, than the author is. But by way of apology, it may be represented, that most of the following papers being written for my own private amusement, a good deal of negligence in them may appear as pardonable, as a careless dress, when a man intends not, nor expects, to go out of his study, or let himself be seen. And that which I now publish being designed, not to satisfy the critics, but to gratify the devout, I hope it will be thought a venial crime, if in some of these meditations I have not aimed to express eloquence, but only to cherish piety. I say in some, because there may be others (where a different style was thought fitter) in whose favour I would produce such suffrages, as would not be slighted, if I were concerned to do any more for those papers, than excuse them.

AND perhaps they, that shall take the pains to try their skill in making meditations indifferently upon the occurrences that shall happen, and wander no farther from the circumstances of their themes, nor lard them any more with sentences and other passages borrowed from the fathers, or the poets, than in most of the following papers I have done; will not find the task so easy, but that they will think it reasonable to be mild in their censures, and will discern, that in such compositions, some unaccurateness is so hard to be avoided, that it should not be hard to be forgiven.

I KNOW the want of uniformity in the style of the ensuing reflections may speciously enough be censured. For, not to mention, that some of them are very long, and others very short; it will be said, that some are written in a very neglected, and others even in a luxuriant strain; and there may (perchance) appear betwixt some of them as great an inequality as can easily be found betwixt compositions, that are none of them excellent. Besides

that the incoherence of the subjects, together with the differing ways wherein they are handled, may make them look so little of kin to one another, as scarce to appear the productions of the same pen. But this uneven way of writing will possibly be rather pardoned than wondered at, by those, that shall be informed,

THAT the nature of this kind of compositions requires not any other, than a loose and desultory way of writing.

THAT these reflections are very far from coming abroad in the order of time, wherein they were set down; but in that casual order, wherein, when I was engaged to tack them together, I was able to light on them among my loose and forgotten papers. Many of which being discovered to have been lost, when some of the rest were to be at the press; I was fain, for the completing of the number, to insert here and there some of a much fresher date, among those that were made (as some know, who then read them) sixteen or seventeen years ago, when my style could hardly be other than differing enough from what it now is.

AND lastly, that the differing natures of several subjects required, that the reflections on some of them should be far longer than others. And as my want of leisure, and sometimes of disposedness to write, induced me to make some of my considerations but short; so I thought fit to let them pass for their sakes, to whom, for want of time or skill, the brevity of those may make them the fitter, and the more recommend them.

BESIDES what has been alledged against the style, I know it may be objected, that in some of the meditations the subjects are very mean, and trivial; and that such themes are not worthy the being descanted on. And indeed, if I aimed at the writer's advantage, more than the reader's, I could easily have left them out, and have substituted in their places some others, that lie by me, less liable to contempt. But I confess, I did not think myself obliged to publish no meditations, but the least censurable ones that I had made; and divers of those intimated in the objection were purposely inserted, when I was prevailed with to bundle up these loose sticks into faggots. For then, designing this treatise for the benefit of the generality of devout readers, I thought it not amiss, amongst divers reflections, (such as most of the second, and of the fourth sections) more suited to those perusers that are either of the more intelligent sort, or good proficients already, to insert some few meditations, of a more familiar sort, and easier to be lighted on; to keep those from being discouraged from trying to make occasional reflections, who may chance to have either barrenner fancies, or more unpractised pens, than even I had then. And those (perhaps) who,

who, without such easily imitable examples, would not be invited to make occasional meditations, may, by the practice of composing them, grow such proficient in the art, as to surpass some, that despise such humble beginnings.

BUT as I send abroad these papers without the author's name, that I may have the greater opportunity to hear other men's opinions of them, and the less temptation to waver the complying with those that shall seem reasonable; so if I shall find, that such readers, as I esteem competent judges in an affair of this nature, shall think, that those reflections, wherein I have complied with the weaker sort of perusers, may be better spared, than I inserted; I can easily repair that fault in the next edition, (if these trifles shall be thought worthy of another.) In the mean time, I presume, that those devout readers, who may be concerned in this matter, will take it kindly, that I have, for their sakes, adventured to treat of subjects too mean and barren to furnish me with almost any thing considerable, save the opportunities of manifesting, how low I can stoop to gratify such persons.

I KNOW it is a new thing, that I have ventured to put some occasional reflections into dialogues. But the reader will be less startled at my deviating in this, and other things, from bishop *Hall's* way of writing occasional meditations, if I acknowledge, that not to prepossess or bias my fancy, I purposely (till of late) forbade my self the perusing of that eloquent prelate's devout reflections. Which intimation being premised, I shall subjoin, that when I wrote for my own divertisement, I sometimes took pleasure to imagine two or three of my friends to be present with me at the occasion, that set my thoughts on work, and to make them discourse, as I fancied persons, of their breeding and tempers, would talk to one another on such an occasion. And one of these, whom I call *Eusebius*, being a Doctor of divinity; two others (*Eugenius* and *Genorio*) being travellers and fine gentlemen; and the fourth, (whom I name *Lindamor*) being a learned youth, both well born and well bred; I was apt to think, that some of their conferences might be allowed to pass among the other papers; both because novelty, and variety, are wont to be not unwelcome things, and because this way of writing allows a scope for diversity of opinions, for debates, and for replies, which most commonly would be improper, where only a single speaker is introduced. Not to add, that possibly if this way of writing shall be liked and practised by some famed and happier pen, that were able to credit and improve it; it may afford useful patterns of an instructive and not unpleasent conversation: and such reflections, being of the nature of short and occasional essays, may afford men the opportunities of saying the handsomest things they know, on several subjects, without saying any thing else of them, or filling above a sheet, or perhaps a side of paper at a time. And the liberty, that this way of introducing speakers allows, brings with

it a conveniency, which it is more easy for an intelligent reader to conjecture at, than it were discreet for the writer to mention expressly.

ANOTHER novelty will probably be taken notice of in the following papers, where the second and fourth sections, though by far the longest in the whole book, are intirely taken up; the former only by meditations on accidents relating to an ague that once afflicted me; and the latter by those, that occurred to some anglers by the river side. But for this matter, I presume, it will not be difficult to apologize. For having observed men to be inclinable, either openly to object, or at least tacitly to suspect, that in occasional meditations, that may hold true, which is (perchance not altogether undeservedly) said of epigrams, that in most of them the conceits were not suggested by the subjects, but subjects were pretended, to which the conceits might be accommodated; I thought, that to manifest, that (at least, some) writers of this kind of composures need not have recourse to the suspected artifice, the fittest way I could take was, by putting together, what the accidents of my ague, and of my angling journey, had suggested to me, to shew, that it is very possible for a person, that pretends not to a very pregnant fancy, to discourse by way of reflection upon the several circumstances, that shall happen to occur to his consideration, though one subject should require above fifteen differing meditations, and the other above twenty. Not to add, that it was rather weariness and design, than want of thoughts upon other passages relating to the same subjects, that kept me from increasing the number of those reflections.

As for the similitude, though some would make me hope, that they will be at least excused; and though it were perhaps no great vanity for one, that does assiduously enough converse with the works of nature and the productions of art, to think he has the means of furnishing himself with pretty store and variety of comparisons: yet for all this, I am not willing to quit my pretensions to a share in the wonted effects of that common equity, which forbids to exact too accurate a likeness in the making of comparisons, which orators confess ought to be judged with indulgence, and without exacting a conformity in other attributes betwixt the things compared, provided there be a competent likeness in reference to the particular, wherein the collation or parallel is made.

AND if I have, on some occasions, profecuted the resemblance through all the particularities, wherein the parallel could be made to hold, more fully and nicely than is usual in ordinary comparisons; and if in so doing I may have at any time a little strained the similitude, the better to accommodate it to my present theme, and design; I have this to represent, that to display resemblances to the full, and insist on their particular circumstances, is oftentimes no more than the nature of these composures does allow, if not require; and that, on such occasions, to stretch the parallel

as far as it can well be made to reach, is but a venial fault, which many readers are disposed not only to pardon, but to like. As if, in some cases, it fared with similitudes as with bows, which they though they may be bent so forcibly, as to be thereby broken or spoiled; yet by being strained somewhat more than ordinarily, they acquire a greater strength, and enable the arrow to pierce farther, and to make a smarter impression, than else it would.

THE protasis (as rhetoricians call the first part of a comparison) may in some of the following reflections appear to be too much amplified, and needlessly to lengthen the meditation. But not to urge, that sometimes the more conspicuous adjuncts of the subject were so mean and barren, that there was a kind of necessity to exaggerate, or to expatiate upon little circumstances to invite attention; the protasis, wherein we display and consider the minute particularities of the theme, being the ground-work of all the rest, and it being far more easy to say little, than much, with equal pertinency upon a subject; I thought it not amiss, to afford unpractised readers the most assistance of examples in such cases, wherein it is probable they will most need it; especially since he, that has accustomed himself to write copiously, may easily contract his discourse when he will, by omitting as many passages as he pleases; and it is far more difficult for a beginner to supply barrenness, than retrench superfluities. Which are not always such faults, but that I remember some great masters in the art of oratory have pronounced redundancy to be a good sign in a young writer, as taking it for a mark of a fruitful and exuberant fancy, that, in its productions, there is something to be cut off. So that if there should be found any luxuriant expressions in some of those thoughts, that were written down, when I had not yet attained my 19th or 20th year, when I might be allowed to write not always to employ, but sometimes to amuse my self; I may hope, that the same youth, that was my temptation to write them, may prove my excuse for having written them, as it may for leaving them unexpunged; that as I desire to invite as well young gentlemen as other readers, to pen occasional meditations; so I find, that some of the readers, I am willing to pleasure, do as little dislike that luxuriant way of writing now, as I did then: as youths and ladies oftentimes better relish must than wine.

I KNOW too, that there may be found, in some of those protases, divers passages, and particularly some descriptions (that often make a great part of them) which to some readers will not seem noble and gaudy enough. But to such perusers it may be represented, that a suitability to the theme, how mean soever it be, may very well, as a piece of decorum, be allowed to a writer, and in few cases more than in point of descriptions; and that these being but pictures drawn (with words instead of colours) for the imagination, the skilful will approve those most, that produce in the mind, not the finest ideas, but the likest; as a critick in limning will more prize the picture of

an old meagre Sibyl, where the wrinkles and the fallow skin are drawn exactly to the life, than a dozen ordinary pictures of the spring, (which yet are wont to charm vulgar eyes) though the youthful face, which represents that florid season, have as gaudy colours upon the cheeks and lips, as imbellish the roses and lilies, which compose the chaplet that adorns the head.

AND possibly there will be found other readers (and those too skilled in rhetorick) that will accuse some other of our meditations, as being too elaborate, or too pompous, for the themes, whereunto they are accommodated. But having laid by a competent number of those lately mentioned reflections, wherein I aimed chiefly at inviting and assisting readers of meaner capacity; I confess, that in the other meditations, aiming either at my own divertisement, or the gratifying another sort of persons, I allowed my self to make choice of such applications of the objects I considered, as I thought every body would not so easily light on. And, provided the reflections were not strained, nor too far fetched, I thought it not amiss they should be somewhat surprising; that I might by the way of handling the subjects I was to treat of, ingage an attention, which otherwise I could scarce expect for such unpromising themes. I know, that if the judgment of some severe criticks were as infallible as themselves think it, the style of some of the following reflections would seem disproportionate to such mean and trifling subjects. I do not perhaps ignore what rhetoricians are wont to teach, of what they call the three differing characters of writing; I have read those discourses, that *Cornificius* proposes as the patterns of the sublime, the moderate, and the humble way of expressing one's self on differing occasions; and I have been taught, and willingly acknowledge, that all themes are not so well capable of that character, which they call sublime; and that, according to the nature and dignity of the subjects that one treats of, the manner of handling them ought to be varied. But if I were much concerned in this matter, I might reply, that notwithstanding all this, I know, that even the artists themselves do not so perfectly agree about the defining of these matters; and the grand rule about these characters being only, that the laws of decorum (or, as the French call it *bien-seance*) be not violated, in the estimate of that decorum, I see no great reason to confine my self to the magisterial dictates of either ancient or scholastick writers. For, living in this age, and in this part of the world, where we are not like to have those for readers, that died before we were born, I see not why one may not judge of decorum by the examples and practices of those authors of our own times and countries, whose writings are generally esteemed by judicious men.

AND certainly, in the judging of what is decent on particular occasions, we must as well consider, who it is that is introduced as the speaker, as what it is he speaks of. And though

though it be improper to do what those have done, that have unadvisedly made shepherds and nymphs discourse like philosophers or doctors of divinity; yet when the writer either speaks himself, or introduces any, whom he represents as intelligent persons; they may be allowed, even about things ordinary and mean, to talk like themselves, and employ expressions that are neither mean, nor ordinary. As *Virgil*, in his admired *Georgicks*, does in some passages, where he treats of contemptible insects, speak of them in so noble and lofty a strain, that when he mentions multitudes of ants, one would think he were speaking of an army of Moors; and when he gives an account of bees, his expressions about their common-wealth would scarce misbecome the majesty of that *Rome*. Such passages do, notwithstanding the great disparity of themes, make the style of his *Georgicks* as well noble (if not strictly heroic) as that of his *Æneids*; and when he writes of ants and flies, he does it in a strain worthy of the same pen, that so loftily describes the destruction of *Troy*, and the adventures of that hero, whom he would have to be (thought not immediately) the founder of *Rome*.

*It nigrum
campis ag-
men.*

I WILL not say, that since there is a mode in language as well as in clothes, I see not, why the fashion, that now-a-days allows our gallants to wear fine laces upon canvals and buckram, might not warrant the tricking up of slight subjects, with the richer ornaments of language: nor will I examine, whether men may not except against the authority of some jejune writers, that taking upon them to prescribe the laws of style, make so many of their precepts negative, that one may suspect them indited not so much by skill, as envy; which makes such assuming law-givers mistake the impotence of a barren fancy for the skilfulness of a critical judgment, and (valuing only the ideas they think they can reach) condemn whatever they despair to imitate. And, from those, that would be thought to censure the moderns, but out of a veneration for the ancients, one might, methinks, reasonably expect but light censures for employing upon occasion that noble figure of rhetoric called hyperbole; since I should be loth to use it often, with no more reserve, than those great orators, *Tully* and *Isocrates*, have sometimes done before me. But a just debate of the rules of estimating the decency would take up so much room, as must make it improper for this place; where all I contend for is, that though when one treats of various subjects, somewhat differing styles are indeed to be accommodated to them; yet this is to be so done, as still to preserve a certain dignity in expressions. So that a writer may be sometimes engaged by his subject to use a lofty style, but without ever being obliged to employ an abject one; though indeed in some cases he may be allowed to stoop below what he is bound to, and forbear soaring, as well as avoid creeping. Nor am I, for my own part, much concerned to insist here on the subject I just now declined to debate. For if I misremember not, *Cicero* himself, as well as some succeeding orators, allow in di-

vers cases to shift characters, even in the same discourse, according to the differing particulars, that happen to fall under consideration; and some of them add this reason, that hence there will arise variety, which is wont to be a welcome thing. And to apply this to the occasional reflections, that may be concerned in this debate, I must desire the reader to take notice of these two things: the one, that though the thing it self, which sets a man's thoughts at work, may be but mean in other regards, yet that, which the reflector pitches upon to consider, may be of another nature; as though the glow-worm, which afforded me the IVth. reflection of the Vth section, be but a small and contemptible insect, yet the light, which shines in his tail, and which makes the chief theme of the meditation, is a noble and heavenly quality, and might have justified the having many things said of it, for which the sublime character would have been the most proper. The other particular I meant to point at, is, that oftentimes, when the protasis, or former part of a reflection, is spent upon considering some mean and trivial subject, the apodosis, or reddition, contains such an application of what one was taking notice of in the subject, that the thing pointed at may be some important moral instruction, or perhaps some theological mystery; and consequently may require and justify another than the former humble style, and admit all the quickness of expression and the richest ornaments, that belong to those two higher characters, which rhetoricians call the subtil, and the magnificent. But if I should now and then deviate from bounds, which, not being conspicuous, it is difficult never to swerve from, I have this peculiar apology to make for such aberrations; that writing for the most part of themes wholly new, and untreated of by others, I must needs want the assistance of examples to regulate or authorize my expressions; about which I need not be yet very solicitous, if I may trust a learned and applauded writer (whose censure I desired) that is both able to judge skilfully, and wont to judge freely.

THESE things I have the more carefully insisted on, because I would not have those ingenious persons, that may chance to cast their eyes on these papers, to be tempted by any imperfections of mine, to think otherwise of occasional meditations, than that though there be some, yet there are not very many, of their themes so low and contemptible, but they are capable of affording reflections of another nature to them, that are dextrous in making application of things. And I would not have such discouraged from hoping to find in many themes, that seem despicable at first sight, some hint or other, that may give those, that have wit or eloquence, opportunity enough to display those qualities. For as there is a great difference betwixt such writers, and common ones; so it is very material by what pens the subject is treated of; and extraordinary persons, in estimating what they are like to perform, must not only consider the unpromising nature of their subject, but the activity

vity of their own fancy, and the pregnancy of their own wit. For though the stars cannot, the luminaries can, clothe the light and wandering vapours of the air with the colour of gold, and of roses; and the sun, by his piercing and improving beams, cannot only make diamonds sparkle, and rubies flame, but by his action upon an obscure cloud can make even that exhibit all those glorious and charming colours, for which we admire the rainbow.

AND, that the following papers may prove to such persons the lesser temptations to undervalue and mis-judge of this kind of composures; I am first to advertise the reader, that they are capable of so much greater variety, than the following treatise presents, that besides the vast multitudes of particulars unmentioned in it, that may be added under those heads, to which the ensuing meditations are referred, there are several distinct sorts or kinds of occasional thoughts, (such as those, that are made upon texts of scripture, or relate to less familiar points of divinity, or other learning, or contain historical applications, &c.) upon which I have, out of haste, and other reasons, purposely forbore (though not to write, yet) to publish reflections. And in the next place, I must here frankly acknowledge, that many of the ensuing reflections are so far from being the best, that even no better a pen than mine could make, that they are much inferior to divers, that I have already made; though (for allowable considerations) I have forbore to publish them. And I must confess, that I am more beholden to my occasional reflections, than they are to me. For, whereas they have furnished me with divers of the thoughts, which have been the favourablest entertained by the readers of my other books of devotion; I did much impoverish these papers, that professedly contain my occasional reflections, by not only leaving, but taking out of them several things, which were the most likely to have recommended them; that I might accommodate other writings, for which I had a greater kindness or concern.

As for the *Discourse of Occasional Reflections*, all that I shall say of it, is, that considering how early I attempted that subject, and that I was fain to repair, as well as I could, the unseasonable misl of divers papers belonging to it, when I dispatched it to the press; considering these things (I say) I despair not, but that it will be thought, that I have not said nothing in favour of a subject that hitherto had so little said to recommend it, that even the eloquent Bishop Hall*, employing but some lines, not pages, upon the praise and utility of it, (which he mentions but in very general terms) left me to find out, by my own thoughts and experience, the various considerations, by which I have endeavoured to display the usefulness of the way of thinking I would invite to. Which I have further manifested, by applying to that scope divers passages of scripture, (which the reader must therefore not wonder, if he do not now meet with) as texts, that either by way of example, or upon other accounts, be-

long to what I have written about the method of making occasional reflections.

It is true, the discourse may seem somewhat incompleat, because of the omission of this way, that is more than once mentioned in it.

BUT though the loose papers, wherein that method, and divers examples of it, are set down, were lying by me, when I tacked up those that now come abroad; yet my occasions easily prevailed with me to continue to suppress them. For though I did not much scruple to comply with my haste, and avocations, by forbearing to swell a book, whose bulk already much exceeded my intention; because that, as the papers, that now appear, were extorted from me, so I confess, that I was not fond of exposing those, that I had an expedient to keep back: but that I think it very fit to observe, first, whether the reception, that the following meditations will find, will make me and others think it worth while to have the ways published, that I was wont to use in making them.

I HAD almost forgot to intimate, that some urgent avocations having obliged me to send the following treatise to the press without reading it over my self, I now find, that my haste will make me need an apology to those readers, that expect to have the passages and phrases of scripture printed in a discriminating letter, and quoted in the margin. For though in books of positive, or of controversial divinity, I confess I have often observed a margin, stuffed with a multitude of citations, to contain divers so un-concluding, if not impertinent, that the number does better shew the author's memory than his judgment; yet in books of devotion, I am not much averie from complying with the generality of readers, who expect to be informed by the margin, where they may find those stories, and expressions, which their being borrowed from an inspired book, make more operative and emphatical. But I must on this occasion further intimate, that as to those citations of passages of scripture, wherein I may seem to have mis-recited the words of the text; though as to some of them, that were set down when I had not a bible or concordance at hand, my memory may have deceived me as to the words (which is no more than has often happened to the fathers themselves in the like case, and is a venial fault, where dogmatical or polemical divinity are not concerned) yet oftentimes my variations from the English version were made on purpose. For having had the curiosity to get my self instructed, as well by Jews as Christians, in the eastern tongues (especially the Hebrew,) I thought I need not strictly confine my self to the words of our translators, whenever I could render the meaning of a text in such terms as to me seemed proper or expressive; or, without injuring the sense of the Hebrew or the Greek, could better accommodate my present purpose.

Now whereas some may think, that in this preface I employ excuses, that seem (some of them) not to agree with one another; I desire it may be considered, that the meditations they relate to, being not only written upon differing subjects, but (which is more) designed for

* In the latter part of his preface, where of the whole amounts not to one page of this preface.

for very differing uses (some of those discourses being intended to invite the more unskilful, and encourage the more despondent sort of readers, and others, to entertain proficient) it was but requisite, that I should, by every differing (and, perchance, seemingly repugnant) considerations, give an account of such differing ways of writing them, as such distant subjects, and my scope, required.

BUT what if it should fare with me now, as it has done on other occasions, on which my friends have accused me, of framing more objections against my self, than were afterwards made against me by my readers? I dare not say it is impossible, but that this may prove the case. But if it do so, I shall not yet think my self to have altogether missed my aim in what I have hitherto represented. For I have mentioned the more particulars, and discoursed the more largely of them, that if they prove not needful apologies for my reflections, they may prove useful considerations for those, whom I would invite to exercise their pens in some such way of writing; divers of whom will probably be encouraged to venture upon making such composures, when they find excuses for divers of those things, that are the most likely to be thought to blemish such essays, (or dishearten beginners from attempting them) to be drawn up already to their hands. But as for my own particular, if I could make none of the apologies now insisted on for the imperfections imputable to this treatise; yet I should not be destitute of a very just excuse for the publication of it. For divers devout persons, that had more partiality for these writings, and less tenderness of my reputation, than I could have wished, having long sollicitated the publication of those they had in their hands, were at length so resolved to effect it, that, in spite of the promises I at length made them to comply with their desires, when some other writings I was then about should be dispatched; I was fain to make use of a legal artifice to hinder for a while at the Stationers hall the publication of divers papers, that I had not so much as read over.

BUT I confess I take notice of these passages, rather to excuse those imperfections, which haste may have occasioned in these immature productions, than to apologize for writing on such a subject. For so many advantages, that may accrue to a devout and skilful person, by assiduously making of occasional meditations, have been displayed in the discourse, that is premised to those that follow; that I hope the former part of this book will sufficiently apologize for my having written the latter; especially if to the other particulars proposed in the newly named discourse, as things fit to recommend that kind of thoughts, I here be allowed to add, that a man's devotion may not alone be cherished by occasional meditations, upon the account of those, which every private Christian makes for himself, but by the help also of those, which he finds made by others, or intends for them. For not only whilst pious reflections are making, they are proper to instruct the mind, and warm the affections;

but the objects, upon which such meditations have been made already, either by our selves or others, do revive the memory of those good thoughts that were suggested by them. So that when diligence and proficiency in the practice of our Meletemicks shall have supplied us with religious, and handsome reflections, upon the most obvious works of nature, and the most familiar occurrences of human life, devout persons will have the advantage to live almost surrounded either with instructors, or remembrancers. And when they want skill, or are indisposed to extract spiritual things out of earthly ones, they may, without racking their invention, be furnished with good thoughts, upon many objects, by their memory. For (as I elsewhere more fully declare,) those truths and notions, that are dressed up in apt similitudes, pertinently applied, are wont to make durable impressions on that faculty; infomuch that though I am far from pretending any of the reflections to be met with in the following treatise, to be made of that nature; yet such as they are, divers considerable persons of differing ages and sexes have been pleased to say (which is an advantage may richly recompense more trouble than those writings cost me) that they scarce ever see such or such particular things, on which I have written reflections, without remembering both those thoughts, and their author. So that they, who have so easily attainable things, as happier pens than mine, in setting down occasional meditations, may have the satisfaction of making almost the whole world a great * *Conclave Mnemonicum*, and a * *Promptuary*, for the service of piety and virtue, and may almost under every creature and occurrence lay an ambuscade against sin and idleness.

NOR is this indirect way of instructing men, unlawful for a Christian, or unworthy of him. For in the spiritual warfare, where our adversary is the old serpent, stratagems are as lawful as expedient; and he that gets the victory, whether or no he wins reputation by the manner, is sure to obtain (a greater recompense) glory, by the success. A teacher is not obliged to imitate *Alexander*, who, upon a disputable punctilio of gallantry, that was neither wise nor charitable, refused to steal a victory. For the prophet *Nathan* scrupled not to deceive *David*, that he might reclaim him, and surprize him into a confession of the criminousness of his fault. And the Apostles being termed by their master, *fishers of men*, were warranted to make use of baits, as well as hooks, and nets. And our Saviour himself, by the parable of the wicked husbandman, that usurped the vine, drew the Pharisees to an acknowledgment, which they started from as soon as they perceived what they had done. And the same divine teacher did so frequently employ fictions to teach truths, that to condemn figurative and indirect ways of conveying even serious and sacred matters, is to forget, how often Christ himself made use of parables. And I am the less troubled to see some thoughts of mine, which, though unpolished, have a natural tendency to inveigle men (if I may so speak)

into piety and virtue, thrust abroad into the world; not only because I see no reason to despair, that even as to the most obnoxious of these meditations, the examples they afford may make them useful, when the things they contain do not make them considerable and equitable, readers will rather pity, than admire to find, that an author does not soar, whilst he is clogged or depressed by the meanness of his subject. But because some experience seems to promise, that their novelty and variety will procure the book in general a favourable entertainment; and, indeed, if I had written in a more usual or a more solemn way, I should, perchance, have had no readers but divines, or humanists, or devout persons, or despisers of the world, or (in a word) the masters, or lovers of that one kind of learning, to which my subject did belong: but treating, as I do, of whatever chanced to come in my way, and consequently of many very differing and unusual things, curiosity will probably invite both the learned and the devout; both gentlemen and ladies; and, in a word, inquisitive persons of several kinds and conditions, to cast their eyes upon these reflections; which, by their variety and shortness, will have this advantage, towards the making them entertained with patience,

that scarce any of them will give him, that peruses them, above half a quarter of an hour's exercise of it.

AND as I thought it not any fault to have a regard to what was like to please a good part of the readers I wrote for, (though it would not else perhaps have pleased me, any more than it will the nicer palates of the critics;) so if these trifles chance to meet with half so kind a reception from the publick, as they have had from particular persons, I shall not, perhaps, want the consolation, which may be derived from the judgment of a great master of wit, who scrupled not to affirm, that he had rather his entertainments should please the guests, than the cooks. Though they, that would compleat the good fortune of these papers, may do it more effectually, by addicting themselves (as considerable persons have been of late induced to do) to write occasional reflections (how excellent soever they may prove) than by being kind to these; since having written them, not to get reputation, but company, I cannot but be unwilling to travel alone; and had rather be out-gone than not at all followed, and surpassed than not imitated.

A

DISCOURSE

TOUCHING

Occasional Meditations.

S E C T. I.

C H A P. I.

THE way of thinking, whose productions begin to be known by the name of Occasional Meditations, is, if rightly practised, so advantageous, and so delightful, that it is pity the greatest part, even of serious and devout persons, should be so acquainted with it: and therefore, dear sister, your desire to bring this way of meditation into request with some of our friends is that, which I cannot disapprove. But I am so far from having the vanity to think, that the trifles of this kind, your commands make me trouble you with, would recommend occasional reflections to those, whose eyes they were not meant for, that I think myself obliged to premise something touching the usefulness of this way of meditating, lest the careless and unpolished instances you will, I fear, meet with, among those I now present you, should disparage and

bring a prejudice upon compositions of this kind in general: wherefore, judging it requisite, to premise something touching this way of thinking, I shall forthwith apply myself to that task. And I should judge it a very natural distribution to divide the following discourse into two parts; the first of which should contain some invitations to the cultivating this sort of meditations, and the latter should offer something by way of method, towards the better framing of them. But lest I should at this time be hindered from treating of each of them distinctly, I will at present omit that division, and endeavour in recompense so to deliver the motives I am to propose, that the first part of the discourse may not appear maimed, though it be unattended by the second; and yet the particulars that might compose the second, may (if it prove convenient to mention them at this time) be commodiously enough inserted in opportune places of the first.

O F

Of inducements to this exercise, I might perhaps name many; but, for order's sake, I shall comprize them in the ensuing five; the first whereof will take up the present section, and the remaining four, as many others.

CHAP II.

AND first, the way of meditating, I would recommend, conduces to keep the soul from idleness, and employments worse than idleness; for while a man's thoughts are busied about the present subjects of his reflections, our ghostly adversary is discouraged to attempt that soul, which he sees already taken up with something, that is at least innocent, if not good. If I had not elsewhere displayed the evil and danger of idleness, and represented it as a thing, which though we should admit not to be in it self a sin, yet may easily prove a greater mischief than a very great one, by at once tempting the tempter to tempt us, and exposing the empty soul, like an uninhabited place, to the next passion or temptation, that takes the opportunity to seize upon it: If (I say) I had not elsewhere discoursed at large against idleness, I might here represent it as so formidable an enemy, that it would appear alone a sufficient motive to welcome our way of meditation; that it banishes idleness. He that is versed in making reflections upon what occurs to him; he that (consequently) has the works of nature, and the actions of men, and almost every casualty, that falls under his notice, to set his thoughts on work, shall scarce want themes to employ them on: and he that can (as it were) make the world vocal, by furnishing every creature, and almost every occurrence, with a tongue to entertain him with, and can make the little accidents of his life, and the very flowers of his garden, read him lectures of ethicks or divinity; such a one, I say, shall scarce need to fly to the tavern, or a worse place to get a drawer, or gamester (perhaps no better qualified) to help him to get rid of his time: such a one will rather pity, than pursue those, who think it their privilege to spend their whole life in diversions from the main business of it; and out of an unskilful, and ill-governed self-love, are come to that pass, that they cannot endure to be with themselves. Such a one will not need to frequent the company of those gamesters, that are sure to lose that, which all their winnings will never be able to buy, or to redeem; and expose themselves coldly to as many casualties, as even war could threaten; and voluntarily tempt those passions it is the task of wisdom to decline, and a virtue to suppress; losing nothing but their time, without losing their patience too, and commonly a great part of that reverence and submission they owe to him, of whom the scripture tells us, that even of *lots themselves, the whole disposal is his*. Nor will he need, for want of knowing what to do when he is alone, to make it his almost daily employment, to make impertinent visits to un sanctified companies, where sometimes he he may lose his good name, often his in-

Prov. xvi.
33.

nocence, oftner his zeal, and always his time.

AND as the exercise, I would persuade, will help to keep us from idleness; so will it, to preserve us from from harbouring evil thoughts, which there is no such way to keep out of the soul, as to keep her taken up with good ones; as husbandmen, to rid a piece of rank land of weeds, do often find it as effectual a course to sow it with good seed, as to cut them down, or burn them up. And indeed, the thoughts of many a person, are oftentimes so active, and restless, that something or other they must, and will perpetually be doing; and like unruly soldiers, if you have not a care to imploy them well, they will employ themselves ill.

WHEREFORE, when a man hath once rendered this way of thinking familiar, sometimes the subject of his meditation will lead him to thoughts, and excite affections, full of serenity, and joy, like those fair mornings, where the cloudless beams, and cherishing warmth of the sun, inviting the lark to aspire towards heaven, make her at once mount and sing; and when the mind is raised to such a welcome and elevated state, to listen to an ordinary temptation, a man must forgo his pleasure, as well as violate his duty, and in the difference betwixt the employment that busies him, and that whereto he is sollicitated to stoop, he will easily discern, that his innocence will not be the only thing, that he would lose by so disadvantageous a change; and sometimes too, whether or no the employment, that busies his thoughts, happen to be so delightful, it will however appear to be so considerable, that it will seasonably furnish him with that excellent answer of *Nebemiab* to those, that would have diverted him from building of the temple, to come to a treaty with them, *I am doing* Nehem. vi. 3. *a great work*, (and such indeed is the serving God, and the improving the mind, whether we consider its importance, or its difficulty) *so that I cannot come down: why should the work cease, whilst I leave it, and come down to you?* Which last expression suits very well with the present case; since, when a pious soul is once got upon the wing of contemplation, she must descend and stoop to exchange her converse with heavenly objects, for one with earthly vanities; and much more must she debase and degrade herself, if the things she is tempted to, be lusts, which she will thence clearly discern, to be as low as the hell they belong to, and deserve.

AND as these objects will afford employment enough to our reflector, so will the wholesome instructions they will suggest, incline him to shun those ways of wasting his time, which they enable him easily to avoid. For I have observed this difference, betwixt ghostly dangers, and ordinary ones, whereas in military hazards, those, that are the most forward to thrust themselves into dangers, are commonly the best able to surmount them; they, on the contrary, are wont to be the most fearful of temptations, that are the most resolved, and best qualified to resist them.

C H A P. III.

Matth.
xx. 6.

NOR will the Meleteticks (or way, and kind of meditation) I would persuade, keep men alone from such gross and notorious idleness; they may be asked the question, proposed by the householder in the gospel, *Why sit ye here all the day idle?* But this way of thinking may in part keep men from the loss of such smaller parcels of time, as though a meer moralist would perhaps censure the neglect of them in others, yet a devout person would condemn it in himself; for betwixt the more stated employments, and important occurrences of human life, there usually happen to be interposed certain intervals of time, which, though they are wont to be neglected, as being singly, or within the compass of one day, inconsiderable; yet in a man's whole life, they may amount to no contemptible portion of it. Now these uncertain parentheses, (if I may so call them) or interludes, that happen to come between the more solemn passages (whether businesses, or recreations) of human life, are wont to be lost by most men, for want of a value for them, and even by good men, for want of skill to preserve them: for though they do not properly despise them, yet they neglect, or lose them, for want of knowing how to rescue them, or what to do with them. But as though grains of sand and ashes be a part, but of a despicable smallness, and very easy, and liable to be scattered, and blown away; yet the skilful artificer, by a vehement fire, brings numbers of these to afford him that noble substance, glass, by whose help we may both see our selves, and our blemishes, lively represented, (as in looking-glasses) and discern celestial objects, (as with telescopes) and with the sun-beams, kindle disposed materials, (as with burning-glasses:) so when these little fragments, or parcels of time, which, if not carefully looked to, would be dissipated, and lost, come to be managed by a skilful contemplator, and to be improved by the celestial fire of devotion, they may be so ordered, as to afford us both looking-glasses to dress our souls by, and perspectives to discover heavenly wonders, and incentives to inflame our hearts with charity and zeal. And since goldsmiths and refiners are wont all the year long carefully to save the very sweepings of their shops, because they may contain in them some filings, or dust of those richer metals, gold and silver; I see not why a Christian may not be careful, not to lose the fragments and lesser intervals of a thing incomparably more precious than any metal, time: especially, when the improvement of them, by our Meleteticks, may not only redeem so many portions of our life, but turn them to pious uses, and particularly to the great advantage of devotion.

AND indeed, the affairs and customs of the world, the employments of our particular callings, the allowable recreations, that health, or weariness requires, and the multitude of unforeseen, and scarce evitable avocations, that are wont to share our time among them, leave us so little of it, to employ in the set and

solemn exercises of devotion, and make those so unfrequent, that our hearts are in great danger of being, by the business, and pleasures, and hurry of the world, if not perverted from aspiring to, at least too long diverted from enjoying communion with God, and kept too much strangers to him; if in the long intervals of our more solemn exercises of devotion, we be not careful to lay hold on the short and transient opportunities of cherishing, and reviving that grace in us, and do not by the rises given us by the things that occur, take occasion to make frequent, though but short flights heaven-wards, in extemporary reflections, serious soliloquies, piercing ejaculations, and other mental, either exercises, or expressions of devotion: by which means, we may make those very objects, and occasions, that would discourage, or at least distract our minds, elevate and animate them; as *Jonathan* made those very things, whereby his enemies, the Philistines, sought to intrap, or destroy him, encouragements to fight with them, and omens of his victory over them. And as scarce any time is so short, but that things so agile, and aspiring, as the flames of a devout soul, may take flight to heaven, (as *Nebemiah* could find time to dart up a successful prayer to the throne of grace, whilst he stood waiting behind the king of *Persia's* chair) so by these extemporary reflections, as well as by other mental acts of piety duly made, a devout soul may not only rescue these precious fragments of time, but procure eternity with them.

S E C T. II.

C H A P. I.

A SECOND inducement to the practice of making occasional meditations, is, that for an exercise of devotion, it is very delightful, and that upon sundry accounts.

FOR first, variety is a thing so pleasing to human nature, that there are many things, which it, either alone, or chiefly, recommends to us, and it is rarely seen, that we love the same things, very much, and very long; and of things that else would appear equally good, we usually think that the better, which happens to be another. Now, a person addicted to make occasional meditations may be supplied with subjects, whose variety is scarce imaginable: for the works of nature and of art are not the only objects, that often present themselves to our reflector's consideration; the revolutions of governments, the fates of kingdoms, the rise and ruin of favourites; and, on the other side, the most slight and trivial occurrences; and in short, all that he sees happen from the highest transactions, to the slightest circumstances, incident to human affairs, may afford matter of contemplation to a person disposed to it. The mind of man is so comprehensive, and so active a faculty, that it can force its passage into those imaginary spaces, that are beyond the outermost part of the outermost heaven, and can in a moment return back, to consider the smallest circumstances of the meanest of human affairs; so

that

that the thinking faculty, being equally fit, and disposed to reflect upon the works of God, and the actions of men, how unlikely is it, that it should want variety of subjects to be employed on, whilst the whole world makes but a part of its object; and the several productions of nature and art, of the providence of God, and the will of man, may be so many ways considered, and so variously compounded, that they may well be supposed capable of affording occasions to notions and reflections far more numberless than themselves; so that the most vigorous, and the most active soul, is in less danger of wanting fresh game, than thoughts to pursue such endless variety of it.

BESIDES, whereas men are wont, for the most part, when they would study hard, to repair to their libraries, or to stationers shops; the occasional reflecter has his library always with him, and his books lying always open before him, and the world it self, and the actions of the men that live in it, and an almost infinite variety of other occurrences being capable of proving objects of his contemplation; he can turn his eyes no whither, where he may not perceive somewhat or other to suggest him a reflection.

BUT that, which may much indear such meditations, is, their surprizing even him, whose thoughts they are: For one of the chief accounts, upon which wit it self is delightful, is, in very many cases, the unexpectedness of the things that please us; that unexpectedness being the highest degree of novelty, which, as I freshly noted, does exceedingly gratify most men's minds. We need not in this case, as in most others, make an uneasy preparation to entertain our instructors; for our instructions are suddenly, and, as it were out of an ambuscade, shot into our mind from things, whence we never expected them, so that we receive the advantage of learning good lessons, without the trouble of going to school for them, which to many appears the greatest trouble, that is to be undergone, for the acquit of knowledge. But though these irradiations of light be oftentimes sudden, as that which we receive from flashes of lightning, yet it is not always upon the single account of this suddenness, that the instructions, presented us by occasional meditations, have an unexpectedness; for oftentimes, the subject, that is considered, appears not to be any thing at all of kin to the notion it suggests. And there are many of these reflections, whose titles, though they name the occasion of them, do so little assist, even an ingenious reader, to guess what they contain, that if you tell him what is treated of, he will scarce imagine, how such thoughts can be made to have a relation to such remote subjects; and the informations we receive from many creatures, and occurrences, are oftentimes extremely distant from what, one would conjecture to be the most obvious, and natural thoughts those themes are fitted to present us; though, when the circumstances are thoroughly examined, and considered, the informations appear proper enough. Thus, when a navigator suddenly spies an unknown vessel

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afar off, before he has hailed her, he can scarcely, if at all, conclude what he shall learn by her; and he may from a ship, that he finds perhaps upon some remoter coast of *Africa*, or the *Indies*, meet with informations concerning his own country, and affairs. And thus sometimes a little flower may point us to the sun, and by casting our eyes down to our feet, we may in the water see those stars, that shine in the firmament, or highest visible heaven.

C H A P. II.

AND lastly, the pleasantness of these meditations to him, that hath attained skill in making them, will, if he be not much mortified, be much increased by their being proofs, as well as effects, of skill. To be able to take up instructions in books, that are replenished with them, and where they are purposely and distinctly exhibited in the form of instructions, requires rather that a man be docile than ingenious: but to be able to collect moral and spiritual documents out of a book of hieroglyphicks, or from a landskip or a map, is more than every attentive considerer can do, and is that, which argues something of dexterousness and sagacity, that is not very ordinary. And so, from ethical or theological composures, to take out lessons, that may improve the mind, is a thing much inferiour to the being able to do the like out of the book of nature, where most matters, that are not physical, if they seem not to be purposely veiled, are at least but darkly hinted. And methinks there is such a difference betwixt him, that but takes up instructions in books of morality and devotion, and him that by occasional reflections derives them from the book of nature, and the accidents he chances to take notice of, as there is betwixt an ant, that contributes nothing either to the production or improvement of the corn she lays up and feeds on, but only carries away that, which she finds ready formed into its little granary or repository; and the industrious bee, who, without stealing from flowers any thing that can prejudice them, does not only gather, but improve and transform her food, and live on that, which otherwise would be useless; and besides, not only has the pleasure to gather its food from flowers, and from variety of them, but lives upon honey, an aliment, that is as sweet and delicious as nutritive. It was doubtless a very great pleasure to *Æsop*, that by his ingenious fictions he could, in a manner, lend reason and speech to lions, foxes, crows, and other animals, to whom nature had denied both; and I know not why it should be less delightful, by occasional reflections, to turn not only birds and beasts, but all kinds of creatures in the world, as well mute and inanimate, as irrational, not only into teachers of ethicks, but oftentimes into doctors of divinity, and by compelling senseless creatures to reveal truths to us, that they were never acquainted with themselves, perform really something like that, which was but pretended by the ancient augurs and other diviners the heathen world admired; who took upon them, by the casual flights of birds, and the inspection of the intrails of beasts, to learn the will of

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of

of heaven. It is a piece of skill, for which mathematicians have been deservedly admired, and which is little less pleasing to those that have it, than wonderful to those that have it not, that as if artists were able to prescribe to the sun and moon, and the rest of the luminous globes of heaven, both their pace and their stages, they can make that inexhausted fountain of light, at so immense a distance, by the shadow of a little gnomon, fitly placed, give us an exact account of all the journeys he performs in the zodiack: but perhaps, it is neither a less noble nor a less delightful piece of skill, to be able, by an innocent kind of necromancy, to consult the dead, and conjure up worm-eaten carcases out of their mossy graves, without fearing to hear from them such dismal discourses, as *Saul* had from dead *Samuel*, and to make, not the stars only, but all the creatures of nature, and the various occurrences that can fall under our notice, conspire to enrich us with instructions they never meant us; since the motion of the celestial lights are known, certain, and invariable; but these particulars are neither to be defined by number, nor limited by rules. Not to say, that this secret does as much excel that other, which recommends astronomy, as wisdom does science, and is as much the more useful of the two, as to know how to pass away our time is more profitable, than to know how our time passes away.

BUT there is a fourth particular, which, though somewhat less directly than the three I have already discoursed of, may be reduced to the pleasantness of occasional meditations; and it is, that whereas our innate self-love is wont to make any thing, that minds us of our faults, exceedingly uneasy and unwelcome; in the discoveries, that, by this way of thinking, are made us of what is amiss, the uneasiness is very much allayed, and the pill very well gilt. For there are two main things, that conduce to the sweetning of reproofs, and to keep men from being offended at them; the one is, when they come from a person, whom we love, and whom we believe to love us, and to have no other design in displeasing us than that of serving us: and the other is, that the discovery, that is made us of our faults, be sweetned by acknowledgments of our having qualities of a commendable nature, whence wise reprovers usually mingle, and, as it were, brew their reprehensions with praises. Now, both these pleasing vehicles, if I may so call them, and correctives of reproofs, concur in those we meet with in making occasional reflections. For, in these cases, being our own instructors, and our own consciences being the makers of the application, we cannot suspect the reprehensions to come from persons, that either mistake us, or are partial against us; and that truth, which a man's conscience applies to him, being found out by the sagacity of his own understanding, extracting from objects that, which every considerer would not have picked out thence; it may very often happen, that the same reflection will discover to a man his excellencies, as well as make him take notice of his faults:

and that which makes him condemn the disorders of his affections, may argue, and thereby commend, the goodness of his parts.

CHAP. III.

I KNOW, it may be objected against the pleasantness of the mental exercise I have been speaking of, that to make occasional meditations is a work too difficult to be delightful.

IN answer to this, I might represent, that there are employments, wherein their being attended with somewhat of difficulty, is so far from deterring us, that it recommends them: as we see, that in hunting and hawking, the toil, that must be undergone, is so much an inderment of the recreation, of which it makes a great part, that when it happens, that we do not meet with difficulties enough, we create new ones; as when huntsmen give the hare law, (as they speak) for fear of killing her, before they have almost killed their horses, and perhaps themselves, in following her. Yet I shall rather chuse to make a more direct answer, by observing, that the difficulties imagined in the practice I am treating of seem to arise, not so much from the nature of the thing itself, as from some prejudices and misapprehensions, that are entertained about it, especially the following two.

THE first is a needless scruple, which makes some fancy themselves obliged to confine their thoughts to the subject, that set them on work. And this dwelling long upon one theme is to many men a thing uneasy and tedious enough. But for my part, I see no necessity of such a strictness; and I have often observed the thoughts successfully to follow objects of a quite differing nature from those that were first started, from which perhaps, though more obstinately pursued, very little instruction or advantage would have been obtained. And it not unfrequently happens, that men trouble themselves in vain to make any profitable use of the considerations of those first objects, where the thoughts being licensed to expatiate themselves, they do often at length pitch upon somewhat or other that is instructive, and at which, perhaps, they aimed at the very first, though they attained it by degrees, and pursued it by winding and untraced ways. As when we let a grey-hound loose in a warren, we confine him not to the first rabbit he makes after, since we see it frequently happens, that one sets him a running, and another proves his quarry. Nor do I conceive such a practice disagreeable to the nature of occasional meditations, nor to be excluded by their name; for that appellation may well enough be applied to those emergent thoughts, which fortuitous occasions did awaken or suggest to us; nor is it necessary, that our thoughts be always calculated for the subject that excited them, provided we thence took occasion to think; so that in some cases, the occasion is not so much the theme of the meditation, as the rise. For my part, I am so little scrupulous in this matter, that I would not confine occasional meditations to divinity itself, though that be a very comprehensive subject; but am ready

to allow men's thoughts to expatiate much farther, and to make of the objects they contemplate not only a theological and a moral, but also a political, and œconomical, or even a physical use. And I doubt, whether the groundless imagination, that occasional reflections ought to be confined to matters of devotion, or, at furthest, of morality, have not much helped to keep our Meleteticks so little cultivated, as hitherto they have been. And indeed there is so perfect an harmony, and so near a kindred, betwixt truths, that, in many cases, the one does either find out, or fairly hint or else illustrate or confirm, the other. And it is no wonder, that divers of them should belong to the same object, and be deduced from it. And if men were solicitous to apply the things they take notice of in occasional objects, to the discovery or illustration of œconomical, political, or physical matters, it would probably bring such kind of thoughts more into request with several sorts of men, and possibly conduce to the improvement of those parts of knowledge themselves.

C H A P. IV.

THE other thing I proposed to mention, as that, which discourages many from the addicting themselves to make occasional meditations, is a fancy, that to practise this kind of thinking, one is obliged to the trouble of writing down every occasional reflection, that employs his thoughts; and they conclude it far easier to forbear making any, than to write down all. But to do this, were to undertake a task no less unnecessary than tedious. Those meditations indeed, that have some excellency in them, that fits them to instruct others, should for that purpose be kept from perishing; and those that were not conceived without some extraordinary affection in a man's self, should be carefully pursued, as bellows to blow or rekindle devotion, by reminding us of the devout thoughts the like objects had excited in us. But for the rest of our occasional reflections, though they fill our heads, they need not employ our hands, as having performed all the service, that need be expected from them, within the mind already.

NOR would I have any man be discouraged from this way of thinking, that cannot express so much wit or eloquence in occasional meditations, as perhaps he may aspire to. For, besides that much subtilty of wit is not to be expected, or at least exacted, in this kind of composures, where we commonly make use of things rather out of haste than choice, as frequently being but the first thoughts we meet with, not the best we have; besides this, I say, that which ought most to endear this sort of reflections to a Christian, is rather that they cherish piety, than that they express wit, and help to make the man good, whether or no they make his style be thought so. It were injurious to nature to fancy, that the fig-tree derives no benefit from the rain and sun, because they do not make it, like other trees, flourish with blossoms, more gaudy than necessary; though without previous buds it brings forth

welcome fruits. Not to add, that the difficulty of framing occasional meditations need not be estimated by that, which we find when we first addict ourselves to the making of them; for practice will by degrees so much lessen that difficulty, that after a while we shall find, that occasional thoughts will need but small invitation to frequent those minds, where they meet with a kind entertainment. And though men should be reduced to purchase this habitude at the rate of a little difficulty, I doubt not but they will find the benefit of it, when gotten, richly to recompense the trouble of acquiring it. Nor will the practice, that must contribute to the attainment of a reasonable degree of skill in making them, be half so troublesome when those exercises but make up the habitude, as they will prove facile and delightful when they flow from it.

S E C T. III.

C H A P. I.

THE third grand advantage, that may be derived from the custom of making occasional meditations, is, that it conduces to the exercise and improvement of divers of the faculties of the mind. And this it may do upon several accounts.

I. FOR, in the first place, it accustoms a man to an attentive observation of the objects, where-with he is conversant. Whereas there is scarce any thing, that may not prove the subject of an occasional meditation; so the natural propensity we have to manage well the themes we undertake to handle, unperceivably engages us to pry into the several attributes and relations of the things we consider, to obtain the greater plenty of particulars, for the making up of the more full and compleat parallel betwixt the things, whose resemblances we would set forth. By which means a man often comes to discover a multitude of particulars, even in obvious things, which, without such an engagement to attention, he would never have minded, and which common beholders take no notice of. And though it may seem, that the habit, produced by the practice of occasional meditating, should accustom a man to heed only such objects, as are like to suggest to him devout thoughts; yet, not to mention now, that I shall advertise you anon, that there is no necessity of confining occasional meditations to matters devout or theological, I shall only represent, that, since we know not, before we have considered the particular objects that occur to us, which of them will, and which of them will not, afford us the subject of an occasional reflection, the mind will, after a while, be engaged to a general and habitual attention, relating to the objects, that present themselves to it. Besides that though we should at first apply our heedfulness to circumstances of only some few sorts of objects; yet the habit being once acquired, would easily reach to others than those that first occasioned it: as men, that by learning to sing anthems are come to have critical ears, will be able to judge, much better than they could before, of the resemblances and differences of tones

tones in other songs, and will take notice of divers particularities in voices, which would not be heeded by an unpractised ear. And as we have made it appear, that the way of thinking, we would recommend, does very much dispose men to an attentive frame of mind; so, that such a frame or disposition is a great advantage in the whole course of a man's life, will not appear improbable to him, who duly considers, that since attention, like a magnifying glass, shews us, even in common objects, divers particularities, undiscerned by those who want that advantage, it must needs make the things, he is conversant with, afford the considerer much more of instruction than they obtrude upon the ordinary regardless beholder; and, consequently, this exercise of the mind must prove a commendable way to experience, and make it attainable without grey-hairs: for that, we know, consists not in the multitude of years, but of observations, from numbers and variety of which it results. Nor is there any reason, why prudence should be peculiarly ascribed to the aged, except a supposition, that such persons, by having lived long in the world, have had the opportunity of many and various occurrences to ripen their judgment: so that if one man can by his attention make, as well he may in a small compass of time, as great a number of observations as less heedful persons are wont to do in a longer, I see not, why such a man's experience may not be equal to his that has lived longer; for it matters not much, whether a man make a competent number of observations, in much time or in little, provided he have made them well.

CHAP. II.

THE practice I would recommend, accustoms a man to make reflections upon the things he takes notice of, and so, by exercising, improves his reasoning faculty. For, as most men have much more strength and agility in the right hand than in the left; and, generally speaking, those limbs of the body that are most exercised, are stronger than the rest of the same kind; so the faculties of the mind are improved by exercise, and those, that we frequently employ, grow thereby the more vigorous and nimble. And, for my part, I have been often inclined to think, that the chief advantage, that the reasoning faculty derives from the institution received in logic-schools, comes not so much from the precepts themselves, which are pretended to make up an art of reasoning, as from the frequent exercises, that, by occasion of such precepts, the students are put upon. And, perhaps, if men were obliged to read the controversies of subtle wits, and to engage in frequent disputations, both premeditated and extemporary, it would add little less of readiness and acuteness to their wits, though they disputed of other matters than such as properly belong to logic, and were not before imbued with the precepts of that art: as we see, that the use of singing with those, that can sing well, does much improve one's voice, both as to strength and clearness, whatever the tunes or songs be, that are sung, and

how little soever those, with whom one sings, make it their business to teach him the art of music.

BUT this is only conjecture; and whether it be true or no, yet this I am confident is so, that the bringing of a man to be a thinking and a reflecting person is to procure him so great an advantage, as though it were the only one may justly endear to him the custom of making occasional meditations; and he, that could bring this practice into the request it deserves, would do a greater piece of service, not only to the particular persons he persuades, but to mankind in general, than the greater part of good men themselves seem to be aware of. For though God having been pleased to make reason the chief part of our nature, among the various objects, that daily occur to us, it can scarce be, but that some or other will in a manner obtrude some notions even upon the unattentive; yet certainly, all that has been found worthy of mankind in mathematics, philosophy, and other kinds of learning, has been attained by thinking men, or by a frequent and regular practice of employing the thoughts. And lest it should be objected, that these various and elaborate effects of assiduous meditation were the productions only of philosophers, or other men of speculative heads; let us but consider, that though gallants and courtiers do seldom love to tire themselves with thinking, and are as seldom fond of writing books, not to add, fit to write them; and though love be not the fruitfulest, that may be pitched on, yet that passion, and some particulars relating to it, frequently busying their thoughts, and being several ways considered by them, has been displayed and contrived even by such writers, as I have been just now mentioning, into those numerous plays, that daily employ the stage, and those voluminous romances, that are too often the only books, which make up the libraries of gallants, and fill the closets of ladies. He that most truly called himself the *Truth*, tells us, that the devil is not only a *John viii. liar*, but the *father of lies*, that is, the great⁴⁴ patron and promoter of falsehood, and, as such, he studiously opposes all useful truths; not only those, for which we must be beholden to revelation, but those also, which may be attained by ratiocination, and the well-regulated exercise of our natural faculties; and he were much less an adversary and an old serpent than he is, if his enmity to God and man did not justly make him think, that scarce any thing is more his interest than solicitously to divert men from thinking, and discourage them in it, there being few things, whereby he could more effectually oppose at once both the glory of God, and the good of men. And sure, if so subtle an adversary did not think it very much his interest to be solicitous about this matter, it could not be, that men should chuse for a privilege, the laying aside that faculty of meditating, which is indeed so much their privilege, that, if experience did not convince the contrary, I could never suspect, that the non-employing of their thoughts could be their choice rather than their punishment; and that

rational creatures, especially professing Christianity, should either keep idle, or confine to employments worse than idleness, so noble and improveable a faculty, that enables an ingenious man to pry into the inmost recesses of mysterious nature, and discover there so much of the wisdom, power, and goodness of the Author, as are most fit to give the discoverer a high and devout veneration for those excellencies. A faculty, whereby an inquisitive soul may expatiate itself through the whole immensity of the universe, and be her own teacher in a thousand cases; where the book is no less delightful than the lessons are instructive: A faculty (to conclude) by whose help the restless mind having dived to the lowermost parts of the earth, can thence in a trice take such a flight, that having traversed all the corporeal heavens, and scorned to suffer herself to be confined within the very limits of the world; she roves about in the ultra-mundane spaces, and considers how far they reach.

C H A P. III.

III. **B**ESIDES the two already mentioned advantages, which the intellectual part of the mind may derive from the practice of occasional reflections, I should not scruple to add a third, if there were not too just cause of apprehending, that my writings may discredit any thing, that comes proposed of that nature by no better a pen, and that the manner of what I am about to deliver may disparage the matter. But since, from the experience even of purblind and dim-sighted persons, good perspectives may be, not improperly, nor unsuccessfully, recommended, though their native and peculiar debility of sight keep them from being able to see as clear and as far through such glasses as other men can do, if themselves can, by the use of them, do far more than they could without them; I will adventure to speak of an improvement I cannot boast of, lest by suppressing the mention of an advantage, because I cannot make it, I should seem either vain, or envious, as well as dull. I shall then take notice, that the Meleteticks we are considering, may, where it finds a capable and disposed subject, much improve that nimble and acceptable faculty of the mind, whereby some men have a readiness and subtilty in conceiving things, and a quickness and neatness in expressing them; all which the custom of speaking comprehends under the name of wit; which pleasing, and (if well managed) useful quality, the exercise I am discoursing of may three or four several ways promote.

FOR (first) the accustoming one's self to make extemporal reflections, and that upon all kind of occasions, does by degrees bring the mind to a readiness of conception, which keeps a man from being easily surprized by the subject he has occasion to consider, and enables him oftentimes to surprize his hearers; and that such a kind of surprize is one of the most endearing circumstances of the productions of wit, he must not have much considered the nature of them, that ignores.

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NEXT, the same exercise inures a man to draw his conceptions from the very nature of the thing he speaks of; which, among those that can judge of wit, is held a far greater sign of it, than the saying things more specious and elaborate, that appear to be antienter than the occasion; as is usual in epigrams, and other solemn premeditated pieces of wit, where oftentimes the thoughts were not made for the themes, but before them: whereas the suddenness of a good occasional reflection, and its congruity to that which gave it rise, persuades the hearers, that the speaker's wit is of its own growth, and is rather suggested by the occasion, than barely applied to it.

A THIRD way, whereby our Meleteticks may conduce to wit, is, by bringing those, that use to write their thoughts, to what may be called a certain *suppleness of style*: for when a man treats of familiar, or of solemn subjects, he is so much assisted by the received phrases and manners of speaking, that are wont to be employed about them, that being seldom at a loss for convenient expressions, his wit is seldom distressed how to furnish him with words fit for his turn. But the subjects, that invite occasional reflections, are so various and uncommon, and oftentimes so odd, that, to accommodate one's discourse to them, the vulgar and received forms of speech will afford him but little assistance; and to come off any thing well, he must exercise his invention, and put it upon coining various and new expressions, to suit that variety of unfamiliar subjects, and of occasions, that the objects of his meditation will engage him to write of. And by this difficult exercise of his inventive faculty, he may by degrees so improve it, and, after a while, attain to so pliant a style, that scarce any thought will puzzle him to fit words to it, and he will be able to cut out expressions, and make them fit close to such subjects, as a person unaccustomed to such kind of compositions would find it very difficult to write of, with any thing of propriety.

C H A P. IV.

IT remains, that I mention one way more, and that a considerable one, whereby the practice of occasional reflections may contribute to the improvement of wit; and that is, by supplying men with store and variety of good comparisons.

How great, and how acceptable, a part of wit that is, which has the advantage to be expressed by apt similitudes, every man's own experience, if he please to consult it, may, in some measure, inform him. And certainly, there is no one part of wit, that is so generally applicable to all kind of persons; for good comparisons serve equally to illustrate, and to persuade; the greatest wits disdain them not, and even ordinary wits are capable to understand them, and to be affected by them: and if a sermon, or a long discourse, be enriched with one apt comparison, what part soever else be forgotten, that will be sure to be remembered. And a but plausible argument, dressed up in fine similitudes, shall be more prevalent among

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among the generality of men, than a demonstration proposed in a naked syllogism; and therefore, the ancient sages did so much chuse to imploy a figurative way of delivering their thoughts, that when they could not furnish themselves with resemblances fit for their turns, they would devise parables, and apologues, to recommend what they said to the attention and memory of those they would work upon. And those famous orators, who, though they lived in commonwealths, did, by their eloquence, exercise a more than monarchical government there, and who, by their enchanting tongues, ruled those warlike people, whose swords had made them masters of the world; those imperial wits, I say, whose oratory performed such wonders, performed them chiefly by the help of their happy comparisons, which alone contributed more to their success, than almost all the other persuasive figures of their triumphant rhetoric: lucky comparisons being indeed those parts of wit, that as well make the strongest impressions upon the mind, as they leave the deepest on the memory. Now, as the being furnished with apt comparisons does so very much conduce to the making a man's discourses and writings appear witty, so there is scarce any thing more fit and likely to supply a man with store and variety of comparisons, than the custom of making occasional meditations; for he, that uses himself to take notice of the properties and circumstances of most things that occur to him, and to reflect on many of them, and thereby observes the relations of things to one another, and consequently discerns, how the properties or circumstances of one may be accommodated, by way of resemblance or dissimilitude, to somewhat that relates to the other, will often find, besides those things which afford him his occasional reflection, divers others, which, though less fit for the meditation, that invited his taking notice of them, may be very fitly applicable to other subjects and purposes, and will easily furnish him with resemblances, wherewith he may, if he pleases, much increase the books of similitudes, already extant. And the comparisons, that may be this way lighted on, may sometimes prove strange, and unobvious enough, to be surprising even to himself, as well as to his auditors, or his readers.

CHAP. V.

BUT, besides those similitudes we may be furnished with by the things we observe, without turning them into occasional meditations, we may find in those very subjects, whereon we do make reflections, circumstances, that, though improper, or at least unnecessary, to be taken into the occasional meditation, may be very fitly accommodated to other things, and plentifully contribute to the store and variety of comparisons we lately mentioned. This must appear so much a truth, to any that is exercised in making occasional reflections, that I should perhaps forbear to illustrate it, by any particular example, but that this part of my discourse recalls into my

mind some thoughts, that were suggested to me by one of the last occasions I had, to make reflections of this nature. I shall add then, that being all alone, and diverted a pretty while by a sudden storm of thunder, lightning, wind, and rain, from the employments I had designed my self to, I had the unwelcome leisure to make some reflections upon the rude objects, that obtruded themselves upon my observation.

AND the chief thing, that presented itself to my thoughts, was a resemblance betwixt prophane or atheistical wits, and the black clouds that then over-cast the sky: for, as those clouds are raised to an elevated station, and do afford flashes of light; so these irreligious wits are oftentimes conspicuous enough, and may bring forth notions, that are surprising, and instructive. But as the same clouds, whilst they give us but heir own momentary light, obscure (by darkning the sky) and hinder us, as much as they can, from receiving that of the sun, which reaches further, and is many other ways preferable to vanishing conusca-tions; so these wits, whilst they seem to enlighten those they dazzle, with their own new opinions, do really deprive them of the true heavenly light, that would else shine forth to them in the revealed word of God. And as the light, that we do receive from the clouds, may dazzle and astonish us, but is not sufficient for us to travel by; so the admired reasonings of these sophisters may surprize and amaze us, but will never prove sufficient to be, like the scripture, a constant lamp unto our feet, and a Psal. cxix. light unto our paths. And as the light afforded 105. by such clouds is not only wont to be attended with affrighting thunder, and hurtful storms, but burns, and destroys, or at least scorches, and blacks, where it passes, and oftentimes falls upon churches, hospitals, colleges, and brings such frights and ruins wheresoever it comes, that it were a great deal better men wanted the light of such flashes, than that they should be exposed to such inconveniencies by them; so the insolent and irregular wits, I am speaking of, do not only make an unwelcome noise in the world, but do oftentimes so denigrate the reputation of them that oppose them, and bear so little respect even to things sacred, or useful to mankind, without sparing the church or seminaries of learning, if either come in their way, that they do far more mischiefs by their errors, or their practices, than the little instruction they give us is able to make amends for.

THIS, if I forget not, was the substance of the occasional meditation suggested to me by the storm; but, besides that, there are in this some particulars, which are not necessary to the meditation it self, and may be fitly enough accommodated, by way of comparisons, to other occasions. I remember, the same subject (the storm) had other circumstances in it, fit to afford similitudes applicable to other subjects, and some of them unobvious enough. For instance, it is not easy to find so illustrious a comparison, to set forth, how the most contrary qualities may proceed from the same subjects,

subjects, as that which we may be supplied with, by considering, that from the same clouds we derive both light and darkness; and a noble comparison of contraries, conjoined in one subject, may be borrowed from the same clouds, which afford us lightning, and rain, shew that they contain in them two of the eminentest and seldomest consistent contraries of nature, fire and water. And another comparison may be derived from the differing productions of these clouds, to illustrate those things, which do at once both much good and much mischief, or sometimes the one, and sometimes the other: for the same clouds both produce the thunder, and the lightning, and thereby blast trees, kill men and beasts, fire houses, and ruin the noblest buildings, without sparing churches themselves; and, on the other side, plentifully afford us those refreshing and fertilizing showers, that correct the heat of the sultry air, and cure the barrenness of the parched earth. And one that is skilled in framing comparisons out of dissimilarities, and exercised in the other ways of turning and winding of simile's, may easily enough find, in the subject we have been considering, circumstances capable of being conveniently enough accommodated to more subjects and purposes, than I have leisure now to take notice of. And since, as the being able to find the latent resemblances betwixt things seemingly unlike, makes up a great part of what we are wont to call wit; so the being able to discern the unobvious disparities of things manifestly resembling is one of the chief things, that displays the faculty men call judgment. And since both these are very much assisted by the custom of making reflections, wherein we must take notice of the several properties, wherein things either are alike, or disagree; methinks it should not a little manifest the usefulness of our Meleteticks towards the improvement of men's parts, that they not only instruct the more serious faculty of the soul, but sharpen the more subtle.

CHAP. VI.

IV. **B**UT the practice I have all this while been recommending, does not only dispose us to attention, in observing the things that occur to us, and accustom us to reflect on them seriously, and express them fitly; but does also, though insensibly, suggest to us ways and methods, whereby to make the objects we consider informative to us.

FOR by example, analogy, or some of those other ways, which we may be invited, on another occasion, to insist on, we are, as it were, led by the hand to the discovery of divers useful notions, especially practical, which else we should not take any notice of. And indeed the world is the great book, not so much of nature, as of the God of nature, which we should find even crowded with instructive lessons, if we had but the skill, and would take the pains, to extract and pick them out. The creatures are the true Ægyptian hieroglyphicks, that under the rude forms of birds, and beasts, &c. conceal the mysterious secrets of knowledge, and of piety. And as

chemists boast of their elixir, that it will turn the ignoblest metals into gold; so wisdom makes all objects, on which it operates, enrich the possessor with useful and precious thoughts. And since even the illiterate husbandman can, with the most abject dung it self, give a flourishing growth to the most useful grains, to medicinable herbs, and even to fragrant flowers; why may not a wise man, by the meanest creatures, and slightest object, give a considerable improvement to the noblest faculties of the soul, and the most lovely qualities of the mind?

BUT the particular method of deriving instruction from the subjects we consider will be more fit to be particularly insisted on, when we shall have more time, or some other opportunity, to treat of the manner of making occasional meditations; and shew, how they may be fetched from example, analogy, dissimilitude, ratiocination, and other topicks, which we must not now take any further notice of.

SECT. IV.

CHAP. I.

HITHERTO we have considered the benefits, that may be afforded by the practice of occasional meditations to the *intellectual faculties*. We will now proceed to the advantages, that may accrue from the same practice to the *will and affections*; these advantages being not only the most valuable in themselves, but those, upon whose account I have been engaged in the present undertaking.

V. **T**HE last therefore and greatest benefit I shall take notice of, in the practice I would invite you to, is, that it awakens good thoughts, and excites good motions in the will and affections. For since we have already manifested, that it is wont to suggest variety of notions to the meditator, and such as are usually accompanied with delight; this friendly property to devotion, which I now ascribe to our Meleteticks, is a very easy and genuine off-spring of the marriage of the two others: the beams of knowledge, acquired by such reflections, having in them, like those of the sun, not only light, but heat. And indeed it were somewhat strange, as well as sad, if a person disposed and accustomed to observe and consider, conversing with such instructive books as those of God's creatures and his providence, with an intention to take out practical lessons, should not find them. For amidst that rich variety of objects, that in differing manners proffer themselves to his consideration, and suggest to him a great diversity of reflections, it cannot reasonably be imagined, that he should not find subjects or circumstances, that are proper, either to afford him examples to imitate, or shew him the danger, or unhandisomness, or inconvenience of something that he should avoid, or raise his thoughts and affections heaven-wards, or furnish him with some new practical consideration, or shew him some known truth in a varied and his

delightful dress, or (at least) recall some notions his frailty makes him need to be put in mind of, or, in a word, either refresh his memory, or otherwise cherish his devotion. Let us suppose a person, who being qualified and accustomed to reflect upon various objects that occur to him, mainly designs, in the exercise of that faculty, the warming of his affections, and the improvement of his piety; and we shall scarce doubt, but when he looks about him in the world, he will find it, what one of the fathers loftily styled it, *παιδευτηρίον τῆς θεογνωσίας ἢ ψυχῶν λογικῶν διδασκαλίον*, (a school for rational souls to learn the knowledge of God.) There is scarce any thing, that nature has made, or that men do or suffer, though the theme seem never so low and slight, whence the devout reflector cannot take an occasion of an aspiring meditation: as in a hopeful morning the humble lark can, from the lowest furrow in the field, take a soaring flight towards heaven, and ascend thitherward with a melody, that delights both herself and her hearers. If such a person considers, how amongst such an admirable variety, and such odd antipathies of the numberless creatures that compose the universe, the constant observation of the laws of their nature makes them universally, and, as it were, unanimously, to conspire to make the author of it appear wonderful in it; he cannot but be willingly possessed with such an awful admiration of the matchless wisdom of their great disposer, as made the Psalmist cry out, upon a somewhat like occasion, * *How manifold are thy works, O Lord, how wisely hast thou made them all?* If he have occasion to consider the merciful dispensations of divine providence to the godly, or to take notice of the severe inflictions of divine justice on the wicked, he will find himself powerfully engaged to rely on the one, and to apprehend provoking the other. If he take notice, that the world is but our storehouse, and that multitudes of admirable creatures seem to have had a being given them, principally for the use of undeserving man; insomuch that many of the beasts, and birds, and fishes, are but our caters for one another; he will burst out into mental, if not vocal, expressions of thankfulness and humiliation to the father of mercies, for so unmerited and ill returned a bounty, and will be apt to say with *David*, *What is man, that thou takest knowledge of him; or the son of man, that thou makest account of him?* And if he compare this munificence of God, in daily giving so many creatures, that never violate the laws of their nature, nor endeavour to disappoint him of his ends in creating them, for the necessities, nay, for the pleasures, of rebellious and unthankful man; he will resent an ingenuous shame, and a noble disdain, that that creature should be of all the least grateful, that has received the most benefits, and that he should of all others prove the most unruly, who alone has been endowed with reason to rule himself withal. If in a starry night he looks upon

the firmament, and considers how many fixed stars there are, and how many thousand times more there might be without wanting room, the least of which astronomers teach us to be far bigger than the whole earth, which yet, by the probablest computation, contains above ten thousand millions of cubick German leagues, (and consequently above threecore times as many *English* miles of solid measure) he will find abundant cause to exclaim with *David*, *When I consider thy heavens, the work of thy hands, the moon and stars which thou hast ordained, what is man, that thou shouldst be mindful of him, or the son of man, that thou visitest him?*

C H A P. II.

AND since our discourse has led us to the mention of a text, where the truly inspired poet (who, by his omitting to speak of the sun, seems to have composed this psalm in the night) makes the moon the chief subject of his meditation; it will not perhaps be amiss, if, on this occasion, we add a few short reflections on the same theme, and thereby confirm what we lately noted about the differing reflections and similitudes, which may be afforded by the same subject, as its several attributes may be differing considered.

IF then, in the first place, when our contemplator takes notice of the greatest brightness of the moon, he remembers too, that it is when she is at the full, that she is subject to be eclipsed; it would put him in mind of the mutability of human things, and that oftentimes prosperity proves never the more secure for appearing the more full and resplendent.

NEXT, our reflector may find in the moon a lively emblem of a true minister of the gospel. For, as the moon communicates to the earth the light, and that only, which she receives from the sun; so the Apostles, and first preachers of Christianity, and (in their measure) their true successors, communicate to mankind the light, which themselves have received from the bright sun of righteousness. And the similitude may be advanced, by adding, that as the moon shines not on the earth, with any other beams than those she derives from that fountain of light, the sun; so the true preachers of the heavenly doctrine mingle not their own inventions, or human traditions, with that pure and sincere light of revelation they are employed to dispense: it being safest, and most desirable, for the church, that Christians should receive the bread of life, as the Jews are recorded to have received the material bread, in a passage of *St. Matthew's* gospel, where it is said, that Christ first brake, and gave to the disciples, the bread, which they afterwards, from him, distributed to the people; so that they might each of them, in a literal sense, imploy that expression of *St. Paul*, *I have received of the Lord, that which I delivered unto you.*

AND

* So *Junius* and *Tremellius* translate the place, *Quam ampla sunt opera tua, O Jehova, quam ea omnia sapienter fecisti?* and so the original will bear, if the Hebrew *Ma* be made applicable as well to the latter, as to the former part of the words.

Psal. civ.
24.Psal. cxliv.
3.Mat. xv.
36.1 Cor. xi.
3.

AND as though the moon be destitute of native light, yet by virtue of that borrowed one, which she plentifully receives from the sun, she affords more to men than any of the stars, which, upon the score of their vast distance from the sun, are, by modern Naturalists, supposed to shine by their own light; so those illiterate fishermen, whom the son of righteousness called, and made the light of the world, did, by virtue of the copious irradiations he vouchsafed them, diffuse far more light to mankind, than the greatest philosophers, that, being unassisted by divine revelation, had only their own native beams to shine with.

AND as oftentimes the same subject, but as variously considered, may afford both somewhat fit to be shunned, and somewhat fit to be imitated; so, in that, which we suppose our reflector now considering, he may easily discern the emblem of an ungrateful person. For as the moon, though she receive all the light that ennobles her from the sun, does yet, when she is admitted to the nearest conjunction with him, eclipse that bright planet, to which she owes all her splendor; so unthankful men abuse those very favours, that should endear to them their benefactors, to the prejudice of those that oblige them.

AND 'tis like, that our reflector may, by the way, take notice, that as what passes betwixt the moon and the sun, does thus afford him a simile, whereby to set forth ingratitude; so what passes betwixt the moon and the sea may supply him with an example of the contrary quality, and put him in mind, that a thankful man will be true and obsequious to his benefactor, though the person that obliged him have lost that prosperity, that before made him conspicuous, and attracted vulgar eyes; as the sea follows the course of the moon, not only when she shines upon it with her full light, but when at the change she can communicate little or no light to it.

To the two above-mentioned attributes, upon whose account the moon afforded a comparison for human prosperity, and another for preachers of the Gospel, we will now add, that she may afford us a similitude to set forth a liberal person by; for as the moon freely communicates to the earth the light she receives from the sun, so the bountiful person imparts to indigent men the largesses he receives from the exuberant goodness of God. And as to intellectual communications, the parallel will hold further, since as the moon enjoys not the less light, for her imparting so much to the earth; so in mental communications liberality does not impoverish, and those excellent gifts cease not to be possessed by being imparted. And it is very possible, (to add that upon the bye) that after the light of the moon has (according to what I lately noted) represented to our contemplator the qualifications of a preacher, it may also put him in mind of the duty of a hearer. For, as it were very foolish in us, and unthankful towards the father of lights, not to make use of the great light we receive from the sun by the moon, or not to acknowledge the moon to be

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a very useful creature, upon the score of that light, wherewith she shines upon the earth, though, in her, that light be destitute of heat; so it were unwise and ungrateful for hearers to refuse to acknowledge, or to be guided by, the conspicuous endowments of learning and eloquence, that God vouchsafes to great scholars, though they themselves were but illustrated, not warmed by the beams they reflect. But therefore, as oysters, and other shell-fish, are observed to thrive at the increase of the moon, though her light be unattended with heat, and though even when she is at full, she wants not her spots; so devout hearers will be careful to prosper proportionably to the instructions they receive even from those preachers, whose illuminations are unaccompanied with zeal and charity, and who, when they shine with the greatest lustre, are not free from their darkneses, as to some points, or from notorious blemishes.

AND as the moon may thus furnish our contemplator with similitudes, to set forth both a virtue and a vice of the mind, so may it supply him with an emblem of its condition; for as the light of the moon is sometimes increasing, and sometimes in the wane, and not only is sometimes totally eclipsed, but even when she is at the full, is never free from dark spots; so the mind of man, nay, even of a Christian, is but partly enlightened, and partly in the dark, and is sometimes more, and sometimes less, illustrated by the beams of heavenly light, and joy; and not alone now and then quite eclipsed by disconsolate desolations, but even when it receives the most light, and shines the brightest, knows but in part, and is in part blemished by its native darkneses, and imperfections. And these resemblances are not so appropriated to the mind of man, but that they might easily be shewn to be applicable to his condition, in point of outward prosperity, and adversity. And to these resemblances other reflections on the several adjuncts of the moon might be also added, together with several examples of this nature on other subjects, were it not, that I think my self to have spent time enough already upon a theme, that fell but incidentally under my consideration; and were it not also, that the reflections, which might here be annexed upon the attributes of other objects, may be more properly subjoined to what may be on another occasion presented to you, by way of illustration of some particulars, that belong to the fourth part of the precedent section, in which my haste, and some other reasons, made me content my self, to give some few general hints about such reflections, and an intimation of the topics, whence I am wont to fetch them.

C H A P. III.

AND having given you this advertisement, *en passant*, we may now proceed a little further, and add, that if we suppose our contemplator's thoughts to descend from heaven to earth, the far greater multitude and variety of objects, they will meet with here below,

S f

will

will suggest to them much more numerous reflections. But because so spacious a field for meditation as the whole earth would afford to us too vast a theme to be attempted on this occasion, we will confine our contemplator to his garden, or rather to any one of the trees of it, and take notice, not of all the meditations he might fetch thence, but only of four or five of the considerablest of those, that the viewing it may, as he walks by at several times, supply him with.

If then, in the spring of the year, our reflector sees the gardener pruning a fruit-tree, we may suppose him invited by that object, to reason thus within himself: Though one, that were a stranger to the art of gardening, would think, that that man is an enemy to this tree, and goes about to destroy it, since he falls upon and wounds it, with a sharp iron, and strikes off several of its youthful parts, as if he meant to cut it in pieces; yet he that knows, that the gardener's arm is not set on work by anger, but by skill, will not conclude, that he hates the tree he thus wounds, but that he has a mind to have it fruitful, and judges these harsh means the fittest to produce that desirable effect. And thus, whatever a man, unacquainted with the ways and designs of providence may surmise, when he sees the church not only exposed to the common afflictions of human societies, (for that is but like our tree's being exposed to be weather-beaten by winds, and rain) but distressed by such persecutions, as seem to be divine inflictions, that invite men to say of the body, what the prophet foretold should be said of the head, *We esteemed him stricken, smitten of God, and afflicted*: whatever, I say, a carnal, or a moral, man would be apt to imagine, upon sight of the churches distresses, the knowing Christian will not from thence infer, that God hates her, or that he has abandoned her; since it is he, that loved his church so well, as to give himself for it, who declares, that as many as he loves, he rebukes and chastens. And this is so fitly applicable also to particular believers, that the divine son of the great * *γεγενυός* does not only give us cause to think, that afflictions do not suppose God's hate, but to hope that they may not always suppose man's guilt, but sometimes rather aim at his improvement; since they are the memorable words of our Saviour, speaking of his father, *Every branch in me, that beareth not fruit, he taketh away, and every branch that beareth fruit, he purgeth it, that it may bring forth more fruit.* And it may somewhat illustrate the similitude to add, that the husbandman uses only to prune the trees of his garden, not those that grow wild in his woods; but though he oftner wound these, yet he wounds the other more fatally, employing but the pruning-hook to pare off the superfluous twigs, or, at most, branches, of the one, whilst he lays the ax to the root of the other, to fell the tree it self.

But these are not the only thoughts, which the pruning of a fruit-tree may suggest to our reflector: for if he considers, that by cutting

off several of the parts of the tree, and by nailing many of the rest to the wall, the gardener does not only secure the tree from being blown down, or torn, by the rudeness of boisterous winds, but makes it look well shap'd; so the divine husbandman, (as we have lately seen God styled in the scripture) by the wife, and seasonable, though seemingly rigorous, and usually unwelcome, culture, he employs upon those children of his, whom he afflicts, does not only protect them from several dangers, whereto, without those harsh restraints, they would be exposed; but as he makes them amends in point of safety for what he denies them in point of liberty, so he adorns them by wounding them; his kind and skilful strokes adding as much to the beauty of a Christian's mind, as they cut away from the superfluities of his fortune; for the pressures of affliction do give such smoothness and gloss to the soul, that bears them patiently and resignedly, that the heathen moralist ventured to say, that if there were any spectacle here below noble enough, and worthy to entertain the eyes of God, it was that of a good man, generously contending with ill fortune. And the hyperbole (though after this manner somewhat loftily expressed) will appear the less strange to him, that considers, that *Job* had not only his patience, when it had been tried to the uttermost, crowned with a fortune double to that, which had been the fairest in the East; but before his constancy was tried near so far, received that much higher recompence of an honour never vouchsafed to mortals until then, when God himself did not only approve, but (if I may so speak with reverence) make his boast of, a man: *Hast thou considered* (says he to man's great enemy) *my servant Job, that there is none like him in the earth, a perfect, and an upright man, one that feareth God, and escheweth evil? and still he holdeth fast his integrity, although thou movedst me against him to destroy him without a cause.* Sure one may call him more than happy *Job*, since, if, as *David* tells us, *the man is happy, whose sins God is pleased to cover*; what may that man be accounted, whose graces he vouchsafes to proclaim?

CHAP. IV.

AND as the consideration of the pruning of trees, under the notion of *that which wounds them*, may afford our contemplator the reflections already pointed at; so the considering of the same action, under another notion, may lead him to reflections of another nature: for if he observes, that, in certain cases, gardeners oftentimes do not only prune away all the suckers, and many of the luxuriant sprigs, but cut off some of the branches themselves, provided they spare the master-boughs; and yet these amputations, tho' they take much from the tree, are design'd to add to the fruit, as accordingly they are wont to do: if, I say, our reflector takes notice of this, it may easily supply him with an illustration of what he may have observed among some men, who, by afflictions

Isaiah liii.
4.

John xv.
2.
* That is,
Cultivator
of the
ground.

John xv.
2.

Job ii. 3.

Ps. xxxii.

fictions, even in point of fortune, are brought to be far more charitable, than they would have been, if their peace and plenty had continued unimpaired. As, besides that St. Paul, speaking of the *Macedonian* churches, gives them this character, *That in a great trial of affliction, the abundance of their joy, and their deep poverty, abounded unto the riches of their liberality*; we have in *Zaccheus* a memorable instance to our present purpose, since, after his repentance had, by his own consent, cut off from his estate more than all that slander, oppression, and other unjust ways of getting, (which used to bring in but too great a part of a publican's) had added to it; he gave away more, out of the remainder of his estate, than every liberal man would have done out of the whole. His wealth, like a skilfully pruned tree, bore the more fruit to piety; for having had some parts of it cut away, he grew rich (in good works) by being despoiled, and his charity increased as much as his fortune was lessened.

² Cor. viii. 2.

Luke xix.

IF, towards the end of the spring, our reflector see the ground under his tree strowed with the blossoms, that time and winds may have cast down thence, it is like it would furnish him with this consideration; That, as though the blossoms are in themselves great ornaments to a tree, and oftentimes both useful and pleasant things, yet to be seasonably deprived of them, is not a mischief to the tree that loses them; since, till the blossoms are gone, the fruit, which is a better and more lasting thing, and more principally intended by nature, cannot be had: so it will not always follow, that because certain things are in their kind desirable, and therefore may be reckoned among goods, the loss or depravation of them must necessarily be an evil. And so, though a fair and healthy body may be look'd upon as a blessing, yet it will not follow, that a *death* (as the Scripture speaks) either *in* or *for* the Lord, because it throws this flourishing body to the ground, and makes it rot there, must needs be a deplorable evil: since, as the blossoms falling off, is, according to the course of nature, necessarily previous to the formation, or, at least, the perfection, of the fruit; so the being deprived of this life is, according to God's ordination, a necessary antecedent to our being enriched with those more solid and durable blessings of perfect virtue and happiness.

Ο: ἐν Κυ-
εἰς ἀποθ-
νήσκοντες.
Rev. xiv.
13.

AND if, whilst our contemplator's tree is adorn'd with leaves, as well as blossoms, (as we often see several of the former come before all the latter are gone) he chance to take notice, how busy the bees are in sucking these, whilst they leave the others untouched, he may peradventure make this, or some such other reflection on it; That, though the leaves be not only ornaments of a tree, but productions, often useful to shade and shelter the fruit, and are of a more solid texture, and a more durable nature than the blossoms, which seem to be of a slighter make, and rather gawdy and delightful than lasting; yet it is not about the leaves, but the blossoms, that the industrious bee assiduously employs her time, as sucking from those gawdy productions of the tree store of

that honey, which the leaves would not afford her.

THUS, though the books written about dogmatical and controversial points in divinity, may be in their kind valuable, and useful productions of skill in theology, and may seem more strong and substantial composures, and likely to retain their reputations longer, than books of devotion; yet it is of these, rather than those, that the devout Christian will be a solicitous peruser; since it is not from barren, though solid assertions or disputes, but from florid and pathetical books of devotion, which first allure the reader, and then affect him, that the devout soul extracts her honey, I mean, those celestial pleasures, that result from, as well as maintain, a free communion with God, which does at once both exercise her devotion, and recompense it, and afford her, as flowers do the bee, an aliment equally nutritive and delicious.

AND he may somewhat illustrate, as well as continue, the allusion further, by considering, that silk-worms, that live upon leaves, and bees, that feed on flowers and blossoms, do indeed both of them thrive upon their respective aliments, and are thereby enabled to present men with useful productions, but with this difference; that the subtle threads of silkworms serve principally to cloath others, whereas the honey, that is elaborated by the bee, does not only supply others with a healing and cleansing medicine in some distempers, but affords a great deal of pleasure to the bee herself: for thus, though as well the diligent studiers of speculative and polemical divinity, as the careful perusers of books of devotion, may be advantaged by what they study; yet this difference may be observed betwixt them, that the former may, by the discourses they read, be assisted to write others of the like nature, whereby their readers may be enabled to talk with more acuteness, and applause; but the latter may not only be assisted by making such composures, as they assiduously converse with, to contribute to the cleansing of men's consciences from dead works, and as well pacify the troubles of their minds, as heal the wounds, which schism or scandal may have given to the church; but do often, in the first place, feel themselves all the joys, and advantages, they would procure to others, and they happily find pious reflections, devout soliloquies, ardent ejaculations, and other mental entertainments of a religious soul, to be of a nature not only so sweet, but so improving, and so advantageous, that whilst many other laudable employments recommend us to the students of theology, these more especially recommend us to the Author of it, and in dear us to God himself.

IF, when our fruit-tree has changed its white livery for a green, our considerer chance to take notice, how thick it is set with leaves, of which it had not one some months before, it may possibly put him in mind of the instability of their condition, that are undeservedly envied for a numerous train of such seeming friends, and gawdy attendants, as are so to the fortune, rather than the person: for, as in the sun-shiny months

months of summer, when the fair weather would keep the tree warm enough, without the help of leaves, it is wont to be cover'd with those verdant ornaments; but loses them all in winter, when it needs their shelter from the rigors of that cold season: so those, that during the sun-shine of prosperity, are beset with seeming friends, of which they had no need, find themselves left naked, and forsaken of them all, when adversity would make their company of some advantage. If our contemplator chance to observe, how his tree flourishes with verdant leaves, and gaudy blossoms, at that season of the year, when it is providing to bring forth fruit, it may put him in mind of the pleasedness and alacrity, with which a charitable person should set himself to the doing of good; and mind him, that as the God of nature loves a chearful giver, so the temper of a liberal person is pointed out by nature herself in a tree, which seems to triumph in all the ornaments it can put on, when it is about to exhaust the greatest part of its own stock of sap, to produce fruits, which only others are to eat.

If he take notice of the order, wherein it is usual for the leaves and blossoms to precede the fruit, it may possibly invite him to look with a more favourable eye upon the green and immature essays of early writers, if they discover, that the author aims at good things, though he does not yet perform great ones: for, however these youthful productions of the pen are commonly rather pleasing and florid, than otherwise considerable; yet if they be good for their season, and in their kind, though that kind itself be not of the usefulest, they may deserve pardon, and perhaps encouragement; since, though they be not yet solid, they may promise something that will be so; and even the best trees present us their blossoms, before they give us their fruit.

If the same contemplator happens to see young people first shake the tree in vain, and then climb it to gather unripe fruit, it may afford him a representation of men's over-eager and untimely pursuits of several desirable things, and especially of honour: for, as green fruit, though of a good kind, will not easily be shaken down by them, that would gather it, but reduces them either to climb the tree, or forcibly strike it off, which commonly bruises, and disfigures what it procures; and as the fruit, when thus obtain'd, is but sour, and unwholesome, being neither sweetened, nor concocted by maturity; so that it usually both sets the teeth on edge, and breeds sickness in the body; whereas, if the same fruit were let alone till it were fully ripe, and in season, it would both readily drop into the eater's mouth, and prove delicious, and more wholesome food: so, when we greedily pursue after honour, and pleasure, of which this life is not the proper season, we not only meet with difficulties in acquiring them, but find not, in possessing them, either that satisfaction, or that advantage, that the eagerness of our unruly appetites promises us; whereas, if we would stay contentedly till God's time be come (which is al-

ways the best, and fittest) we should not steal, or force, but receive unfading honours, and uncloying delights, by being presented with *incorruptible crowns of glory*, by him, *with whom there is fulness of joy, and at whose right hand* (the station designed for those, that overcome the world's allurements, and their own impatience) *there are pleasures for evermore*; that is, eternal ones.

LASTLY, if towards the end of summer, or of autumn, our reflector, coming to visit his instructive tree, find it present him store of fruit, and perhaps observes it to be grown taller since the last winter, each bough will afford him a lively emblem of a true believer. For, as the loaded branch makes use of the moisture it attracts from the dirty ground, to recede as much as it can from the earth, and spends its sap in shooting up towards heaven, and bearing fruit for men; so the devout Christian improves the blessings he receives of this inferior world, to elevate his mind above it; and the use, that he makes of earthly goods, and advantages, is to raise his grateful soul nearer to God, and dispense them by works of charity to men.

CHAP. V.

THESE, *Sophronia*, are some, and but some, of the thoughts, which the occasional consideration of a fruit-tree might suggest to a considering person. And if we should lead our reflector from the garden to the woods, or to the river-side, or into the fields, or to the street, or to a library, or to the exchange; or, in a word, to I know not how many other places I could name, I have some reason to think, that each of them would supply him with variety of occasional meditations. Wherefore, since the want of themes will not, it is fit that somewhat else should, place bounds to this discourse. And since by finding, that I myself begin to be weary of writing, I have too much cause to fear, that you are quite tired with reading, I think it high time to hasten to a conclusion: only, before I make one, I must do our Meleteticks the right to advertise you, that you would do them wrong, if you should imagine, that in the passed discourse I have either carefully enumerated, or fully display'd, the advantages, which a devout and ingenious contemplator may derive from the exercise of the ways of thinking I have been treating of. For, though I have in the past discourse, especially those parts of it, that are contained in the third precedent, and in this present fourth section, said enough to recommend the subject to any that is not much indisposed to be prevailed with; yet I will not deny, but that, even in those two sections, I have left much unsaid.

FOR, besides the several advantages and ways of making occasional meditations already pointed at, there are other accounts, upon which the practice I would persuade may both benefit a pious soul, and be made use of by an ingenious one. For the respects one thing may have to another are so numberless, and the mind of a rational man, versed in meditations, may

may compound and disjoin notions so many ways, and may make such inferences from them, and such applications of them, that it frequently happens, that besides the reflection, suggested by that which gave the first rise to his meditations, he lights upon conceits differing enough from them, and perhaps better than they: as when hounds, hunting a hare, meet in their way with a stag. For, though philosophers seem to have justly enough rejected the opinion, attributed to *Plato*, that all knowledge is but reminiscence; yet certainly the mind of a man, well furnished with variety of notions, is, by the analogy or contrariety of things and notions, in reference to each other, so easily and readily excited to lay them together, and discourse upon them, that he is oftentimes by any slight occasion helped to light (and that with a strange and surprizing facility) upon things, that he would else have scarce taken the least notice of. When the mind is once set on work, though the occasion administered the first thoughts, yet those thoughts themselves may, as well as the object that excited them, become the themes of further meditation: and the connection of thoughts within the mind may be, and frequently is, so latent, and so strange, that the meditator will oftentimes admire to see, how far the notions he is at length led to, are removed from those, which the first rise of his meditation suggested. And by these incidental excursions he may sometimes be as much delighted and surprized, as *Sampson* was, when going aside to look upon the carcase of a lion, he met with a stock of honey.

Judges
xiv. 8.

BUT I can add one thing towards the inducing you to exercise your self in the way of thinking we have all this while been speaking of; which though I had almost forgot to take notice of, it will, I doubt not, seem important to *Sophronia*, to whom it need not be a discouragement from aiming at one of the noblest uses of occasional reflections, that it supposes not a bare acquaintance with them, but springs from an entire, and (if I may so speak) intimate familiarity with our Meleteticks. For this use of occasional meditations, though it do but gradually differ from some of those, that have been already mentioned, will perhaps by the devout (and consequently by *Sophronia*) be esteemed the highest advantage, that this way of thinking can confer; and it is, that the custom of making occasional reflections may insensibly, and by unperceived degrees, work the soul to a certain frame, or temper, which may not improperly be called heavenly-mindedness, whereby she acquires an aptitude and disposition to make pious reflections upon almost every occurrence, and oftentimes without particularly designing it. But as this privilege will, as I was intimating, scarce fall to the share of any but those, that, by long or frequent exercise, have so accustomed their minds to reflect upon what they see, that they continue that practice, as it were, of their own accord; so when once, by such a constant kindness and hospitableness to such thoughts,

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that they will, as it were, come to the mind without calling, and make themselves its guests, without particular invitations, the soul has attained that desirable frame we lately called heavenly-mindedness, which is a disposition and a readiness to make spiritual uses of earthly things, both the advantage and the delight of that frame of heart cannot but be extraordinary. It must surely afford a great deal of satisfaction to an ingenious and devout person, to be able to make the world both his library and his oratory; and which way so ever he turns his eyes (not only upon unobvious things, but even upon the most familiar ones) to behold something that instructs, or that delights him; and to find, that almost every object, that presents it self to his notice, presents also good thoughts to his mind, to be gathered with as much innocency and pleasure, and with as little prejudice to the things, that afford them, as honey is gathered by the industrious bee from the differing flowers she meets with in her way. Certainly, if we would carefully lay hold on, and duly manage, this help, it would prove a powerful remedy to prevent or cure much of that dullness and drowsiness, that do so frequently smother or blemish our devotion. There would scarce any thing pass us, out of which we would not strike some spark or other of that heavenly fire, or that would not contribute something, either to kindle it, or to feed it, or to revive it. If but half the precious time we impertinently trifle, or squander away, upon employments, that will be sure to cost us either tears or blushes, were carefully laid out in the cultivating of this kind of thoughts, it might often save our ministers the labour of insisting so long upon the uses of their doctrines, when the whole world would be a pulpit, every creature turn a preacher, and almost every accident suggest an use of instruction, reproof, or exhortation. No burial but would toll a passing-bell, to put us in mind of our mortality: no feast but would make us aspire to the marriage-feast of the lamb: no cross but would add to our desires to be dissolv'd, and to be with Christ: no mercy but would be a fresh engagement unto obedience to so good a master, as the author of it: no happiness of others, but would prove an encouragement to serve him, that can give that, and much greater: no misery of others, but would awake and heighten our gratitude, that we are privileged from it: no sin in our neighbours, that would not dissuade us from what we see looked so unhandfomely in others: nor any virtue of theirs, but would excite our emulation, and spur us on to imitate or surpass it. In a word, when the devout soul is come to make that true use of the creatures, as to look upon them as men do upon water, that the sun gilds with his beams, that is, not so much for it self as for the reflective virtue it has to represent a more glorious object; and when she has, by long practice, accustomed her self to spiritualize all the objects and accidents that occur to her, I see not why that practice may not be one of

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the most effectual means for making good that
 Rom. viii. magnificent assertion of the Apostle, *That all*
 28. *things work together for good to them that love*
God: a devout occasional meditation, from

how low a theme soever it takes its rise, being
 like *Jacob's ladder*, whereof though *the foot* Gen.
leaned on the earth, the top reached up to heaven. xxviii. 12.

OCCASIONAL REFLECTIONS.

SECT. I.

REFLECTION I.

Upon his manner of giving meat to his dog.

IGNORANTLY thankful creature, thou
 beggest in such a way, that by what would
 appear an antedated gratitude, if it were
 not a designless action, the manner of thy pe-
 titioning before-hand rewards the grant of
 thy request; thy addresses and recompence
 being so made and ordered, that the meat I
 cast thee may very well feed religion in me.
 For, but observe this dog, I hold him out
 meat, and my inviting voice loudly encourages
 and invites him to take it: it is held indeed
 higher than he can leap; and yet, if he leap
 not at it, I do not give it him; but if he do,
 I let it fall half way into his mouth. Not un-
 resemblingly deals God with us; he shews and
 holds forth to us (the soul's true aliment) eter-
 nal glory, and his most gracious word sum-
 mons and animates us to attempt it. Alas!
 it is far above the reach of our endeavours, and
 our deserts; and yet if we aspire not to it, and
 strive not for it, in vain do we expect it; but
 if we faithfully do what in us lies, and our
 endeavours strain themselves to their utmost,
 God mercifully allows the will for the effect,
 measures our performances by what they aim'd
 at, and favourably accepting what we can do,
 for what we should do, he supplies the imper-
 fections of our faint, but yet aspiring attempts,
 by stooping condescensions; and what our en-
 deavours want of reaching up to, his grace
 and acceptation brings down. Piety is the
 condition, though not the price, of heaven;
 and (like the wedding garment in the parable)
 though it give us not a right to the beatifick
 feast, is, yet that, without which none shall
 be admitted as a duly qualified guest: for
 though we cannot reach heaven by our good
 works, we shall not obtain it without them.

REFLECTION II.

Upon his distilling spirit of roses in a limbeck.

ONE, that knew how well I love the scent
 of roses, and were ignorant of the uses
 of this way of distillation, would, questionless,
 think me very ill advised, thus hastily to de-
 prive my self of the flowers I most love, and

employ art to make them wither sooner than
 nature would condemn them to do: but those
 that know, both the fading condition of flowers,
 (which, unimprov'd by art, delight but whilst
 they are, what they cannot long be, fresh) and
 the exalting efficacy of this kind of distillation,
 will think this artificial way, that chymists
 take, of spoiling them, is an effect as well of
 their providence as their skill: for that pleas-
 ing and sprightly scent, that makes the rose
 so welcome to us, is as short-lived and perish-
 ing, as the flower, that harbours it, is fading;
 and though my limbeck should not, yet a
 few days inevitably would, make all these
 roses wither. But by this way of ordering my
 roses, though I cannot preserve them, I can
 preserve that spirituous and æthereal part of
 them, for whose sake it is, that I so much
 prize and cherish this sort of flowers; which,
 by this means, I preserve, not indeed in the
 fading body, but in the nobler and abstracted
 quintessence; which purer and lastinger por-
 tion of them will be more highly fragrant
 than ordinary roses are wont to be, even whilst
 they are fresh, in that season, when those
 flowers, that have not been thus early and pur-
 posely destroyed, will, according to the course
 of nature, whereto they are left, wither and
 putrify.

Thus he that sees a charitable person libe-
 rally part with that money, which others are
 so fond of, if he be a stranger to the opera-
 tions of faith, and the promises of the gospel,
 he will be apt to mistake the Christian's libe-
 rality for folly, or profusion, and to think
 that he is fallen out with his money: but he
 that remembers, how clear a prospect, and how
 absolute a disposal of the future, the Scripture
 of truth (to use an angel's expression) af-
 cribes to him, that bid his disciples *make them-*
selves friends with the uncertain (or unfaithful)
mammon, (for so the use I sometimes meet
 with of the Greek word, together with the
 context, invites me to render it) *that when he*
fail, they may receive us into everlasting habi-
tations; and he that shall likewise consider,
 not only the transitory nature of worldly pos-
 sessions, (from which their perishing, or ours,
 will be sure ere long to divorce us) but the in-
 estimable advantage, with which we shall re-
 ceive in heaven whatever we employ in pious
 uses

uses here on earth, will conclude this way of parting with our wealth the surest and gainfullest way of preserving it; since the Christian, by parting but with what (however) he could not long keep, shall, through God's munificent goodness, obtain a much more valuable treasure, that he shall never lose: so that thus to sacrifice wealth to charity is not an early loss of it, but the right way of securing it; for by this gainful way, when we shall, in another world, be past the possibility of possessing our riches in kind, such an employment of them may help us to enjoy them, though not in the capacity of riches, yet in that noble capacity of goods, under which notion alone they are desirable; and thus laid up they may there procure us, what they could never here afford us, happiness.

REFLECTION III.

Upon his being in great danger wandring, on Mendip hills, among covered lead mines, that he knew not of.

HOW have I travelled all this while upon the brink of the grave! I thought only to be out of my way, but little dreamed to be so near the end of all my journeys, in that of my life by traversing to and fro amongst those deep and covered pits, upon any one of which if my horse had but chanced to stumble, (and the very mine-men I at length met with, think it a kind of miracle he did not) I had been killed and buried at once, and my fate had been for ever as much concealed from my friends as my body: and all this escape a work so totally of God's goodness, that I did not so much as know my danger till I was past it; so that it seemed sent, but to give me occasion of rejoicing in my deliverance. How vast a debt of gratitude then do I owe to God? and how extremely do I fall short of acquitting my self of it? since, besides that I make him but very unsuitable returns for the blessings I know I have received, I receive from him signal blessings, that I do not so much as know of, and which consequently I am very unlike particularly to acknowledge. But this gracious rescue, from so great and unexpected a hazard, shall, I hope, teach me henceforth to beware, both of security, since I often fall into dangers that I know not, and of distrusts of God's providence, since I have found it so watchful to deliver me from those that I feared not.

REFLECTION IV.

His horse stumbling in a very fair way.

HERE is a patch of way, to which any less smooth than a bowling-green were rugged, and in which it seems not only so unlikely, but so difficult, for a horse to trip, that nothing could have made me believe a horse could have stumbled here, but that mine has dangerously done so. This jade has this very evening carried me safely through ways, where stumbles were so much to be expected, that they were to have been forgiven; and now in

a place so smooth, that sure he could not falter in it, only out of curiosity and trial, he falls under me so lubberly, that I as much admired my escape as danger. But it is too usual with us, unflinchingly to traverse adversity's rough ways, and stumble in prosperity's smoothest paths. The observation is almost as old as prosperity, that fortune ruins more persons whilst she embraces them, than whilst she would crush them: but though the observation be very common, it is not more so, than it is to see even those, that make it, add to the instances that justify it. I have seldom yet been so fortunate, as to be obnoxious to that less frequently pitied than disarming danger: Fortune has seldom yet vouchsafed to turn Syren to pervert me; and she has hitherto given me much more exercise for my constancy than for my moderation. I think too, that without flandering my self, I may confess, that I have sometimes wished my self in the lists with that bewitching enemy, prosperity; and increased the number of those many, who never think so fair an adversary formidable, till they find themselves vanquished by her: but upon second thoughts, I judge it better, to leave the choice of my antagonist to him, who not only best knows my strength, but gives it me; especially, when I consider, that as we are all of us naturally such stumblers, that (as Solomon speaks in somewhat another sense,) *even the just man falls seven times a day*, so it is observed in Prov. xxiv. 16. stumblers, that they are most so in fair way; into which if providence lead my steps, I shall think it seasonable to pray, *and lead us not into temptation*; and shall not think it unseasonable to remember, that ice is at once the smoothest and the slipperiest of ways, and that (the jadedness of our natures well considered) there is no way, wherein we ought to travel with more heed, than that, whose treacherous evenness would divert us from taking heed to our way.

REFLECTION V.

Upon two very miserable beggars, begging together by the high-way.

BEHOLD this fore-most wretch, whose strange deformity and ghastly fores equally exact our pity and our horror; he seems so fit an object for compassion, that not to exercise it towards him can scarce proceed from any other cause than the not having any at all: the sadness of his condition is augmented by his want of eyes to see it; and his misery is such, that it calls for an increase of pity, by his being so distracted, as to desire a longer life, or rather longer death: he sues more movingly to the eye than to the ear; and does petition much less by what he says, than what he is: each several member of his tortured body is a new motive to compassion, and every part of it so loudly pleads for pity, that (as of scolds) it may (in another sense) be said of him, that he is all tongue. But yet this other beggar thinks not his condition the less deplorable for his companion's being the

the more so: he finds in the diseases of his fellow as little consolation as cure; nor does he at all think himself supplied with a deficient hand, because the other wants one. And therefore he is as importunate for relief, as if all miseries were not only heaped on him, but confined to him: his fellow's burthen lightens not his load; and if fortune never had persecuted any other, he could not more deplore nor resent her persecutions. So that, if we should judge of their miseries rather by the ear than by the eye, this latter's sadder complaints would move us to decree him the advantage in point of wretchedness.

TRANSLATE now, my soul, all this unto spirituals; and as we measure the straightness of lines, not by a ram's horn, but a ruler; so be not thou so rash, as to infer thy health from others more forlorn and desperate diseases. Let not the greater difficulty of another's cure lessen the solicitousness of thy care for thine, nor make thee the less earnest in the imploring and labouring for relief. In so depraved an age as ours, one may (and perhaps in vain too) search hell to find wicked men than are to be, but too frequently, met with upon earth: he will scarce be innocent, that will think himself so, as long as he finds a man more culpable than he; and he shall scarce ever judge himself guilty, whom the sight of a guiltier will absolve. Nor will that man (till it is perhaps too late) be apt to attempt an escape from the pollutions of the world, that stays till he can see none more inextricably entangled in them than himself. Do not, therefore, O my soul, content thyself with that poor comparative innocence, that in heaven (which it will never bring thee to) has no place, by reason of the absence of all vicious persons; and in hell itself (which it secures not from) can afford only the ill-natured consolation of not being altogether as miserable, as the wretchedest person in that place of torment.

REFLECTION VI.

Sitting at ease in a coach, that went very fast.

AS fast as this coach goes, I sit in it so much at ease, that whilst its rapid motion makes others suspect, that I am running for a wager, this lazy posture, and this soft seat, do almost as much invite me to rest, as if I were a-bed. The hasty wheels strike fire out of the flints they happen to run over; and yet this self-same swiftness of these wheels, which, were I under them, would make them crush my bones themselves into splinters, if not into a jelly, now I am seated over them, and above their reach, serves but to carry me the faster towards my journey's end. Just so it is with outward accidents, and conditions, whose restless vicissitudes but too justly and too fitly resemble them to wheels: when they meet with a spirit, that lies prostrate on the ground, and falls groveling beneath them, they disorder and oppress it; but he, whose high reason, and exalted piety, has, by a noble and steady contempt of them, placed him

above them, may enjoy a happy and a settled quiet, in spite of all their busy agitations; and be so far from resenting any prejudicial discomposure from these inferiour revolutions, that all those changes, that are taken for the giddy turns of fortune's wheel, shall serve to approach him the faster to the blest mansion he would arrive at.

REFLECTION VII.

Upon the sight of a windmill standing still.

GENORIO, EUSEBIUS, LINDAMOR.

GEN. YOUR eyes, gentlemen have been so long fixed upon this windmill, that, in spite of the barrenness of the subject, I cannot but suspect, it may have afforded one, or each of you, an occasional meditation.

EUSEB. To justify your conjecture, *Genorio*, I will confess to you, that I was considering with myself, that if one, who knew not the miller's trade and design, should look upon this structure, he would think the owner worthy of so incommodious a mansion, if not of a room in *Bedlam*; for, we see, he has chose to erect this fabrick in a solitary place, and upon the cold and bleak top of a swelling ground, where nothing shelters it from the violence of a wind, whilst its high situation exposes it to the successive violences of them all. But he that is acquainted with the exigencies of the miller's design and trade, will think he has made a very proper choice, in seating himself in a place, where no wind can blow, that he shall not be able to make an advantage of. And having considered this, *Genorio*, my thoughts, when you interrupted them, were making this application of it; that we ought not to be too forward to censure men, otherwise virtuous, and discreet, for engaging themselves, upon some accounts, to troublesome and unsettling employments: for if the end be not mischoven, the means are to be estimated by their tendency thereunto; and though a calmer condition of life might be in itself more desirable, yet when a more exposed one can make him, that is qualified for such employments, more serviceable in his generation, this may, upon that account, be more eligible than the other; since, as it exposes him to more hardships, it affords him more opportunities of prosecuting his aims; so that his station is recommended to him by those very circumstances, that make other men dislike it.

GEN. But may not I also know what thoughts this worthy theme suggested to *Lindamor*?

LIND. I was, *Genorio*, taking notice, that this whole fabrick is indeed but a large engine, where almost every thing, as well as the sails and the wheels, is framed and fitted for the grinding of corn: but, though this whole structure be artificially enough contrived, yet it can now do nothing in order to its end, for want of such a light and airy thing as a breath of wind, to put all this into motion. And, *Genorio*, this windmill, thus considered, brought into my mind the condition of a great lord, that you and I not long since visited, and who

who is far from being the only person, to whom the reflection may be applicable; for one, that not knowing his humour, and his aims, should see how great a provision his plentiful fortune, and his skill to manage it, have laid together, of those things, which are wont to be thought the chiefest instruments (and, perchance, the chief parts) of happiness, would be apt to envy his condition, as discerning nothing that is wanting to it. But alas! the man expects and covets esteem and reputation; and though fame have these resemblances to the wind, that it is an airy and unsolid thing, which we must receive from others, and which we are not only unable to procure for our selves, but know not how long we shall keep it when we have it; yet the want of this alone makes all the rest utterly insufficient for his satisfaction. Thus the not so great as ambitious *Alexander*, after all the blood he had spilt in conquering the world, is said to have shed tears, that he had conquered but one, when a philosopher told him there were more. And all the favours, that the greatest potentate upon earth could heap upon proud *Haman*, were, by his own confession, unable to make him think himself happy, as long as he could not neglect a captive's neglect of him; all his greatness did him no good, if but one man had the courage not to bow to it; and an unsatisfied appetite of revenge quite spoiled the relish of the great monarch's favours, and the fair *Esther's* banquets. Nor do I doubt, *Genorio*, that we often marvel, if not repine, at providence, upon a great mistake; for by refusing to be God's servants, men usually become so to their own unruly passions, and affections. And therefore we often very causelessly envy the great and rich, as if they were as happy as the advantages vouchsafed them, would make a wise and good man; whereas perhaps the man courts a reputation, that is not to be acquired by what men have, but by what they are, and do; or else he is in love with a lady, that loves not him, or loves another better: and the coyness of a mistress, the greater title of a neighbour, or some such trifling accident, that another would either not be subject to, or not be much concerned for, will keep him from enjoying any of those very things, for which by-standers envy him: so just it is, that in estimating a man's condition, we should not only consider what possessions he has, but what desires.

REFLECTION VIII.

Upon his paring of a rare summer apple.

HOW prettily has curious nature painted this gaudy fruit? Here is a green, that emeralds cannot, and *Flora's* self might boast; and *Pomona* seems to have affected, in the fresh and lively vermilion that adorns this smooth rind, an emulation at rubies themselves, and to have aimed at manifesting, that she can give her vegetable productions as lovely and orient, though not as lasting colours, as those that make jewels precious stones; and if, upon the hearing the praises this scarlet deserves, her blushes enoble her own cheeks with so vivid

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a colour, perhaps such a livery of her modesty might justify her pride. In a word, such pure and tempting green and red dye this same polished skin, that our vulgar boldness must be no longer questioned, for rendring that fruit an apple, that inveigled our first parents. But though these winning dyes delight me strangely, they are food for my eye alone, and not my stomach; I have no palate for colours; and to relish this fruit well, and know whether it performs to the taste what it promises to the sight, and justify that Platonick definition, which styles beauty the lustre and flower of goodness, all this gay outside is cut and thrown away, and passes but for parings. Thus, in opinions, though I look with pleasure on that neat fashionable dress, that smother pens so finely cloathe them with; and though I be delighted with the pretty and spruce expressions, that wit and eloquence are wont to trick them up with; yet when I mean to examine their true relish, that, upon liking, I may make them mine, I still strip and divest them of all those flattering ornaments (or cheating disguises rather) which so often conceal or misrepresent their true and genuine nature, and (before ever I swallow them) after they have been admitted by the more delusible faculty we call fancy, I make them pass the severer scrutiny of reason.

REFLECTION IX.

Upon his coach's being stopt in a narrow lane.

HERE, for aught I can guess, my stay is like to be long enough, to afford me the leisure of a reflection on it: for I have found already, in this narrow lane a very large scene to exercise my patience in; and this churlish drayman seems resolved to be as tedious to me, as *Ludgate-Hill* is to his horse, when his cart is overladen. They, that are going on foot to the same place this coach should carry me to, find not their passage hindered, or their way obstructed by that, which keeps me here; and were I disposed to leave my coach behind, and foot it after them, I might in their company sooner reach the place my designs and affairs call me to, than I shall (probably) be supplied with hopes of getting quickly out from hence. Alas! how frequently falls it out thus in our journeys towards heaven? Those, whom their adverse fortune, or a noble scorn, hath stript of, or released from, these troublesome and intangling externals, may tread the paths of life nimbly and cheerfully, being unstopt by many obstacles, that intercept the progresses of others. But those stately persons, whose pride or effeminacy will not permit them to move an inch towards heaven, unless they may be carried thither in pleasure's easy coaches, and who will not bate a superfluity, or lay by the least circumstance or punctilio of grandezza, to lessen themselves into a capacity of entering in at the strait gate, may soon find these treacherous and over-loved conveniences turned into cumbersome clogs, and real impediments, that will, if not block up, at least obstruct the passage to the seat of so much joy; that even

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to be cast ashore there, by shipwreck, were a blessing ; and that he is thought unworthy to be admitted there, that cannot think it his happiness to reach that place himself, though he leave all behind him to get thither.

REFLECTION X.

Looking through a perspective glass upon a vessel we suspected to give us chase, and to be a pirate. [Sailing betwixt Rotterdam and Gravesend on Easter-day, 1648.]

THIS glass does indeed approach the trusted vessel, but it approaches her only to our eyes, not to our ship; if she be not making up to us, this harmless instrument will prove no loadstone to draw her towards us; and if she be, it will put us into a better readiness to receive her. Such another instrument in relation to death is the meditation of it; (by mortals so much, and so causelessly, abhorred :) for though most men as studiously shun all thoughts of death, as if, like nice acquaintances, he would forbear to visit, where he knows he is never thought of, or as if we could exempt ourselves from being mortal, by forgetting that

we are so; yet does this meditation bring death nearer to us, without at all lessening the real distance betwixt us and him: if that last enemy be not yet approaching us, this innocent glass will no more quicken his pace, than direct his steps; and if he be, without hastening his arrival, it will prepare us for his reception. For my part, my beardless chin allows me to presume, that by the course of nature, I have yet a pretty stock of sand in the upper part of my hour-glass: wherefore, though I am now too young to say with *Isaac*, *Behold, now I am old, and I know not the day of my death*, Gen. xxvii. 2. yet since the youngest and lustiest of us all has cause to say with the mirror of patience, *When a few years are come, then shall I go the way whence I shall not return*, Job xvi. 22. and since it is the wise man's counsel, *Not to boast ourselves of to-morrow, because we know not what a day may bring forth*: I will endeavour (to use our Saviour's terms) *to take heed to myself, lest at any time that day come upon me unawares*, Luke xxi. 34. And, as the only safe expedient in order thereunto, I will (in imitation of holy *Job*) *All the days of my appointed time, wait till my change come*, Job xiv. 24.

S E C T. II.

Containing OCCASIONAL REFLECTIONS upon the
Accidents of an Ague.

MEDITATION I.

Upon the first invasion of the disease.

THIS visit, dear * *Sopbronia*, which you intended but for an act of kindness, proves also one of charity; for though it be not many hours since we parted, and though you left me free from any other discomposure than that, which your leaving me is wont to give me; yet this little time has made so great a change in my condition, as to be, I doubt not, already visible in my looks: for whilst I was sitting quietly in my chamber, and was as far from the thoughts of sickness, as from any such disorders, as are wont to be the occasions of it; and whilst I was delightfully entertained by an outlandish virtuoso, that came to visit me, with an account of the several attempts, that are either made, or designed in foreign parts, to produce curiosities, and improve knowledge; I was suddenly surprized with a chillness, and a shivering, that came so unexpected, and increased so fast, that it was heightened into a downright fit of an ague, before I could satisfy myself what it was. But I con-

fess, that this unwelcome accident had not amazed me, as well as troubled me, if I had sufficiently considered, to what a strange number and variety of distempers these frail carcases of ours are obnoxious; for, if I had called to mind, what my curiosity for dissections has shown me, and remembered how many bones, and muscles, and veins, and arteries, and gristles, and ligaments, and nerves, and membranes, and juices, a human body is made up of, I could not have been surprized, that so curious an engine, that consists of so many pieces, whose harmony is requisite to health, and whereof not any is superfluous, nor scarce any insensible, should have some or other of them out of order, it being no more strange, that a man's body should be subject to pain, or sickness, than that an instrument with above a thousand strings (if there were any such) should frequently be out of tune; especially since the bare change of air may as well discompose the body of a man, as untune some of the strings of such an instrument; so that even the inimitable structure of human bodies is scarce more admirable, than that such curious and elaborate engines can be so

* A Name often given by the Author to his excellent Sister R. who was almost always with him, during his sickness.

so contrived, as not to be oftner out of order than they are; the preservation of so nice and exact a frame being the next wonder to its workmanship. And indeed, when I consider further, how many outward accidents are able to destroy the life, or, at the least, the health, even of those, that are careful to preserve them; and how easily the beams of a warm sun, or the breath of a cold wind, or too much, or too little exercise, a dish of green fruit, or an infectious vapour, or even a sudden fright, or ill news, are able to produce sickness, and perhaps death; and when I think too how many evitable mischiefs our own appetites, or vices, expose us to, by acts of intemperance, that necessitate the creatures to offend us, and practices of sin, whereby we provoke the Creator to punish us: when, I say, I consider all this, and consequently how many mischiefs he must escape that arrives at grey-hairs; I confess, the commonness of the sight cannot keep me from thinking it worth some wonder, to see an old man, especially if he be any thing healthy. But these kind of thoughts, *Sophronia*, are seldom entertained, unless they be excited by some unwelcome occasions; and when we are long accustomed to health, we take it for granted, that we shall enjoy it, without taking it for a mercy that we are so: we are not sensible enough of our continual need and dependence on the divine goodness, if we long and uninterruptedly enjoy it; and by that unthankful heedlessness we do, as it were, necessitate providence to deprive us of its wonted supports, to make us sensible, that we did enjoy, and that we always need them: it being but fit, that mercies should cease to be constant, which their constancy only, that should be their in-dearment, keeps us from entertaining as mercies. I will therefore, *Sophronia*, endeavour to derive this advantage from this sudden fit of sickness, to make me thankful for health, when God shall be pleased to restore it me, and to keep me from reckoning confidently upon the lastingness of it. For though we are very unapt to take even the wise man's counsel, where he forbids us to *boast ourselves of to-morrow, because we know not what a day may bring forth*; yet by such accidents I find, that *Solomon* spoke much within compass, and had not done otherwise, if for a day he had substituted an hour: for so many, and so various are the unforeseen accidents, to which we poor mortals are exposed, that the continuance of our health or prosperity do much more merit our thanks, than the interruption of them can deserve our wonder. And I must confess, *Sophronia*, that though my falling sick may be but my unhappiness, my being so much surprized at it was my fault.

MEDITATION II.

Upon the immoderate heat and cold of the aguish fit.

ONE that, not knowing what ails me, should come in, and see me in this soft bed, not only covered, but almost oppressed with clothes, would confidently conclude, that,

whether or no I be distressed by the contrary quality, I cannot at least be troubled with cold; and if he himself were so, he will be apt to envy me. And if, instead of coming in my cold fit, he should visit me in my hot one, and see me with my shoulders and arms quite uncovered, and nothing but the single sheet on the rest of my body; he would be apt to think, that I must lie very cool. But alas! in spite of all that lies upon me, an internal frost has so diffused it self through every part, that my teeth chatter, and my whole body does shake strongly enough to make the bed it self do so; and, though I still wish for more clothes, yet those, that are heaped on me, can so little controul this preternatural cold, that a pile of them might sooner be made great enough to crush, than to warm me: so that when I travelled even in frosty nights, the winter had nothing near so strong an operation on me. And as that external cold was far more supportable whilst it lasted, so it was incomparably more easy for me, by exercise, and otherwise, to deliver my self from it.

Thus, when a great or rich man's mind is distempered with ambition, avarice, or any immoderate affection, though the by-standers, that see not what disquiets him, but see what great store of accommodations fortune has provided for him, may be drawn to envy his condition, and be kept very far from suspecting, that he can want that contentment, the means of which they see him so richly supplied with: and yet alas! as the colder heat of the external air is much less troublesome to a man in health, though furnished with an ordinary proportion of clothes, than the cold or hot fit of an ague, with a pile of blankets first, and then a single sheet; so to a vigorous and healthy constitution of mind, external inconveniences are much more supportable, than any accommodations can make the condition of a distemper'd soul. Let us not then judge of men's happiness, so much by what they have, as by what they are; and consider both, that fortune can but give *much*, and it must be the mind, that makes that *much enough*: and that, as it is more easy to endure winter, or the dog-days in the air, than in the blood; so a healthful mind, in spite of outward inconveniences, may afford a man a condition preferable to all external accommodations without that.

MEDITATION III.

Upon the succession of the cold and hot fit.

WHEN the cold fit first seized me, methought it was rather melted snow than blood, that circulated in my veins, where it moved so inordinately, and maintained the vital flame so penuriously, that the greatest sign, which was left to distinguish this cold from that of death, was its making me shake strong enough to shake the bed I lay on. I called for more and more clothes, only because I needed them, not because I found any relief by them: I fancied the torrid zone to be of a far more desirable constitution than that we call the temperate;

perate; and as little as I am wont to reverence vulgar chymists, I then envied their laborants, whose employment requires them to attend the fire. But when the cold fit was once over, it was quickly succeeded by a hot one, which after a while I thought more troublesome than it. I threw off the clothes much faster than my former importunity had procured them to be laid on me; and I, that could a little before scarce feel all that had been heaped on me, could not now support a single sheet, but thought its weight oppressed me.

I ENVIED the inhabitants of *Norway*, and *Iceland*, far more than those, that dwell either in the richest province of *East-India*, or of the Golden Coast it self: and of all creatures, not rational, I thought the fishes the happiest, since they live in a cool stream, and, when they please, may drink as much as they list.

IF then, *Sophronia*, the self-same person may, within less than two hours, have such different apprehensions of his own condition, as now to complain of that as a sad grievance, which but an hour before he wished for as a relief; we may well acknowledge, that we frequently mistake in estimating the hardships and afflictions we complain of, and find them not so uneasy as we make them, whilst we not only endure the whole affliction, that troubles us, but often increase it, by repining at the envied condition of others.

AN afflicted man is very apt to fancy, that any kind of sickness, that for the present troubles him, is far less supportable, than if it were exchanged for another disease; and imagines his case to be so singular, that one cannot say to him in *St. Paul's* language, *No temptation has befallen you, but that which is common to men*, 1 Cor. x. 13. He presumes, that he could far more easily support his crosses, if instead of his present disease, he had this or that other; though, if the exchange were made, he would, perchance, wish for his first sickness, if not be as much troubled at his own folly, as with the disease. He that is tormented with the gout, is apt to envy any sick man, that is exempted from that roaring pain, and able to walk about: he that is swelled with the dropsy, fancies all persons happy, whose diseases allow them drink to quench their thirst: and the blind man envies both these, and thinks no persons so miserable in this world, as those that cannot see the world. Fevers burn us, agues shatter us, dropsies drown us, phrenies unman us, the gout tortures us, convulsions wrack us, epilepsies fell us, colicks tear us; and in short, there is no considerable disease that is not very troublesome in it self, however religion may sanctify and sweeten it: for as a fortress, whose defendants are not treacherous, can scarce be taken otherwise than either by famine, or storm; so life, for whose preservation nature is so faithfully solicitous, cannot be extinguished, unless either chronical diseases do lingeringly destroy, or some acute do hastily snatch it away. And indeed, if a disease prove mortal, it is no more than is to be expected, if it tire out the patient with tedious languishments, or else dispatch him with

dismal symptoms: nor is it in point of sickness only, that we are often more unhappy than we need, by fancying ourselves more unhappy than we should be, if we were allowed to exchange that, which now troubles us, for any thing which does not. But there are evils, which, though exceeding contrary in appearance and circumstances, do yet agree in being extremely troublesome; as the poorest wretch our Saviour cured in the Gospel, though he were sometimes cast into the fire, and sometimes into the water, yet in both states was tormented by the same devil, who, in variety of inflictions, still expressed the same malice. But we should make a righter estimate of suffering, if we did but consider, that much uneasiness is annexed to an afflicted condition in general; and that therefore, which we are sensible of, may proceed rather from the general nature of sicknesses, and crosses, than from the particular kind and degree of ours. And indeed, if a man were permitted to exchange his disease with those of others, he would often find his granted wishes to bring him a variety of mischiefs, rather than an exemption from them; and many of those, that we envy, as thinking them far less sufferers than our selves, do look with invidious eyes on us, and do but dissemble their grievances more handsomely than we, not find them more easy than ours. And that of *St. Peter* may be more generally applied, than most men think, where he exhorts to constancy, upon this consideration, *That the same sufferings are accomplished upon our brethren in the world*, 1 Pet. v. 9. For it is all one as to the efficacy of this lenity, whether our afflictions be the same with those of others, in kind, or not superior to them in degree: and I doubt not, but we should support many of our grievances as easily as those, for which we wish them exchanged, if the chief account, upon which they trouble us, were not rather, that they are the present ones, than the greatest.

MEDITATION IV.

Upon the being let blood.

ONE of the most troublesome symptoms in almost all feverish distempers is wont to be thirst; and in mine it was importunate to a degree, that made me very much so, in frequently soliciting those, that were about me for drink, which, in the heat of the fit, seemed so desirable an object, that it then much lessened my wonder at that parch'd king's agreement, who, urged with thirst, sold his liberty for a full draught of cold water. But alas! I sadly found, that the liquor I swallowed so greedily, afforded me but a very transient relief, the latter being gone almost as soon as the former had passed thorough my throat; so that not only it did but amuse me, not cure me; but, which is worse, drinking it self increased my thirst, by increasing the fever, whose uneasy symptom that was. Wherefore, seeing all the cooling juleps that could be administered, did free me from nothing but the expectation of being much relieved by such slight and palliative

liative medicines; the doctor thought himself this day obliged to a quite contrary, and yet a more generous remedy; and ordered, that, instead of giving me drink, they should take away blood, as judging it the best and far the surest course to take away the uneasy symptoms, by removing that, which fomented the cause.

THUS when the mind is distempered with turbulent commotions, and the disquieted appetites does too restlessly and eagerly crave objects, which, though perhaps in themselves not absolutely bad, are at least made, by a conjunction of circumstances, unfit and dangerous for the person that longs for them: we, like unskilful or unruly patients, fondly imagine, that the only way to appease our desires is, to grant them the objects they so passionately tend to. But the wise and sovereign physician of souls, who considers not so much what we do wish, as what we should wish, often discerns, that this præternatural thirst indicates and calls for a lancet, rather than a julep, and knows it best to attempt the cure, rather by taking away somewhat that we have, than by giving us that, which only a spiritual superfluity reduces us to want. And in effect, we often see, that as a few ounces of blood taken away in a fever do cool the patient more than the giving him ten times as much drink would do; so a few afflictions, by partly letting out, and partly moderating our corrupt affections, do more compose and appease a mind molested with inordinate appetites, than the possession of a great many of the objects we impotently desire. Whilst our appetites are roving, and unreasonable, and insatiate, the obtaining of this or that particular object does but amuse the patient, not take away the disease; whereas seasonable and fancified crosses, that teach us to know our selves, and make us sensible how little we deserve, and how little the things we are so greedy of could make us happy, if obtained, may reduce us to a resignation, and tranquillity of mind, preferable to those over-valued things, which, as it keeps us from enjoying, so it keeps us from needing. Thus *Zacheus*, who, whilst a publican, never thought he had enough, when he had once entertained our Saviour, though he offered to make a quadruple restitution of whatever he had fraudulently acquired, was, upon a sudden, by being freed from avarice, grown so rich, that he was, forward to give no less than half he had to the poor; as if his divine guest had wrought upon his goods such miracles, as he had done upon the five loaves, and two fishes, of which the remains amounted to more than the whole provision was at first.

MEDITATION V.

Upon the taking of physick.

THE last bitter potion that I took, *Sophronia*, was, I remember, sweetned with the hopes were given me with it, that it might prove the last I should need to take, and would procure me a settled and durable

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health: but I find by sad experience, that the benefit I derived from it is nothing near so lasting as it was welcome; for I am now reduced to take physick again, and I fear must often do so, before I shall be able to dislodge this troublesome ague that haunts me. For though the last physick I took, wrought so well, that I hoped it had brought away not only the ill-humours themselves, but the very sources of them; yet by the effect of what I took this morning, I not only find there is as much to be purged away now, as there was then, but, what is sadder, I can scarce hope this physick will excuse me from the need of taking more again ere long. But though it is a troublesome thing, and must be often repeated, yet it is a salutary thing too, and cannot be more unpleasant than it is useful; and as loathsome as it is, a sickness were far worse. Thus when a relenting sinner has endeavoured to wash away his sins with his tears, he may possibly think himself so thoroughly washed in that absterfive brine, (which yet owes its cleansing virtue not to its own nature, but to the blood of Christ) that if he be a new convert, and be entertained with those ravishing delights, wherewith God is often pleased to engage such returning prodigals, (as the kind father welcomed his riotous son with feasting, and with musick) that he is apt to fancy repentance to be like baptism, which, being received once for a man's whole life, needs never be renewed. But though, during such transports, an unexperienced convert may be apt to cast the gauntlet to the world, saying in his spiritual prosperity, that he should never be moved; yet, as our Saviour speaks, *The spirit indeed is willing, but the flesh is weak*: and too commonly our resolutions flag with our joys, and those that a while before imagined they despised the world, find themselves worsted, if not captivated, by it; and find it far more difficult than they thought it, to live in the company of sinners without being of their number, and in so defiled a world without being spotted by it.

AND as the same *David*, who said in his prosperity, he should never be moved, said in his distress, he should one day perish by the hand of *Saul*; so many of those, that whilst their tears of repentance, and of joy, are not yet dried off their eyes, are apt to defy and contemn all the ghostly enemies, and difficulties, that oppose their present zealous resolutions, will, perhaps, in a while after, when they meet with unexpected impediments, and foils, change their confidence into despair, and think those very enemies, whom they lately looked on as despicable, to be insuperable. But as physick, that does good for a time, ought not to be rejected, because it does good but for a time; nor should we reject the only sure means of our present recovery, for fear of future relapses: so, though we sadly find, that repentance must be repeated, and that after we have practised it often, we must have need of it again; yet since it is the only proper means to recover a soul out of a state of sin, which is

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worse

worse than any disease, and leads to the worst of deaths, we must never suffer our selves to be so far discouraged, as to forego so necessary and so profitable a duty, and must not more frequently relapse into faults, than renew our sorrow for them, and our resolves against them: for innocence indeed is far more desirable than repentance, as health is than physick. But as physick is more eligible than the continuance of sickness, so is repentance more eligible than continuing in the state of sin: and as the drinking even of a bitter potion is a less evil than the heat, and thirst, and restlessness of an ague; so to lament for sin here, is a far less uneasy thing, than to do it in a place, where there is nothing but remediless wailing, and gnashing of teeth. It is true, that our souls are in this too like our bodies, that our whole lives are spent betwixt purging away of naughty humours, and accumulating them: and methinks, I hear the flesh still saying unto the spirit, as *Ruth* did to *Naomi*, *the Lord do so to me, and more also, if aught but death part thee and me*, *Ruth* i. 14. But although there are defilements, which, though often washed off, will as often come again to blemish us; and though the *deeds of the * body* will scarce all of them perfectly be put to death, but with the body it self; yet next to an uninterrupted state of health, frequent and early recoveries are desirable: and though the shameful necessity of needing to beg many pardons for the same fault may justly make an ingenuous Christian cry out with *Saint Paul*, *O wretched man that I am! who shall deliver me from the body of this death?* yet the same sense of his own frailty, that puts this exclamation into his mouth, may comfort his heart, by its being a pledge, that he shall one day be able exultingly to say with the same Apostle in another place, *Thanks be to God, which giveth us the victory, through our Lord Jesus Christ*, *1 Cor.* xv. 57.

MEDITATION VI.

Upon the syrups and other sweet things sent him by the Doctor.

THIS complaisant physician, *Sophronia*, is, you see very solicitous, that his remedies should as well gratify the patient, as oppose the disease: and besides that this julip is ting'd with syrup of clove-july-flowers, that it may at once delight the palate, and the eye; some of these other remedies are sweetned with as much sugar, as if they came not from an apothecary's shop, but a confectioner's. But my mouth is too much out of taste to relish any thing, that passes through it; and though my sickness makes this flattering of the palate almost necessary to the rendering these medicines takable by me, yet upon the account of the same distemper, all that the Doctor's tenderness and skill could do to make them *pleasant*, can at most but keep them from being *loathsome*. And therefore you will easily believe, *Sophronia*, that I enjoy these sweet things upon a score, that, if it does imbitter them, does

at least, as to me, deprive them of their nature: so that he, that, for the sake of these syrups and electuaries, should, notwithstanding the malady that needs them, envy me, might be suspected to be troubled with a worse disease than an ague is, a frenzy.

THUS there are many favourites of fortune, whose seeming enjoyments may, perchance, be envied by those, that do but gaze on their condition, whilst it is rather pitied by those that know it. To be brought by greatness of power, or riches and effeminacy of mind, to that pass, that they seldom hear any thing but their own praises, even when their actions merit reprehension, and that they can relish nothing that is not sweetned with so much of flattery, as quite to disguise, and perhaps pervert, its nature: these, as I was going to say, and such other unhappy privileges, are things, which (whatever fools may think) will not recommend greatness to a considering man, and are far more fit to procure the possessor's ruin, than wise men's envy: and besides that a vain and impotent soul is, by those disquieting qualities, molested with greater distempers, than those gratifications can make amends for, and which often hinder the full relishing of these or any other pleasures. The delight these treacherous delicacies afford, is so much less considerable than the weakness they suppose; that it is far more eligible to be without them than to need them.

MEDITATION VII.

Upon the want of sleep.

AH! dear *Sophronia*, in spite of all the care and officiousness of those diligent attendants, that you were pleased to send to watch with me, I have slept all night as little as I do now, or as I shall desire to do whilst you stay here.

THIS unwelcome leisure brought me as much a necessity, as an opportunity to spend the time in entertaining my thoughts, which on this occasion were almost as various, and seemed too as wild, as, if I had slept, my dreams themselves would have been: and therefore, I presume you will not wonder, if I can now recall but few of them, and if the rest be as easily vanished out of my memory, as they came abruptly into my mind.

THE first thought, that I remember entertained me, was that, which was the most naturally suggested by the condition I was in: for when I found how tedious and wearisome each hour was, and observed how long a time seemed to intervene betwixt the several divisions, that the striking of the clock made of a night, that must at this time of the year be much shorter than the day; I could not but consider, how insupportable their condition must be, to be cast into outer darkness, where tormented wretches lie, not as I do upon a soft bed, but upon fire and brimstone, where no attendance of servants, or kindness of friends, is allowed them, that need it as much as they deserve it little; and, which is worst of all, where

Rom. viii.
13.
* Οὐκ ἐστιν
τὸ σῶμα.

where no beam of hope is permitted to console them, as if the day should dawn after so dismal a night, though protracted to millions of ages, each of whose miserable hours appears an age.

THE next thing I was considering, was, how defective we are in point of gratitude to God: I now blush, that I cannot call to mind the time, when I ever thought, that his having vouchsafed me the power of sleeping deserved a particular acknowledgment. But now I begin to see, that it is our heedlessness, not their usefulness, that keeps us from daily being thankful for a multitude of mercies, that we take notice of; though it be injurious, that ~~that~~ only commonness, that heightens the benefit, should keep us from ~~us from~~ being sensible of the greatness of it. I confess I was very lately one of them, who looked upon sleep as one of those inconveniencies of human nature, that merit a consolation; and I very little apprehended, that I should ever complain of the want of sleep, as of a grievance, the necessity of it being what I always looked upon under that notion. But I now perceive, he was a wise man, who said, *That God made every thing beautiful in its season.* And yet, when I consider the affinity betwixt sleep and death, whose image it is, I cannot but think it very unlikely, that this life should be designed for our happiness, since not to lose almost half of it were an infelicity.

ANOTHER thing I remember I was considering, was this, that though want of sleep be one of the uneasiest accidents, that attend on sickness, yet in many cases it proves as useful as it can be unwelcome. For there is a sort of jolly people, far more numerous than I could wish them, who are at utter defiance with thinking, and do as much fear to be alone, as they should to do any course, that is naturally productive of so unmanly a fear: and the same sinful employments, or vain pastimes, that make them afraid of being alone, do so much keep them from the necessity of being so, that they keep them almost from the very possibility of it. For in the time of health, visits, business, cards, and I know not how many other avocations, which they justly style diversions, do succeed one another so thick, that in the day there is no time left for the distracted person to converse with his own thoughts: and even, when they are sick, though they be debarred of many of those wonted diversions, yet cards and company will give them enough to prove a charm against thinking, which the patient is so willing, or rather sollicitous, to decline, the need of that sickness less troubles him, as it keeps his body from going abroad, than as it tends to drive his thoughts home; so that sickness does little or nothing towards the making such men consider, by casting them upon their beds, unless it also hinder them from sleeping there. But in the long and tedious nights, when all the praters, and the gamesters (who are usually called good companions, but seldom prove good friends) are withdrawn, and have left our patient quite alone, the darkness of the night begins to make

him discern, and take some notice of his own condition, and his eyes, for want of outward objects, are turned inwards, he must, whether he will or no, during the silence of the night, hear those lessons, which by the hurry and avocations of the day he endeavoured to avoid. And though this be a very unwelcome mercy, yet it is a mercy still, and perhaps the greater for being so unwelcome: for if he could sleep in sickness, as he used to do in health, he were in great danger of having his conscience laid asleep, till it should be awaked by the flames and shrieks of hell. And the design of God in chastening being to reclaim and amend us, we not only do, by our want of reflecting, endure the trouble of sickness, without reaping the benefit of it; but also by our shunning to consider, we are so ill-natured to our selves, as to lengthen the sickness, we are so impatient of; which is in us as foolish, as it would be in a nice patient, after having been made to take a bitter, but a salutary potion, to send unseasonably for cordials and juleps to hinder the working of it, and so by such unruliness lose the benefit of the operation, and lengthen his pain and sickness, to avoid the far less trouble of complying with the nature of the medicine, and the designs of the physician: so that repentance being necessary to recovery, and the considering of a man's own ways as necessary to repentance, the want of sleep, which both allows us time, and imposes on us a necessity to think, may well be looked upon as a happy grievance, since it very much tends to the shortning of our afflictions, by the disposing us to co-operate towards God's aims in sending them.

MEDITATION VIII.

Upon telling the strokes of an ill-going clock in the night.

THE same violence of my fit, that made me very much need sleep, allowed me so little of it, that I think I miss'd not hearing one stroke of the clock all the night long. But since you know, *Sophronia*, that the clock is kept by the soldiers, that are quartered in the place where it stands, you will easily believe, that it is not very carefully looked to; especially since they are not only wont to let it go ill, but do oft times make it do so on purpose, and as may best comply with the officers occasions, and as they would have the guards, that are to be set here, or to be sent hence, sooner or later relieved. Of this uncertain going of the clock I never had occasion to take so much notice as the last night, when, lying too constantly awaked, I began to observe, that though all the hours were so tedious, as to seem every one of them extraordinarily long, yet they manifestly appeared to me not to be equally so; and therefore, when the clock struck eleven, to satisfy my self, whether it did not mis-inform me, I called to one that sat up by me for the watch I use to measure the time with in nice experiments, and found it to want but very little of midnight; and not much above an hour after, when by my watch it was but about one, those that

that kept the clock, whether out of negligence, or design, or to make amends for past slowness, made it strike two; which seemed to me to hint a not unuseful rule in estimating the length or shortness of discourses: for there are cases, where the difficulty or importance of the subject is such, that though it cost a man many words, yet if what he says be not sufficiently fitted to the exigency of the occasion, and the theme, he may speak much, without saying enough. But on the other hand, if (as it often happens) a man speak either unseasonably, erroneously, or impertinently, he may, though he say little, talk too much; the paucity or number of words is not, as many think it, that, which is in such cases to be chiefly considered; for it is not many, or few, that are required, but enough. And, as our clock struck not so often as it should have done, when it struck eleven, and yet struck a while after too often when it struck but two, because the first time it was midnight, and the second time it was but one of the clock; so to estimate, whether what is said have its due length, we are not so much to look, whether it be little, or much, or whether a man speak in the right time, and say neither more nor less than he should.

MEDITATION IX.

Upon comparing the clock and his watch.

THE occasion I had, *Sophronia*, to compare the clock and my watch, suggested to me this other reflection, that the dial-plate of the clock being I know not how many times larger than that of the watch, the circle, on which the hours were marked in the one, did by vast odds exceed the correspondent circle of the other: and yet, though the index of the clock had then past through a far greater quantity of space than that of the watch, this little index, being, when it was indeed midnight, arrived at the mark of the twelfth hour, when the greater index was come but to that of the eleventh, I justly concluded, that the watch did only go truer, but more forward than the clock.

THUS in estimating men's lives, there is something else to be looked at than the mere duration of them; for there are some men, who having loitered and trifled away very many years in the world, have no other argument of their age, than the church-books of their grey-hairs; and as little do they indeed live, that waste a number of insignificant years in successive or perpetual diversions from the true business and end of life. These, and many other kind of persons, that consume much time to little purpose, may be said rather to have lasted long, than to have lived long: as the careless wanderer, who, instead of travelling, does nothing but stray from one wrong way to another, though he do so at midsummer, from morning to night, may be said to have been long on horse-back, but not to have performed a long journey: whereas he, that by thrifty husbanding his time, and industriously improving it, has early dispatch-

ed the business, for which he was sent into the world, needs not grey-hairs, to be reputed to have lived long enough, and consequently longer than those, that wear grey-hairs, only because they were born many years before him. In a word, to one of those sort of men we may attribute a longer time, but to the other a longer life; (for even the Heathen could say, *Non est vivere, sed valere vita*) and within how narrow a compass soever a man's life be confined, if he have lived so long, as, before he comes to the end of life, he have reached the ends of living; the attainment of that measure of knowledge, and the practice of those graces and virtues, that fit a man to glorify God in this short life, and to be glorified by him in that which shall have no end.

MEDITATION X.

Upon a thief in a candle.

THE silence of the night, and my being unable to sleep, disposing me to have my attention very easily excited; I chanced to take notice, that the dim light of the candle, which the curtains were not drawn so close as to exclude every where out of the bed, was on a sudden considerably increased, and continued so long in that condition, that, for fear of some mischance, I put my head out of the bed to see, whence it was that this new and unexpected increase of light proceeded; but I quickly found, that it was from a thief (as they call it) in the candle, which by its irregular way of making the flame blaze, had melted down a good part of the tallow, and would have spoiled the rest, if I had not called to one of those, that watched with me, to rescue the remains by the removal of the thief. But I had scarce done this, when, I confess to you, *Sophronia*, I found my self invited to make some reflections upon what I had done, and to read my self a new lesson by the beams of this new light. For though this thief made the candle shine more strongly, and diffuse a much greater light than it did before; yet because it made a great and irregular waste of the candle, I ordered it to be taken away; and on this occasion methought I might justly make use of that saying of *Pharaoh's* forgetful butler, *I do remember my faults this day*: For Gen. xli. though I find no great difficulty in abstaining from other kinds of intemperance, yet to that of studying, my friends, and especially my physicians, have often accused me of being too indulgent. Nor can I altogether deny, but that in mental exercises there can be exorbitancies, and excesses, I may have sometimes been guilty of them; and that the things, for which I think life valuable, being the satisfaction, that accrues from the improvement of knowledge, and the exercise of piety, I thought it allowable, if not commendable, to consume or hazard it for the attainment of those ends; and esteemed sickness more formidable for its unfitting me to learn, and to teach, than for its being attended with pain and danger; and looked upon what it made me forbear, as far more troublesome than what

whatever else it made me endure. But I find my body is a jade, and tires under my mind, and a few hours fixed contemplation does sensibly to spend my spirits, as to make me feel my self more weary than the riding post for twice as many hours has ever done. Wherefore, since, though the proper use of a candle be to consume it self, that it may give others light, I yet thought it fit to have the thief taken away, because, though it made the candle give more light, it would have wasted it too fast, and consequently made it expire too soon. I see not how I can resist their persuasions, that would have me husband better the little stock of strength nature has given me; and the rather, by a moderate expence of it, endeavour to make it shine longer, though but dimly, than consume it too fast, though for a while to keep up a blaze: I will therefore endeavour to learn of this sickness, and of this accident, what the doctors hitherto could never teach me, and enjoin my self an abstinence, which to me is more uneasy, than if wine, or women, or other sensual pleasures were to be the objects of it; but if in so difficult an exercise of self-denial, I do not always perform what I am now persuaded to, it is like I shall easily forgive my self, for but a little hastening the end of my life to attain the ends of it.

MEDITATION XI.

Upon the being in danger of death.

I KNOW, that physicians are wont, after their master *Hippocrates*, to tell us, that fevers which intermit are devoid of danger. But though an ague, whilst it continues such, could not be a mortal disease; yet why may it not degenerate into such a one? And for my part, who take the prognosticks of physicians to be but guesses, not prophecies, and know how backward they are to bid us fear, till our condition leave them little hopes of us; I cannot but think that patient very ill advised, who thinks it not time to entertain thoughts of death, as long as his doctor allows him any hopes of life: for in case they should both be deceived, it would be much easier for the mistaken physician to save his credit, than for the unprepared sinner to save his soul.

WHEREFORE, *Sophronia*, finding my disease attended with unusual threatening symptoms, not knowing where they would end, I last night thought it fit to suppose they might end in death: and two things especially made me the more ready for such an entertainment of my thoughts.

ONE, That we can scarce be too careful and diligent in fitting our selves for the acting of a part well, that we can never act but once: for where the scripture tells us, *it is appointed for all men once to die*; it is immediately subjoined, that *after that comes judgment*; and if we die ill once, we shall never be allowed to die again, to see if we would die better the second time than we did the first: but as the wise man allegorically speaks, *Where the tree falls, there shall it lie*. So that the faults committed in this last and importantest of human

actions, being irreparable, I think the only safe way is to imitate him, who, having said, *If a man die, shall he live again?* presently annexed by way of inference and resolution, *All the days of my appointed time will I wait till my change come*.

THE other consideration, that recommended to me the thoughts of the grave, was this, that we may be often solicitous to provide against many evils and dangers, that possibly may never reach us; and many endure, from the anxious fears of contingent mischiefs, that never will befall them, more torment, than the apprehended mischiefs themselves, though really suffered, would inflict. But death will sooner or later infallibly come, and never finally deceive our expectations; and therefore the fore-thoughts of it are an employment, which may prove, we know not how soon, of use, and will (however) prove of excellent advantage: the frequent meditation of the end of our lives, conducing so much to make us lead them well, that the expectation of death brings not less advantages to those that escape the grave, than those that descend into it.

SUCH like considerations, *Sophronia*, having put me upon the thoughts of death, I presume you may have some curiosity to know what these thoughts were; and therefore, though I have neither fitness, nor inclination to mention to you those, that almost every sober person would have upon a death-bed, as a man, and as a Christian, I will only take notice to you of those few, that were suggested to me, by the less general circumstances of my condition. And I am the more willing to satisfy your curiosity now, because I have my self been very inquisitive on the like occasion: for the approach of death will (if any thing can) make men serious and considerate; being for good and all to go off the stage, they make a truer and sincerer judgment of the world they are ready to leave, and then have not the wonted partiality for the pleasures and profits of a life they are now abandoning. And as the mind looks with other eyes upon the world, when death is ready to shut those of the body; so men are then wont as well to speak their thoughts more frankly, as to have them better grounded; death stripping most men of their dissimulation, as well as of other things it makes them part with; and indeed it is then high time for the soul to put off her disguises, when she is ready to put off the very body it self.

ONE thing then, that I was considering, *Sophronia*, was, in how wretched a condition I should now be, if I had been of the same mind with the generality of those, who are of the same age with me: for these presume, that youth is as well made for pleasures as capable of them, and is not more a temptation to vanity, than an excuse for it. They imagine themselves to do a great matter, if, whilst youth lasts, they do so much as resolve to grow better when it is gone; and they think, that for a man to be otherwise than intentionally religious before his hair begin to change colour, were not only to lose the privileges of youth, but

but to inroach upon those of old age. But alas! how few are destroyed by that incurable disease, in comparison to those that die before they attain it? And how little comfort is it upon a death-bed, to think, that by the course of nature, a man might have lived longer, when that very thought might justly prove dismal to an unprepared man, by suggesting to him, that this early death may argue the measure of his iniquities exceeding great, and that this untimely end is not so much a debt due to nature, as a punishment of sin? All the fruition of these deluding pleasures of sin cannot countervail the horror, that a dying man's review of them will create, who not only sees himself upon the point of leaving them for ever, but of suffering for them as long. And on the contrary, the review of youthful pleasures declined for virtue's or religion's sake will afford a dying man far higher joys, than their fruition would ever have afforded him.

MEDITATION XII.

Upon the same subject.

AND one thing more there is, *Sopbronia*, that I dare not conceal from you, how much cause soever I have to blush at the disclosing it; and it is, that I judge quite otherwise of a competent preparation for death now I am near it, than I did when I was in health. And therefore, if one, that, since his conscience was first thoroughly awakened, still resolved to be a Christian, and though he too often broke those good resolutions, never renounced them, but tripped and stumbled in the way to heaven, without quitting his purpose of continuing in it, finds a formidableness in the approach of death; how uncomfortable must that approach be to those, that have still run on in the ways of sin, without once so much as seriously intending to forsake them? A youth free from scandal, and sometimes productive of practices, that were somewhat more than negative piety, is not so frequent among those, that want not opportunities to enjoy the vanities and pleasures of the world, but that the charity of others being seconded by that great inward flatterer self-love, made me imagine, that I was in a condition fitter to wish for death, than to fear it. But now I come to look on death near at hand, and see beyond the grave, that is just under me, that bottomless gulph of eternity; methinks it is a very hard thing to be sufficiently prepared for a change, that will transmit us to the bar of an omniscient judge, to be there doomed to an endless state of infinite happiness or misery. There is no art of memory like a death-bed's review of one's life; sickness, and a nearer prospect of death, often makes a man remember those actions, wherein youth and jollity made him forget his duty; and those frivolous arguments, which when he was in health, and free from danger, were able to excuse him to his own indulgent thoughts, he himself will scarce now think valid enough to excuse him unto God, before whom, if the sinless angels cover their faces, sinful mortals may justly tremble to be brought

to appear. When the approach of death makes the bodily eyes grow dim, those of the conscience are enabled to discern, that as to many of the pleas we formerly acquiesced in, it was the prevalence of our senses, that made us think them reason: and none of that jolly company, whose examples prevailed with us to join with them in a course of vanity, will stand by us at the bar to excuse the actions they tempted us to. And if they were there, they would be so far from being able to justify us, that they would be condemned themselves. It is true, *Sopbronia*, if we consider death only as the conclusion of life, and a debt all men sooner or later pay to nature; not only a Christian, but a man, may entertain it without horror: but if one consider it as a change, that after having left his body to rot in the grave, will bring his soul to the tribunal of God, to answer the miscarriages of his whole past life, and receive there an unalterable sentence that will doom him to endless and inconceivable joys, or everlasting and inexpressible torments; I think it is not inconsistent either with piety or courage, to look upon so great a change with something of commotion: and many, that would not fear to be put out of the world, will apprehend to be let into eternity.

MEDITATION XIII.

A further continuation.

ANOTHER thing, *Sopbronia*, which my present state suggested to me, was a reflection on the great mistake of those, that think a death-bed the fittest and opportunist place to begin repentance in: but sure these men are very little acquainted, either with the disadvantages of a dangerous sickness, or the nature of repentance. It is true, that sin and death do more easily frighten one, when they are looked on as both together; but I much doubt, whether the being frightened by hell be sufficient to give a man a well-grounded hope of heaven: for when we see sin and torment at one view, and so near one to another, it is not so easy to be sure, which of the two it is, that, as we presume, scares the sinner towards heaven. And surely repentance, which ought to be the change of the whole man, and in some sense the work of the whole life, is very improperly begun, when men have finished that course, which it should have guided them in: nor have men cause to presume, that when God is severely punishing them for their sins, he will vouchsafe them so great a grace as that of repentance, which they would none of, till it could not make them serviceable to him. And as for the opportunity, it is hoped an expiring state may give men for repentance, they must needs be great strangers to great sicknesses, that can promise themselves so unlikely a matter. Who can secure them, that the acuteness of the disease will not invade the brain? And as deliriums and phrenies are not unfrequent in fevers, and other acute diseases; so in case they happen to persevere, the wretched patient is cast into a desperate condition, even on this side the grave, and

and as near as the body is to its dissolution, the man may be dead a pretty while before it.

But supposing he escape these accidents, which make repentance impossible, a dangerous sickness has other circumstances enough to make it very uneasy: for the organical faculties of the mind cannot but be dulled and prejudiced by the discomposure of the spirits, by which their functions are to be exercised; and the sense of pain, the troublesome prescriptions of physicians, the loathsome and bitter potions, the weakening operation of physick, the languishments produced by want of spirits, the restlessness proceeding from heat and want of sleep, the distracting importunity of those interested persons, especially if any of them be suspected to hover about the dying man's bed, as birds of prey, that wait for a carcase; the sighs and tears of friends and relations, that come to take their last farewell, and to imbitter it; the lawyer, that must be directed to draw up the will; the divine, that must be allowed to say something concerning the soul; and the affrighted conscience, that alone brings more disquiet than all the rest put together; do make a dying man's condition so amazing, so dismal, and so distracting, that to think this an opportune time to begin such a work, (which may well enough imploy the whole man in his calmest state of mind) is a madness as great as any, that even a death-bed can, by the translation of the humours into the brain, occasion. For my part, I think it so wild, and so unadvisable a thing to put off the beginning to provide all graces to a death-bed, that I think it uneasy enough so much as to exercise *then* those that were acquired *before*; men being in that state commonly unable so much as to reap the consolation they have been sowing all along a pious life.

And this, *Sophronia*, brings into my mind a consideration, which being taken from the very nature of a death-bed repentance, should, methinks, very much deter men from resolving beforehand to rely on it; and it is this, that granting those (Socinians, and others) to be mistaken, that think so late a repentance to come too late to be available; yet the dying sinner, though he may be kept from despair of passing to heaven, can scarce in an ordinary way have a comfortable assurance of getting thither; for though it be said, that a true repentance cannot come too late, yet it is a hard thing to be certain, that so late a repentance is true. Since repentance confessedly importeth an abandoning and renouncing of sin, at least in hearty purpose and resolution; it is very difficult for an habitual sinner, that remembers what vows and purposes of change of life, sicknesses or dangers have formerly induced him to make, which were forgotten, or violated, when the apprehensions that occasioned them were over; it is hard, I say, for such a one to be sure, that his present repentance is not of the same ignoble and uncurrent kind, since he has no experience to satisfy him, that it would be ordinarily, though not constantly, prevalent over the opposite temptations; and since also (which

is mainly to be considered) it is so easy for a man to mistake for the true hatred of sin, and the love of God, a horror of sin springing from the present painful sense of the mischief procured by it, together with the great fear of the approaching torments that it threatens, and a strong desire of going to heaven, when seeing himself unable to stay any longer on earth, he must get thither to escape hell. And as it is thus difficult, when a man already feels much punishment for sin, and sees himself in danger of more, to discern clearly upon what account it is, that he is sorry for what he has committed; so it must be certainly a state unspeakably anxious and uncomfortable to find one's self dragged to the grave, without knowing, whether the last trumpet shall call him thence to heaven, or to hell. And if he should be deceived in judging of the validity of his repentance, the fatal error would be remediless, and the mistake far sadder and more horrid than that of the Syrians, who, when they thought they were arrived victorious at *Dothan*, found themselves at the mercy of their enemies in *Samaria*, 2 Kings vi. 18. To conclude, *Sophronia*, he, that resolves not to renounce his sins, till he thinks Christ ready to renounce him for them, may very probably lose his soul, and has most certainly lost his ingenuity; and that will appear a very sad loss for a man, that being by death denied the opportunities of actually leading a new and pious life, must derive his comfort from the assurance, that he sincerely intends it.

MEDITATION XIV.

Upon the apprehensions of a relapse.

I HAVE now at length, *Eusebia*, by the goodness of God, regained that measure of health, which makes the doctor allow me to return to my former studies, and recreations, and diet; and in a word, to my wonted course of life: so that the physician having dismissed himself, nothing seems more reasonable and pertinent to my present condition, than that of our Saviour to the paralytick man, to whom he gave both recovery, and an admonition, which, if he obeyed, he found the more advantageous of the two; *Behold, thou art made whole; sin no more, lest a worse thing come unto thee.* But I am not so free from the apprehensions of an ague, as my friends think me from the danger of it: for having sadly experienced the uneasiness of sickness, I am thereby brought, though at no easy rate, to set a high value upon health, and be a very jealous preserver of so great a blessing; and those petty chilnesses, that formerly I regarded not, but was apt to impute to nothing but fumes of the spleen, or melancholy vapours, are now able to give me hot alarms, and make me apt to fancy them the fore-runners, if not the beginners, of the cold fit of an ague, the first invasion of that disease having been preceded by the like distempers; and accordingly, I carefully avoid the least irregularities in point of diet, or of any other kind, that may any ways endanger a relapse into the disease

disease, that once handled me so ill. But why should I be more apprehensive for my body than my mind? and if at any time (as it may but too often happen) any sin should come to be prevalent in my mind, why should I not be solicitously afraid of all the occasions and approaches of it, and tremble at these commotions of the appetite, which would not else perhaps be formidable to me, in case I have found that such beginnings indulged or neglected have ended in actual sin, the real disease of the soul? And as dangerous sicknesses do for the most part leave a crazy disposition behind them, which threatens relapses; so sins once prevalent, though afterwards suppressed, do yet leave behind them a secret disposition or propensity to the reception of the same faults. And as it is less difficult to find examples of bodily diseases, than of spiritual ones, where the patient is protected from relapses; so I think we should be more watchful against falling back into the sins, than into the sicknesses, we have once found our selves subject to, unless we should think, that a greater danger, and of a nobler part, deserved less of our care.

MEDITATION XV.

Upon his reviewing and tacking together the several bills, filed up in the apothecary's shop.

EITHER my curiosity, *Sophronia*, or my value of health, has made it my custom, when I have passed through a course of physick, to review the particulars it consisted of; that taking notice by what remedies I found most good, and by what, little or none; if I should fall into the like distemper for the future, I might derive some advantage from my past experience. In compliance with this custom, as I was this day reviewing and putting together the doctor's several prescriptions sent me back by the apothecary; good God! said I, in my self, what a multitude of unpleasant medicines have I been ordered to take! the very numbering, and reading them, were able to discompose me, and make me almost sick, though the taking of them helped to make me well. And certainly, if when I was about to enter into a course of physick, all these loathsome medicines, and uneasy prescriptions, had been presented to me together, as things I must take, and comply with, I should have utterly despaired of a recovery, that must be so obtained, and should not perhaps have undertaken so difficult and tedious

a work, out of an apprehension, that it would prove impossible for me to go thorough with it. Thus when a man considers the duties, and the mortifications, that are requisite to a recovery out of a state of sin into a state of grace, he must be resolute enough, if he be not deterred from undertaking the conditions, that piety requires, by so many and great difficulties, as will present themselves to his affrighted imagination. But let not this make him despondent; for it is true, that these discomposing medicines, if I must have taken so much as a tenth part of them in one day, would have either dispatched me, or disabled me to endure the taking any the next. But then, although I now see these troublesome prescriptions all at once, I did not use them so, but took only one or two harsh remedies in one day, and thereby was enabled to bear them, especially being assisted by moderate intervals of respite, and supported both by other seasonable cordials, and by that highest cordial, the hope, that the use of these troublesome means of recovery would soon free me from the need of them. And thus, though the hardships of piety are, by the ghostly and carnal enemies of it, wont to be represented to one that begins to grow a convert, so great and formidable a multitude as to be insuperable; yet if he considers, that though his foresight meet with them all at once, yet he will need to grapple with them but one after another, and may be as well able to overcome a temptation this day, or to-morrow, as he did another yesterday: so that to this case also may in some sense be applied that (either counsel, or precept) of our Saviour, not to be solicitous for to-morrow, but to charge no more upon a day than the trouble that belongs to it. And if he considers too, that as a wise physician has always a great care, that his remedies be not disproportionate to the patient's strength, and after harsh physick to relieve him with cordials; so God will not suffer those, that intrust themselves to him, to be tempted above what they are able, but will allow them cordials after their sufferings, in case he do not turn the sufferings themselves into cordials. If, I say, our new convert shall consider things of this nature, he will not be much discouraged by the appearance of difficulties, that will as much enoble and indear his success, as they can oppose it; and he will never despair of victory in an engagement, where he may justly hope to have God for his second, and heaven for his reward.

OCCASIONAL REFLECTIONS.

S E C T. III.

R E F L E C T I O N I.

Upon the sight of some variously-coloured clouds.

THERE is amongst us a sort of vain and flaring grandees, who for their own unhappiness, and their age's, do but too much resemble these painted clouds; for both the one and the other are elevated to a station, that makes most men look upon them, as far above them; and their conspicuousness is often increased by the bright sunshine of the prince's favour, which, though it really leaves them creatures of the same frail nature, that it found them of, does yet give them a lustre and a gaudiness, that much attracts the eye, and perhaps the envy and respect of those superficial gazers upon things, that are wont to be amused, if not dazzled, with their insignificant outshines. But the parallel holds further; for as, in spite of these clouds' sublimity and conspicuousness, they are but airy and unsolid things, consisting of vapours, and steered by every wind: so the fine people I am comparing them to, in spite of their exaltation, and of all the show they make, are really but slight persons, destitute of intrinsic and solid worth, and guided either by their own blind lusts and passions, or else by interests as fickle as those, (to which it will be no addition to say) or as variable as the wind. And as these clouds, though they seem vast as well as high, and are perhaps able, for a while, to make the sky somewhat dark, have usually but a short duration, and either quickly fall down in rain, or are quite dissipated, and made to disappear; so those titled persons, what show soever their greatness makes, do oftentimes, either by a voluntary humility and repentance, as it were, descend of their own accord, and, by doing of good, endeavour to expiate and make amends for their former uselessness, if not mischief; or else, after having been a while stared at, they do (some of them more slowly, and some more abruptly) vanish, without leaving behind them any thing that can so much as entertain our sight in the very place, where before they engrossed it: and this ruin sometimes happens to the most elevated persons, from that very prince, whose favour made them attract so many eyes; as clouds are oftentimes dispersed before night by the same sun, that had raised and gilded them in the morning.

R E F L E C T I O N II.

Upon his making of a fire.

HOW many fruitless blasts have I been spending upon this sullen fire! It was not, though, the greenness of this wood, that made it so uneasy to be kindled; but, it was

alone the greatness of the logs, on which the fire could take no hold, but by the intervention of such smaller sticks as were at first wanting here: witness, that I had no sooner laid on a little brushwood, but the flame from those kindled twigs, invading and prevailing on the billets, grew suddenly great enough to threaten to make the house itself part of its fuel, and turn it to such ashes, as it makes haste to reduce the wood into. Methinks the blaze of this fire should light me to discern something instructive in it: these blocks may represent our necessary; these sticks our less important, religious practices; and this aspiring flame, the subtle inhabiter of that of hell. It will be but successlessly, that the devil can attempt our grand resolves, till he have first mastered our less considerable ones; and made his successes against these, not only degrees, but instruments, in the destroying of the other: our more neglected and seemingly trivial affections, having once received his fiery impressions, do easily impart them to higher faculties, and serve to kindle solder materials. It is therefore the safest way, to be faithful even to our lesser determinations, and watchful over our less predominant passions; and whensoever we find our selves tempted to violate the former, or neglect the latter, not so barely to cast one eye upon the seeming inconsiderableness of what we are inticed to, as not to fix the other upon the consequences that may attend it; and therein, to consider the importance of what such slighted things may, as they are managed, prove instrumental, either to endanger, or to preserve.

R E F L E C T I O N III.

Upon my spaniel's carefulness not to lose me in a strange place.

DURING my stay at home, whilst every body this cur chanced to meet, made so much of their landlord's spaniel, that they seemed to have added to oracles that proverb of *Love me, love my dog*, the cajoled cur would never keep at home; but being welcomed to so many places abroad, made me few visits, that cost me not the trouble of sending for him. But now, that we are in a place, where he sees no more men than strangers, he stirs not from my heels, and waits so close, and carefully, that it were now more difficult to lose him, than it was formerly to keep him from wandering. Thus doth it generally fare with us; whilst we are environed with numerous outward objects, which, smiling on us, give our gaddings to them, the temptation of an inviting welcome; how inclined are we to forget and wander from our great master? But when we are deprived of those enveigling courtiers, our Maker too is freed from those seducing rivals, and our undistracted affections are brought

brought to settle on their noblest object, by the removal, and the displacing, as well as they would be by the knowledge and the undervaluation, of inferiour ones. Lord! when I lose a friend, or any outward idol of my fondness, teach me to reduce him to leave thee his heir, by taking that loss for a summons, to transfer and settle my whole love on thee: and if thou but vouchsafe to make me so happy, I shall think my self enough so, not to envy him, to whom the loss of his asses proved an occasion of his finding a crown; and shall not so much regret what thy dispensations shall have taken from me, as gratulate to my self their having reduced me unto thee.

REFLECTION IV.

Upon the prodigiously wet weather, which happened the summer that Colchester was besieged. (1648.)

HOW strangely unseasonable is this melancholy weather! and how tedious a winter have we endured this summer? More than these few last weeks have not afforded us half as many days, wherein we were neither troubled with showery, or threatened by cloudy weather; and we in *England* have great temptations to envy nature's kindness unto *Rhodes**, if it be true what geographers relate of that island, that it is a rarity for the inhabitants to see a day pass without their seeing the sun: for, among us, the confusions of our country seem to have infected our very air, and serenity is as great a rarity in the sky, as in men's consciences; so that those, who are wont to make fires, not against winter, but against cold, have generally displaced the florid, and the verdant ornaments of their chimneys, and think *Vulcan* more proper there than *Flora*; and some begin to doubt, whether our almanacks be not mistaken, by calling this month *July* instead of *November*. But notwithstanding all this appearance of winter above our heads, yet whilst we see, that cherries and strawberries, and other summer fruits, do grow, and, though but slowly, make a progress towards maturity in our orchards, we doubt not that it is summer, and expect, that these fruits, though they will not be early ones, will at length come to be ripe ones.

Thus, for reasons, which, though we know not yet, our knowing of God may assure us to be both wise, and just, a pious soul may sometimes be reduced to so sad a condition, that the face of heaven does to her appear perpetually overcast; and the tokens of God's displeasure do so closely follow one another, that, to borrow *Solomon's* phrase, *The clouds return after the rain*. But if, notwithstanding all this, the seemingly deserted soul, do, like the good ground mentioned in the gospel, bring forth fruit with perseverance; if prayer, charity, resignation, and those other divine graces, that are wont to be the proper and genuine productions of God's spirit, do flourish, and prosper in the soul, we may safely conclude that soul, though never so disconsolate, to be in

the state of grace, and that she really receives the blest assistances of him, who can alone give the increase (to the seeds of piety and virtue) though not in the glad and conspicuous way of an unclouded heaven, yet in the effectual, though secret, method of fructifying influences; and we may reasonably hope, that he, that has not only begun a good work, but carried it on thorough such impediments, and disadvantages, will perfect it, by bringing the slow, but yet gradually, ripening fruit to the due perfection: for those, that are the humble Christian's proper graces, do so much depend upon the author, that, if they flourish, his hiding himself in clouds need not make us doubt the fruits we see, to be the productions of the Sun of righteousness, though we see him not. We must not hastily conclude it winter with the soul, though the heaven be lowering, provided the earth be fruitful; but remember, that the saving influence of God's spirit may be, where his comfortable presence is not perceived: the living in sensible comforts and joys is rather a part of our reward, than of our duty; and that (consequently) it may save many modest and pious persons a great deal of disquiet, if they would learn to judge of their spiritual condition, rather by the duties, and services, they pay God, than by the present consolations he vouchsafes them; or, in a word, rather by what they do, than by what they feel.

REFLECTION V.

Upon his being carved to at a feast.

THOROUGH many hands hath this plate passed, before it came to mine; and yet, though I bowed to every one of those that helped to convey it, I kept my chief and solemnest acknowledgment for the fair lady that sent it. Why shouldest thou not, O my soul, instruct thy gratitude to tread in the steps of thy civility? When thou receivest any blessing from *that Father of lights, from whom every good and perfect gift comes down*, pay a fitting share of thy thanks to them, that hand it to thee; but thorough all those means, look principally to that God, that sends it. Let not the pipe usurp upon the spring, (that were as absurd, as it were for me to kiss my hand to the plate, or at best, to those that helped to convey it, with a neglect of the lady) but so pay thy due acknowledgments to the reachers, that thou be sure to reserve thy principal thanks, and highest strains of gratitude, for the giver.

REFLECTION VI.

Upon the sight of a looking-glass, with a rich frame.

EUGENIUS, LINDAMOR, EUSEBIUS.

Lind. **T**HIS glass has a frame so curious, and so rich, that though I could scarce, if I would, withhold my eyes from gazing here; yet, I believe, the operation it has

* At *Rhodes* the Air is never so dim and cloudy, but one hour or other the sun shineth out. *Pliny*, l. 2. c. 62. Where he also says the same of *Syracusa*.

has on my curiosity, is no more than what it generally has on that of others; and by the attention, with which I saw, even you, gentlemen, survey it, I am easily persuaded, that one needs not be a lady, not to pass by such a looking-glass without repairing to it.

Eug. I AM much of your opinion, *Lindamor*; and such a sight as this has often made me a greater friend, than many severer persons are, to eloquence in sermons: for as if this very glass had been placed here in a mean or common frame, it would scarce have stopped us in our passage through the room, or have invited us to consult it; so a sermon may, by the nicer sort of auditors, be left unregarded, though it be for substance excellent; when as the frame, though it be not part of the glass, nor shews us any part of our faces, does yet, by its curious workmanship, attract our eyes, and so invite us to consult the glass, that is held forth in it; so the wit, and fine language, wherein it is dressed up, though it be no essential or theological part of the sermon, yet it is often that, which invites men to hear, or read it.

Lind. I THINK indeed, *Eugenius*, that wit and eloquence do highly recommend sermons, and devout compositions, to the curiosity and attention of some, that else would scarcely mind them; and upon that account, I allow of your comparison: but give me leave to carry it on a little further, by observing, that as the curious frame doth as well please, as attract, the eye, without representing to it the lively image of the beholder's face; so the fine expressions you applaud, are commonly parts of a sermon, that have no specular virtue in them; I mean, that have no power, like a good looking-glass, to acquaint the beholder with the true image or representation of his own complexion, and features: nor will this gaudy frame shew him what is otherwise than it should be; the discovery of which, nevertheless, in order to the rectifying what is amiss, is the principal and genuine use of a looking-glass. And therefore, as no skilful man will judge of the goodness of a glass, by the fineness of the frame, but rather by its giving him a true representation of his face, without liking it the worse, for shewing him its moles, and warts, or other blemishes, if it have any; so no wise Christian will judge of a rousing sermon, rather by the language, than the divinity, or will think the worse of a good book, for discovering his faults, or making him think the worse of his own, or other men's ill courses.

Euseb. LET me add, gentlemen, that as when a glass has a rich and gaudy frame, children's eyes are oftentimes so entertained and amused with it, that they are regardless of any thing else; and for the sake of that part, which they can but see, they are unmindful to consult that usefuller part, whose office it is to discover to them, themselves: so, when there is too much of rhetorick in a sermon, many, that should not be children, have attention, not only so attracted, but so detained, by that, that they are not thereby invited to consult, but diverted from regarding, the more instructive part of

the discourse. And the more witty and critical sort of auditors, are so much more accustomed to judge of sermons, than to judge of themselves by them, that they deal with them, as if, in this glass, a man should only praise or discommend the workmanship of the imbossed images of the frame, without caring to make use of the glass itself, to mend any thing he finds out of order about him. For thus, these fastidious and censorious hearers make no other use nor repetition of sermons, than to censure or applaud the expressions, and contrivances, (which should be looked upon but as the ornaments of it) without minding the doctrine, or caring to amend what that has discovered to be amiss in them. But it must be confessed, though I must grieve and blush, it can be truly so, that it is but too often, as the scripture somewhere complains, *like people, like priest*; and that there is a sort of preachers, and those of the most celebrated, who take a course more likely to encourage, than reform, such hearers; and which would, perhaps, make men such, if it did not find them so: for one of this sort of preachers (for I am loth to call them divines) appears more solicitous to make his expressions, than to make his hearers, good. And whereas, these, that are concerned for the winning or the saving of the souls, think it a less sure sign of a good sermon, that it makes the hearers applaud the preacher, than that it makes them condemn themselves; the orator I am mentioning, had much rather hear their praises than their sighs; and, accordingly, is more solicitous to tickle their ears, than, how much need soever there be of it, to lance their consciences. He may, with far more truth than piety, invert the profession of *St. Paul*, and say, that he preaches *not Christ crucified, but himself*; and though now and then he seem very vehemently to declaim against vices, yet one may easily enough perceive, that it is but a personated anger, and that he rather fences with sin, than is concerned to destroy it, and speaks against it rather to shew skill, than to exercise hatred: and as he affects to appear rather an orator than a divine, so he is well enough content his auditors should rather admire his good language than follow his best counsel; and, as if all that belongs to ministers, and their flocks, could be performed in the pulpit, and the pew, he is more careful to remember his sermons before he has delivered them, than to keep his auditors from forgetting them afterwards; and unconcerned for their proficiency, seeks but their praises, scarce ever aiming at so much as his own discharge. In a word, in such kind of sermons, there is little spoken, either from the heart, or to the heart; the orator and the auditory tacitly agreeing to deceive themselves; and the conversion of sinners being neither the effect, nor the aim of such florid, but unedifying discourses, the business is transacted on both sides, as if the preacher thought he had done his part, when he had shewn his wit, and the hearers thought they had done theirs, when they have commended it.

REFLECTION VII.

Upon my spaniel's fetching me my glove.

POOR cur! how importunate is he to be employed about bringing me this glove? and with what clamours, and how many fawnings, does he court me to fling it him? I never saw him so eager for a piece of meat, as I find him for a glove: and yet he knows it is no food for him, nor is it hunger, that creates his longings for it; for now I have cast it him, he does nothing with it, but (with a kind of pride to be sent for it, and a satisfaction, which his glad gestures make appear so great, that the very use of speech would not enable him to express it better) brings it me back again; as he meant to shew me, he desired not to keep it for himself, but only to have it in his power to return it as a present to his master. But he must not bring me thus an empty glove; it is in thee, my soul, to fill this accident with instruction, by learning from religion as disinterested a behaviour towards God, as nature taught this brute creature towards me. I will, in my addresses for externals, less earnestly implore them for the service they may do me, than for the service I may do God with them; and (as princes commands are looked upon by courtiers as honours, and as favours) contenting myself with the satisfaction of being trusted, and employed by him, I will rejoice at the liberal expressions of his love, as they may be improved into proportionable expressions of mine, and will beg no largesse of his bounty, without a design of referring it to his glory.

REFLECTION VIII.

Upon the taking up his horses from grass, and giving them oats before they were to be ridden a journey.

JUST so does God usually deal with his servants: when he vouchsafes them extraordinary measures of grace, they are to look for employments that will exercise it, or temptations that will try it.

Thus that great *captain of our salvation*, Heb. xii. 2. whom the scripture so much and so deservedly exhorts us to have our eyes on, when at his solemn inauguration into his prophetick office, the heavens were opened, from whence the spirit of God did in a bodily shape descend like a dove upon him, accompanied with a heavenly voice, proclaiming him the beloved son of God, *in whom the Father is well pleased*, Matth. iv. Then, I say, that is, (as St. Mark tells us) *immediately Jesus (being, as an evangelist has it, full of the Holy Ghost*, Luke vi. 1) *was led up of the spirit into the wilderness to be tempted of the devil*. That wise and merciful disposer of all things, who will not suffer his children to be tempted above what they are able, seasonably fortifies them by these preparatory provisions and consolations, for the labours and difficulties they are to be exposed to. But whereas, if these horses had reason wherewith to foresee the journey in order

whereunto the provender is so plentifully given them, they would (if not be troubled at their good cheer) at least lose much of the pleasure of it, by thinking of the labour to ensue. With the servants of God the case is much otherwise; for such is his goodness to those he is pleased thus to deal with, in proposing and reserving them a crown in some sort proportionate to, and yet inestimably outvaluing, the toils and difficulties requisite to obtain it; that as advantageous and as welcome as his preparatory vouchsafements can be, the pious soul may well think them less favours upon their own account, than as they enable the receiver to do the more service to the giver.

REFLECTION IX.

Upon the making of a fire with charcoal.

THOSE that lust fascinates are apt to imagine, that if they can suppress its visible effects, and sensible heat, that will be sufficient to free them from all the mischiefs, they need fear from it: but lust is so pernicious a guest, that not only he is very watchful to intrude again where he has once been entertained, but, notwithstanding his absence, he may continue to do mischief to those, that seem to have quite expelled him. For as wood, that is once thoroughly set on fire, may afterwards have that fire quite choaked, and extinguished, and yet by those changes be turned into charcoal, whereby it is not only made black, but disposed to be far more easily kindled, and consumed than before; so those, who have once had their hearts thoroughly possessed by the pernicious flames of lust, (which is indeed, to employ an inspired expression, *to be set on fire of hell*) even when they have stifled these criminal flames, and feel no more of their heat, may not only have their reputation irrecoverably blemished by what is past, but commonly carry about with them an unhappy disposition to be re-inflamed, and to have by a few sparks, and a little blowing, those destructive fires so re-kindled, as to rage more fatally than ever.

REFLECTION X.

Looking through a prismatical or triangular glass.

THIS more than flattering glass adorns all the objects I look on through it, with a variety of colours, whose vividness does as much charm my sense, as their nature poses my reason; without the help of the sun, and clouds, it affords me as many rainbows as I please. And not only when I look on trees, and meadows, and gardens, and such other objects, that are of themselves acceptable to the sight; this glass lends them ornaments above any they are beholden for either to nature, or art: but when I cast my eyes upon coarser, and homely things, and even on dunghills, this favourable interposer presents them to me in such curious and gaudy colours, that it does not so properly hide their deformities, as to make them appear lovely.

So

So that which way soever I turn my eyes, I find them saluted, as if I were in some rich jeweller's shop, with sapphires, topazes, emeralds, and other Orient gems, the vividness of whose colours may justify those, that think colours to be but disguised light, which, by these various reflections, and refractions, comes to be rather dyed than stained.

BUT this glass must as well afford me instruction, as delight, and even by deceiving me, teach me: for thus sinful Christians, when God looks upon them in themselves, must needs seem too polluted, and disfigured, not to appear loathsome to him, *who is of purer eyes than to behold iniquity* without abhorrency; but when Christ interposes betwixt his eyes and us, we then seem far other things than otherwise we should, and not only we do not appear filthy, but we do appear lovely, if not glorious. And as though some objects, as things purely white, and flames, look better through this glass, than homely and dirty ones; yet even these, looked upon through this glass, are more richly adorned, than the others beheld without it: so, whatever difference there may be betwixt persons, that are either innocent, or exemplary, upon the bare account of morality; and those ignorant or frail children

of God, that, in themselves considered, would be much inferiour to those newly mention'd; yet when these are looked upon through Christ, they are much more acceptable in God's eyes, than the others considered out of him. And I shall add this further, that whereas my looking upon objects through the prism, however it makes them appear to my eyes, does work no real change in the things themselves, but leaves those, that were homely and foul before, foul and homely still; God's gracious looking upon us in Christ makes us by degrees become fit for his goodness to take delight in, and has an improving and transfiguring power on us; like the sun, that cherishes green and unblown flowers, and paints them with their curiousest colours, by his looking on them. Since then the Scripture tells us, that we are not only reconciled to God, but, if I may so express it, are *ingratiated and endeared to him in the beloved*; how much do we owe to that blessed Saviour, upon whose account we enjoy the invaluable privilege to appear (and grow fit to do so) pleasing in God's eyes? which, besides that it is the highest honour, leads to the highest happiness; or rather, is the one as well as the other.

An Advertisement touching the Fourth Section.

A Reader, that is not unattentive, may easily collect from what he will meet with in some of the ensuing discourses, that they were written several years ago, under an usurping government, that then prevailed. And this may keep it from appearing strange, that in papers, which contain some things not likely to be relished by those, that were then in power, the author should take occasion to speak of himself as of another person; as well to avoid the being suspected by them, in case his papers should come into any of their hands, as to comply with the design he then had; that if these discourses should happen to be made publick, the reader might be left to guess, whether or no he were entertained with a fiction, or a true narrative. And though a change of circumstances has occasioned the publication of these papers, which should have come forth by themselves (if at all) in such a way as will make most readers

look upon them as containing a story purely romantick; yet they may have in them much less of fiction, than such will (it is like) imagine. For being really a great lover of angling, and frequently diverting my self at that sport, sometimes alone, and sometimes in company; the accidents of that recreation were the true themes, on which the following discourses were not the only meditations I had made. Nor is the intimation given at the end of this (fourth) section, of a further continuation of such discourses, an artifice or shift, to steal away from a conversation I was unable to continue, without seeming to do so; there being in readiness divers reflections relating to our anglers, which had furnished *Eusebius* and his friends with discourses for the afternoon, if I had judged, that to invite an addition to so prolix an account as I had given of them already, nothing could be requisite but a supply of thoughts.

OCCASIONAL REFLECTIONS.

S E C T. IV.

Which treats of Angling improved to spiritual uses.

DISCOURSE I.

Upon the being called upon to rise early on a very fair morning.

THE sun had as yet but approached the east, and my body as yet lay moveless in the bed, whilst my roving thoughts were in various dreams, rambling to distant places; when, methought, I heard my name several times pronounced by a not unknown voice. This noise made me, as I was soon after told, half open my eyes, to see who it was that made it, but so faintly, that I had quickly let my self fall asleep again, if the same party had not the second time called me louder than before, and added to his voice the pulling me by the arm. But though this waked me so far, as to make me take notice, that I was call'd upon to rise, yet my drowsiness, and my unwillingness to forgo a not unpleasant dream, keeping me from discerning distinctly, who it was, that called me, made me briskly enough bid him, whatever his business were, let me alone: but though at the same time I turned away my head to shun the light, though dim, which at the half-opened curtain shone in upon me, yet the party, instead of complying with my desires, did by the throwing open the curtains, further let in so much more light upon my face, that finding it would not serve my turn to keep my eyes shut, I open'd them to see, who it was, that gave me this unwelcome disturbance. This I had no sooner done, than that I perceived that it was *Eusebius*, who with *Lindamor*, and two or three other friends, was come to call me to go a fishing, to a place, where by appointment we were to meet about sun-rising. The respect I paid *Eusebius*, and the value I placed upon his conversation, covered me with blushes to be thus surprized by him; and obliged me to satisfy him as well as I could, how much I was troubled and ashamed to have the favour of his company brought me to my bed-side, when I ought, and intended to have waited on him. And thus, whilst I was making him my apologies, and he was pleasantly reproaching me for my laziness, and laughing at the disorder I had not yet got quite out of, I made a shift hastily to get on my clothes, and put my self into a condition of attending him and the company to the river-side.

WHILST we were walking thither-ward, and *Lindamor* was minding *Eusebius* of the promise he had made the day before, to exercise, upon most of the things that should occur to us, his art of making occasional reflections, I was delighting my self with the deliciousness of that promising morning, and in-

deed the freshness of the air, the verdure of the fields and trees, and the various enamel of the meadows, the musick of the numerous birds, that with as melodious as chearful voices welcomed so fair a morning; the curious orient colours, wherewith the rising sun embellished the eastern part of the sky, and above all that source of light, who, though he shews us all, that we see of glorious and fair, shews us nothing so fair and glorious as himself, did so charm and transport me, that I could not hold expressing my satisfaction in terms, that, *Eugenius* was pleased to say, needed not rhymes to make them poetical. And the sense of this invited me to add, that I now would not for any thing have missed being waked, and thought my self hugely obliged to *Eusebius's* freedom, that would not suffer me to sleep out so glorious a morning, nor lose the satisfaction of such desirable company.

Eusebius, who was but a little way off in discourse with *Lindamor*, over-hearing a good part of what I had said, thought fit to take thence a rise, to begin complying with his friends requests; and accordingly, walking up towards me, and addressing himself to me, he told me, You are unconcerned enough, *Philaretus*, in what I am about to say, to make it allowable for me to tell *Lindamor*, that what has this morning happened to you, puts me in mind of what I have several times observed on another occasion. For when a man is so lulled asleep by sensual pleasures, that, like one that sleeps, he has but the faculty, not the exercise of reason, and takes his dreams for realities; if some serious divine, or other devout friend, concerned for the sinner's soul, or his glory, that died to redeem it, endeavour to awaken him, and rouse him out of that state, wherein he lies so much at ease; such attempts are wont at first to be looked upon by the lazy sinner, enamoured of his ease, and present condition, but as pieces of unseasonable, if not uncivil officiousness; and entertaining the light it self but as an unwelcome guest, he obstinately shuts his eyes against that, which alone makes them useful; and, instead of looking upon the attempter as his friend, he checks him, and expostulates with him, and uses him almost as an enemy: insomuch, that too often those, that love the welfare of souls too little, or their own ease too much, forgo, with their hopes, their endeavours to reclaim him. But if, by God's blessing, upon the constancy of this kindness, and the letting in of so much light upon the sinner, that he finds himself unable to continue his slumber any longer with it, he comes to be thoroughly awaked, he quickly grows sensible, that he is brought out of the kingdom of darkness, into a true and marvellous light; and, instead

instead of those empty fleeting dreams, which did before amuse and delude him, and which, to relish, and be fond of, the eyes of his mind must be as well closed, as those of his body, he is admitted to noble, and manly entertainments, such as reason chuses, conscience applauds, and God himself approves. And this change of his condition he finds so advantageous, that he would not, for all the world, return again to that, he was at first so angry to be dissuaded from; and he does not forgive, but thank the person, that disquieted him, and blushes at the remembrance of his having reduced others to importune him to be happy: and, betwixt shame and gratitude, the sense of his present, and of his past condition, possessing him, how much he has reason, to make his rescuer as well amends for what he endured, as retributing for what he acted for him, he does, perchance, especially in the first fervors of his zeal, think himself as much obliged to his awakener, as *Philemon* was to *St. Paul*, to whom, the Scripture says, that he owed even himself. And sometimes such a new convert, as I am speaking of, will think his obligation, to the instrument of his change, so suitable to the transcendent satisfaction he finds in the change itself, that he would despair of seeing his benefactor sufficiently recompensed, if he did not remember a saying of the Prophet, (*That those, that turn others to righteousness, shall shine as the stars for ever and ever,*) that gives him ground to hope, that God himself (whose plenty, as well as bounty, is inexhausted) will make the recompence his work. Wherefore, concludes *Eusebius*, if you chance to have any friends, (as it is odds most men have) that stand in need of this as great, as unwelcome, expression of kindness, let us not be too soon discouraged, by finding the effects of our friendship coldly received, and possibly too looked upon as disturbances; for besides, that the less they are desired, and the worse they are entertained, the more they are needed; a Christian is not bound, so much to concern himself in the success of his endeavours, as to leave it in the power of every one that will be obstinate, to make him unhappy; when the business, one way or other, come to an end, he may miss his aim, without losing his labour, since he serves a master, that is as ready to reward, as able to discern intentions; and, in case your endeavours do succeed, you will at once make a man your friend, and worthy to be so. And you shall scarce ever find men more affectionate to you, than those you have made your friends by making them enemies to vice.

DISCOURSE II.

Upon the mounting, singing, and lighting of larks.

THE agreement we had made at our setting forth, that the motion of our tongues should not hinder that of our feet towards the river-side, was the cause, that the past discourses not having discontinued our walk, by that time they were ended, we began to traverse certain plowed lands, that lay

in the way betwixt us and the river. But we had scarce entered those fields, when our ears were saluted with the melodious musick of a good number of larks, whereof some mounted, by degrees, out of sight, and others, hovering and singing a while over our heads, soon after lighted on the ground, not far from our feet.

AFTER we had a while enjoyed this costless, and yet excellent musick, both *Eusebius* and I, chancing to cast our eyes towards *Eugenius*, observed, that he did very attentively wait upon the motions of a lark, that, singing all the way upwards, and mounting, by degrees, out of sight, not long after descended, and lighted among some clods of earth, which being of the colour of her body, made us quickly lose sight of her. Whereupon *Eusebius*, who was full as willing to hear as speak, and, in the occasional reflections that he made, was wont at least as much to aim at the exciting others thoughts, as the venting of his own, begged *Eugenius* to tell us what it might be, which his attentiveness to the motions of the lark made us presume he was thinking on.

Eugenius, after a little backwardness, which he thought modesty exacted of him, soon answered us in these terms:

AMONG all birds, that we know, there is not any, that seems of so elevated, and, I had almost said, heavenly a nature as the lark; scarce any give so early and so sweet a welcome to the springing day. And that, which I was just now gazing on, seemed so pleased with the unclouded light, that she sung as if she came from the place she seemed to go to; and during this charming song, mounted so high, as if she meant not to stop, till she had reached that sun, whose beams so cherished and transported her; and in this aspiring flight she raised herself so high, that though I will not say, she left the earth beneath her very sight, yet I may say, that she soared quite out of ours. And yet when from this towering height she stooped to repose or solace herself upon the ground, or else when to seize upon some worthless worm, or other wretched prey, she lighted on the ground, she seemed so like the earth, that was about her, that I believe you could scarce discern her from its clods. And whereas other birds, that fly not half so high, nor seem any thing near so fond of the sun, do yet build their nests upon trees, the lark does as well build hers upon the ground, as look like a part of it.

THUS I have known, in these last and worst times, many a hypocrite, that when he was conversant about sublimer objects, appeared, as well as he called himself, a saint; nothing seemed so unwelcome to him as new light; one might think his lips had been touched with a coal from the altar, his mouth did so sweetly shew forth God's praise, and sacred dispensations. In sum, take this hypocrite in his fit of devotion, and to hear him talk, you would think, that if he had not been already in heaven, at least he would never leave mounting, till he should get thither.

BUT when the opportunities of advantaging his lower interests called him down to deal about

about secular affairs here below, none appeared more of a piece with the earth than he, for he looked, as if he had been besmeared all over with the earth round about him, and he seemed, in providing for his family, to be of a meaner and a lower spirit, than those very men, whom in discourse he was wont to undervalue, as being far more earthy than himself.

SINCE we know, says *Eusebius*, that the best things corrupted prove the worst, it can be no disparagement to piety, to acknowledge, that hypocrisy is a vice, which you cannot too much condemn. And when the pretending of religion grows to be a thing in request, many betake themselves to a form of religion, who deny the power of it; and some perchance have been preferred less for their *Jacob's* voice than for their *Esau's* hands.

BUT, *Eugenius*, let us not, to shun one extreme, fondly run into the other, and be afraid or ashamed to profess religion, because some hypocrites did but profess it: his course is ignoble, and preposterous, that treads the paths of piety, rather because they lead to preferment than to heaven; but yet it is more excusable to live free from scandal for an inferior end, than not to live so at all: and hypocrites can as little justify the profane, as themselves. It may be, that all, that own religion, are not pious; but it is certain, that he, that scorns to own it, must less be so. And if scoffers at piety should succeed the pretenders to it, they cannot be said (as sometimes they would be thought) to be an innocent sort of hypocrites, that are better than they seem; for scandal is a thing so criminal, and contagious, that whosoever desires, and endeavours to appear evil, is so: to refuse to be religious, because some have but professed themselves to be so, is to injure God, because he has been injured. A skilfull jeweller will not forbear giving great rates for necklaces of true pearl, though there be many counterfeits for one that is not so; nor are the right pearls a whit the less cordial to those, that take them, because the artificial pearl made at *Venice*, consisting of mercury and glass, for all their fair shew, are rather noxious, than medicinal. And indeed our knowledge, that there are hypocrites, ought rather to commend piety to us, than discredit it with us; since as none would take the pains to counterfeit pearls, if true ones were not of value; so men would not put themselves to the constraint of personating piety, if that it self were not a noble quality. Let us then, *Eugenius*, fly as far as you please from what we detest in hypocrites: but then let us consider, what it is that we detest; which being a bare, and therefore false pretence to religion, let us only shun such a pretence, which will be best done by becoming real possessors of the thing pretended to. •

DISCOURSE III.

Upon the sight of a fair milk-maid singing to her cow.

EUGENIUS, who was not at all indisposed to listen to exhortations of this nature, not only embraced this made him by his

friend, but with earnestness enough continued the conference to explain his meaning, and satisfy *Eusebius*, that he did not think piety fit to be discountenanced, though he thought hypocrisy was so; and that he was no enemy to the profession of religion, but to those, that blemished it by unsuitable practices. And with such kind of discourses we continued our walk, till being come to a stile, over which we were to pass out of one meadow into another, I chanced to stop, and turn about to pay *Lindamor* the respect of desiring him to lead me the way over: but not finding him there, I hastily cast my eyes all over the field, till at length they discovered him a good way off, in a posture, that seemed extremely serious, and wherein he stood as immovable as a statue. This sight soon carried me towards him, and I had dispatched half my way, before his changing his posture gave him an opportunity to discover me; which as soon as he did, he immediately came to meet me, and almost before I had asked him the occasion of what I had seen, Whilst (replied he) *Eugenius* was purging himself from a fault, that none that knows him will suspect him to be guilty of; I was detained a little behind you by the mulick of one of those larks, whose melody was so charming, that I could not find in my heart to make haste from it: but whilst I was listening to it, my attention was diverted by a nobler object; for I heard from the further corner of this meadow, a voice, which, though not governed with skill, did so repair the want of it by its native sweetness, that art was absent without being missed, and I could not but have some curiosity to see, who was the possessor of so much power to please. Turning then my steps towards that part of the field, whence the voice came, my eyes quickly ceased to envy my ears; for they discovered, kneeling by a cow, and singing to her whilst she milked her, a person, who, in the habit of a milk-maid, seemed to disguise one of those nymphs, that poets are wont to describe to us. And that you may not wonder, continues *Lindamor*, at what I shall say to you of a country girl, know, that methought I saw in her face something more like *Hermione*, before she proved inconstant, than I expected to find in any of her sex. I will not tell you, that this fair creature had the blushes of the morning in her cheeks, the splendor of the sun in her eyes, the freshness of the fields in her looks, the whiteness of the milk she expressed in her skin, and the melody of the larks we were admiring in her voice, lest you should think Mr. *Boyle's* Seraphick Love had lost its operation on me. But I may perhaps, without much hyperbole, give you this account of her, that though her clothes are almost as coarse as cleanly; and though they are suited to her condition, yet they are very ill suited to her beauty; which, as if nature intended a triumph over fortune, has, without any assistance of ornament, more distressed my liberty, than others have been able to do with all their most curious dresses. And this fair creature, continues *Lindamor*, as she is rich in nature's bounty, appeared as well by the cheerfulness

of the tune she sung, as by the manner of her singing it, so satisfied with the unpurchased treasures she possessed, that she seemed almost as much pleased as I was to look upon her. This character of *Lindamor's* inviting me to go see, whether or no it were deserved; and the frequent experience I have had, that even upon such bright eyes as poets, and lovers, called suns, I could gaze undazzled enough to approve my self a right eagle, assuring me I might safely do it, I fearlessly, but softly, approached the place, where the fair milk-maid was solliciting the udder of a fresh cow; and I found, that though indeed some resemblance she had to *Hermione* had made *Lindamor* flatter her, yet she looked at once so innocently, and prettily, that she seemed like to do mischief, without at all intending it; and I could not but fancy, that if some ladies, that are much cried up, and are very imperious mistresses, because they are so, were bound to change dresses with this unsophisticated and unadorned maid, the one would appear to owe her beauty to art, and the other to be beholden for her's to nothing but nature. But *Lindamor*, who is not naturally indisposed to be amorous, did not think, that this imagination of mine did that pretty creature right; for when I told him, she would eclipse a hundred of our fine ladies, if she had but the dress of one of them, why, that (replies he, with a kind of indignation) she can do without it; and perhaps, (subjoins he,) as much as with it. For her present habit leaves her most herself; and bravery would but disguise, or hide what it cannot adorn. And I am confident, (continues he) that should such a genuine beauty appear among the gallants, she would really captivate many, even of those wary ones, that do but pretend to be so, to the designing and applauded ladies; for though skill may encounter the wiles of art, it would scarce be able to resist the charms of nature. But whilst *Lindamor* was thus complementing with what he fancied the picture of his once loved *Hermione*, and had his eyes as much fixed upon her, as dazzled ones could be, the lovely milk-maid, (who all this while having not taken notice of us, was as regardless of *Lindamor*, as he seemed to be of all things but her) having dispatched what she was doing, took up her pail to carry it homewards: but her way chancing to lie by that part of the meadow, where we were yet standing, she could not but discover us; and judging by our clothes, and more by *Lindamor's* mien, that we were of a quality differing from theirs she was wont to converse with, she gave us a salute low enough to let us see, that she forgot not her condition; but attended with so much gracefulness, as made *Lindamor* conclude she merited a better, and, as she passed by him, to return the gesture of respect, which he thought so much beauty had a right in any habit to exact. She vouchsafed him a smile, which, I after told him, would have made him happy, if he had thought it had proceeded from kindness, not civility; and she went away with a look so

serene, as well as taking, that she seemed to carry home with her far more quiet, than she left him possessed of. But I, that had lost sight of her, without losing any thing with it, save the expectation of seeing in haste so fair a milk-maid, was going to railly with *Lindamor* about what had passed, when I was restrained, by perceiving, that the sight of a person, that seemed so contented, together with the native pleasantness of that place, and of that glorious morning, had such an operation upon him, that he could not forbear to celebrate the happiness and innocency of a country life. And after he had, with much transport, and fluency, repeated the substance of what *Ovid* and other ancient poets had in their strain delivered, concerning the felicity of the golden age, he began to apply as much of it as the matter would bear, to the recommending of a rural life; and was very sollicitous to make me acknowledge, that though we are wont to look upon villagers, as an inferior and wretched sort of people, yet they are the persons of the world, whose condition is the most proper, not only to keep them innocent, but to make them happy; their cheap and simple way of living allowing them to rest contented with what bounteous nature has provided for them, or an easy industry can procure them. Whereas among men nobly born, or persons of quality, it is looked upon as want of breeding, for a man not to think himself unhappy, as long as he hath not a thousand pounds a year.

LINDAMOR, though he here made a pause to take breath, would yet perhaps have prosecuted his discourse, had he not been prevented by the intervening of *Eusebius*, who, a while after we had left him, having missed us, had followed us to the place he found us in; and who, when he drew nigh, having overheard *Lindamor* speaking, stood still a while at some distance off, to listen to what he said, and so became an unsuspected auditor of the last part of his friend's discourse. Whereupon taking him by the hand, and leading him towards the river, he told him, with a serious, not to call it a severe look; I had thought, *Lindamor*, you had made righter estimates of the several courses of life, than by what I have newly over-heard you to say, I now suspect you do. Know then, *Lindamor*, (adds he) that innocence and contentment depend more upon a man's mind, than upon his condition. To manifest this to you, I shall in the first place observe, that it is not always the occasion, or the object, but rather the degree, that makes an affection of the mind unruly and troublesome: nor is it according to the intrinsic value of things, which none save the wife can discern; but the rate, how unskillfully soever fixt, which we put upon them, that they operate upon our passions. And therefore, you shall see a child take on more sadly for the scape of a sparrow, or the breaking of a rattle, than some will do for the loss of a good estate, nay, of a friend; and *Haman*, for the want of a bow from *Mordecai*, complained

plained more in his palace, than *Job*, till his miserable comforters had exasperated his grief, did for the loss of the biggest fortune in the East, and of the children he reserved it for, and valued far above it.

AND then, *Lindamor*, (continues *Eusebius*) do not imagine, that though courtiers and gallants have more splendid and glittering temptations to sin and discontent, country people are exempted from temptation to either: theirs may be as great, though not the same, nor so specious as the other; their faults and infelicities are indeed less taken notice of, because their persons and conditions are obscure, and their poverty conceals their vices, as well as their virtues, from our eyes; as in a sharp winter, the snow does as well hide their dung-hills, as cover their gardens. But if your quality allowed you to acquaint yourself with the true state of this inferiour sort of people, you would soon perceive, that even of rural families, there is scarce any, that, as far as their wits will reach, has not its several parties, and little intrigues; nor is there any cottage so low, and narrow, as not to harbour care, and malice, and covetousness, and envy, if those, that dwell in it, have a mind to entertain them. And what envy alone may do to produce crimes and discontents, we may conjecture by what happened betwixt *Cain* and *Abel*, since their being heirs to the whole world could not keep two brothers at peace, whilst one of them was envious: and there are some fordid vices, which are more incident to the meaner and more necessitous sort of men, as spiders and cobwebs are wont to abound more in thatched cabins, than in great men's houses. I should perhaps (says *Eusebius*) think these people happy, if I found they thought themselves so; but the pomp and vanities of the world have oftentimes stronger allurements for them, than for the grandees and courtiers themselves: for those, that are possessed of these imaginary joys, are disabused by their own experience; and those, that live among these theatrical persons, are near enough to discern, that they are but causelessly envied. As, for my part, when I had occasion to be conversant in great men's families, and the honour to preach in princes courts, the sight of their course of life did as thoroughly convince me of the vanity of the world, as my sermons endeavoured to convince them. Whereas country people see but the glittering and deluding outside of greatness; and beholding it but at a distance, see it in the favourablest light which men can behold it in; and consequently are strongly tempted to envy what they admire, and repine at their own condition, for the want of it: nay, every gaudy trifle, that those that live in towns and cities chance to make shew of, is wont to make a country-man envy, as well as gape; and it is odds, but that very milk-maid, whose condition you are pleased to think so happy, envies some neighbouring farmer's daughter for a piece of taudry ribbon, or a black hood. Nor are they so much more privileged from the assaults of temptation, than men of higher rank; for it is not so much

a man's outward condition, as his inward disposition and temper of mind, that makes temptations either to sin, or to discontent, prevalent, or unsuccessful. When *Joseph* was sold into *Egypt*, and sollicitated by a woman, that would needs be his mistress upon more scores than one, though his condition exposed him more to hopes and fears, than almost any other condition could expose another man; and though his youth made him very capable of relishing the pleasures, that his beauty made him courted to receive, by giving them; yet this chaste youth chose rather to be imprisoned any where, than in a fair lady's arms, and preferred the being made a captive, before the captivating of his amorous mistress. But whilst young *Joseph* was thus chaste in the Egyptian *Potiphar's* house, his eldest brother *Reuben* was incestuous in good *Jacob's*, whose family was then the visible church of God; and *Lot*, who was chaste and temperate in *Sodom* itself, was drunk, and committed incest in a cave: so much more does the success of temptations depend upon the temper of a man's mind, than upon the place he lives in.

I KNOW not (says *Eugenius*) whether the innocence of rural people be more easy than that of great men, but sure it is not so commendable: for as a woman, that has never yielded, because she was never sollicitated, may be called rather innocent than virtuous; so their condition, that owe their not being inveigled by the vanities of the world to their ignorance of them, has more in it of good fortune than of merit. I thank you for that consideration, (subjoins *Eusebius*) for I confess I think there is a great disparity betwixt an unacquaintedness with the bewitching pleasures of the world, and a contempt of them. And he is the truly heroick spirit, that can (as *David* could) plentifully enjoy all those sensual delights and vanities he chose to reject: for he could feast a nation, and prefer temperance before all that abundance: he could gain strange victories at once over his outward enemies, and over the temptations he was exposed to by such successes: he could build stately palaces, and then profess himself to be but a stranger, and a sojourner upon earth: he could afford humility room to sit with him on his throne, and could listen to her memento's amidst all the acclamations of his people, and the panegyricks of his courtiers: he was not to be resisted by beauties, that to others were irresistible, when he postponed the fairest objects, that could here charm his eyes, to such as were visible only to those of faith: he had got together the greatest treasure, that for aught I remember we read of in any history, and yet seems never to have been much pleased with it, but when he dedicated it to the building of the temple, and made the fruits of his valour the oblation of his piety. To be short, he was the greatest person upon earth, when he was content to leave it; and was willing to descend from the throne into the grave, whilst he looked upon that as the place whence he must ascend to the mansion of his God: so much did he, even whilst he wore an earthly crown, aspire to an heavenly one. And though

(continues

(continues *Eusebius*) we must now-a-days as little expect to meet with a man of *David's* condition, as of his temper, yet proportionably we may put a vast difference betwixt those that but escape the sight of the world's allurements, and those that reject the profers of them.

Eusebius was in this part of his discourse, when we were come near enough to the river, to discover it within a little way of us: and therefore finding by his silence, that he thought it seasonable to desist, I only ventured to tell him with a low voice, as we continued our walk, that I suspected, that in some of the things he had been saying, he had a design rather to check *Lindamor* a little, and keep up the discourse, than to deny, that a retired and rural life has great advantages towards contentation. To which, that he might conclude what he had to say, before we reached the river, he made haste to reply in the same tone, that I was not altogether mistaken; for (says he) I think the case may be pretty well represented, by saying, that as there are some airs very much wholesomer than others, and fitter to preserve men from diseases; so a very private and quiet condition of life does, much more easily than a more exposed and turbulent one, protect most sorts of men from vices and disquiets. But then, on the other side, as there are some men of such sound and strong constitutions, that they will enjoy their health in the worst airs, when men of tender and vitiated complexions will be sickly in the best; so there are some generous and steady souls, that will pass thorough the most troublesome and most exposed courses of life, with more of both innocence and contentment, than others can enjoy in a condition far remoter from disturbances and temptations. And, annexes *Eusebius*, (purposefully raising his voice) as for these villagers, that *Lindamor* thought so happy, I must dissent from him, as long as I see they can admire, and almost worship, a man for wearing a gaudy suit of clothes, or having two or three footmen behind his coach, before they know whether he be not a knave, or a fool, or both: for I shall scarce think, that he, who is himself possessed with envy, deserves mine.

DISCOURSE IV.

Upon fishing with a counterfeit fly.

BEING at length come to the river-side, we quickly began to fall to the sport, for which we came thither; and *Eugenius* finding the fish forward enough to bite, thought fit to spare his flies, till he might have more need of them, and therefore tied to his line a hook, furnished with one of those counterfeit flies, which in some neighbouring countries are much used, and which being made of the feathers of wild-fowl, are not subject to be drenched by the water, whereon those birds are wont to swim. This fly being for a pretty while scarce any oftener thrown in, than the hook it hid was drawn up again with a fish fastened to it, *Eugenius* looking on us with a smiling countenance, seemed to be very proud of his success; which *Eusebius* taking notice of, Whilst, (says he) we smile to see, how

easily you beguile these silly fishes, that you catch so fast with this false bait, possibly we are not much less unwary ourselves; and the world's treacherous pleasures do little less delude both me and you: for, *Eugenius*, (continues he) as the Apostles were fishers of men in a good sense, so their and our grand adversary is a skilful fisher of men in a bad sense; and too often in his attempts, to cheat fond mortals, meets with a success as great and easy, as you now find your's. And certainly, that tempter, as the Scripture calls him, does sadly delude us, even when we rise at his best baits, and, as it were, his true flies: for, alas! the best things he can give, are very worthless, most of them in their own nature, and all of them in comparison of what they must cost us to enjoy them. But, however, riches, power, and the delights of the senses are real goods in their kind, though they be not of the best kind; yet, alas, many of us are so fitted for deceits, that we do not put this subtle angler, to make use of his true baits to catch us! We suffer him to abuse us much more grossly, and to cheat us with empty titles of honour, or the ensnaring smiles of great ones, or disquieting drudgeries disguised with the specious names of great employments. And though these, when they must be obtained by sin, or are proposed as the recompences for it, be, as I was going to say, but the devil's counterfeit flies; yet, as if we were fond of being deceived, we greedily swallow the hook, for flies, that do but look like such; so dim-sighted are we, as well to what vice shews, as to what it hides. Let us not then (concludes *Eusebius*) rise at baits, whereby we may be sure to be either grossly, or at least exceedingly deceived; for whoever ventures to commit a sin, to taste the luscious sweets, that the fruition of it seems to promise, certainly is so far deceived, as to swallow a true hook for a bait, which either proves but a counterfeit fly, or hides that under its alluring shew, which makes it not need to be a counterfeit one to deceive him.

DISCOURSE V.

Upon a fish's struggling after having swallowed the hook.

FORTUNE soon offered *Eusebius* a fair opportunity to confirm this last part of his reflection; for he had scarce made an end of it, when a large fish, espying the fly, that kept my hook swimming, rose swiftly at it, and having greedily chopt it up, was hastily swimming away with it, when I struck him, and thereby stopt for a while his progress: but finding himself both arrested and wounded, he struggled with so much violence, that at length he broke my slender line, (that was fitted but for weaker fishes) and carried away a part of it, together with the annexed hook and bait. If philosophers (says hereupon *Eusebius*) be not too liberal in allowing brutes to think, we may well suppose, that this fish expected a great deal of pleasure from the bait he fell upon so greedily; and that when once he had got it into his mouth, he might well look upon it

it as his own; and those other fishes, that saw him swallow it, and swim away with it, did probably envy his good fortune. But yet indeed he does not enjoy his wish, though he seem to have the thing wished for within his power; for by the same action, in which he sucked in the fly, he likewise took in the hook, which does so wound and tear his tender gills, and thereby put him into such restless pain, that no doubt he wishes, that the hook, bait, and all, were out of his torn jaws again, the one putting him to too much torture to let him at all relish the other. Thus men, who do what they should not, to obtain any object of their sensual desires, whatever pleasure they may beforehand fancy to themselves in their success, are oftentimes, even when they obtain their ends, disappointed of their expectations; sometimes conscience, reason, or honour, making them, even when their desires are not of the worst sort, do as *David* did, when he had, more vehemently than became a pious general, longed for water out of the well at *Bethlehem*; and by the strange venturoufness of his bold and affectionate officers obtained it, could not find in his heart to drink it, but poured it untasted on the ground. But when the things we so long for must be criminally obtained, then it not only often fares with them, as it did with *Annon*, who immediately upon the incestuous fruition of his ravished sister, hated her more than before he had loved her: but it sometimes happens to those, that sin more heinously in this matter, as it did to *Judas*, who, after having betrayed a master, that was incomparably more worth than all the world, and thereby for ever lost himself for a few pieces of silver, seemed to have it in his power, without having it in his will, to enjoy them, and in a desperate but unseasonable fit of anguish and remorse, did of his own accord disburthen himself of that money, which he had sold his conscience to get; so that though he had what he sought, he had not what he expected. And when what he coveted was in his possession, he had the guilt of acquiring it, without the power of enjoying it. And even in cases far less heinous, (concludes *Eusebius*) when men seem to have got what they aimed at, and to have carried it away as their booty, in spite of all opposition the wound thereby inflicted on injured conscience puts them to so much of deserved pain, that the wishes they are thus criminally possessed of, they do not enjoy, but detest.

DISCOURSE VI.

Upon the sight of one's shadow cast upon the face of a river.

THE sight of some fishes playing to and fro upon the top of the water diverted us from prosecuting our conference, and drew us to apply our selves attentively to the catching of them, in which accordingly we spent some part of the morning; yet whilst we continued angling, not far from one another, we often cast our eyes (as is usual in such

cases) upon each other's fishing corks, to learn as well the success of our friends, as in what places the fish were forwardest to bite. As I chanced to look towards that cork, at which *Eusebius's* hook was hanging, I perceived, that it was divers times drawn under water, without his endeavouring thereupon to strike that fish, that made thus bold with his bait: wherefore laying down my angle a while, I went softly towards *Eusebius*, to see what it was, that made him so regardless of his sport, whilst yet, by the posture he continued in, he seemed to be intent upon it; but approaching near enough, I quickly perceived, that instead of minding his hook, his eyes were fixt sometimes upon his own picture, reflected from the smooth surface of the gliding stream, and sometimes upon the shadow projected by his body, a little beside the picture upon the same river.

THE unwilling noise I made in coming so near having obliged *Eusebius* to take notice of me, I thought fit, since I found I was discovered, to ask him smilingly, whether he were, *Narcissus*-like, making love to his own shadow.

EUSEBIUS guessing by these words, that I had conjectured what he was doing, answered me with a look somewhat more serious than that I had spoken to him with; I was indeed, *Philaretus*, attentively enough considering, sometimes my picture, which the water presents me with, and sometimes the shadow, which the sun and I together cast upon the water: but (says he, with a half smile) I looked upon both these, not with the eyes of a *Narcissus*, (for that would make me much madder than he was) but with those of a Christian. For I was considering, that one of the differences betwixt the law, and the gospel, might not be ill represented by the difference betwixt a common looking-glass, and that afforded me by this crystal stream: for though, both being specular bodies, I can see my face in either; yet if my face be spotted with dirt, or grown pale by reason of the faintness usual in such hot weather, a common looking-glass will indeed discover those things to me, but will not otherwise assist me to remedy them: whereas, when I consult this stream, if it shew me any spots in my face, it supplies me with water to wash them off, and by its cooling and refreshing waters, can relieve me from that faintness, that reduces me to look pale.

THUS the law, which is commonly, and which seems even by an Apostle to be comparéd to a looking-glass, shews us indeed the pollutions of our souls, and discovers to us the effects of our spiritual languidness, and faintness; but the gospel does not only do so, but tells the embracers of it, by Saint *John's* mouth, *If any man sin, we have an advocate with the Father, Jesus Christ the righteous, who is the propitiation for our sins, and whose blood cleanses us from all sin.* And the author of the same gospel invites all those, that find themselves tired and thirsty, to come unto him, and to be refreshed.

By this time *Lindamor*, who was angling not very far off, perceiving us stand together,

as if we were engaged in some discourse, laid by his rod a while, and came to listen to what he expected he might learn from *Eusebius*; who pausing here, I put him in mind, that he had also mentioned to me the sight of his shadow upon the face of the river, as another object of his contemplations, and that therefore my curiosity (wherein I knew *Lindamor*, as soon as I should acquaint him with the occasion, would share) made me very desirous to know what thoughts had been suggested to him by a subject, that seemed so slight and barren.

SINCE you will needs know, (replies *Eusebius*) I will confess to you, that my thoughts were theologically enough employed, and therefore, lest you should think, I affect to preach out of the pulpit, I will but succinctly mention some of those various things, that this shadow, as despicable as you think it, suggested to me: but since I was only entertaining and exciting my self, not discoursing with Naturalists, or disputing with Atheists, I presume you will not wonder, that I take the doctrine of the creation for granted, as it is acknowledged by Christians in general, and particularly by you.

I WAS then considering, that this shadow, related to me, might in some particulars be no unfit one of the universe in reference to God: and indeed, perhaps the world may without much extravagance be termed the shadow of him, of whose attributes, or perfections, it exhibits to an attentive considerer divers excellent impresses, and the resemblance may thus far be advanced: that as though it represents the shape and out-lines of my body, which projects it, yet it represents but them, and consequently this shadow in reference to it is but a superficial and worthless thing; so the world, though it be not destitute of several impresses, and as it were lineaments or features of the divine wisdom and power, yet, for all this, its representations of the divine author of it are but very imperfect, superficial, and dark, and the excellency of the adorable author of things keeps him infinitely above all the works, that he has made.

BUT to mention some of the comparisons I took notice of: In the first place we may consider, that I make this shadow here without taking the least pains to do so, and with as little toil God made the world: *He spake and it was done; he commanded, and it stood fast,* (says the Psalmist, speaking of the creation.) And elsewhere the scripture says, *That the everlasting God, the Lord, the Creator of the ends of the earth fainteth not, neither is weary;* and therefore that rest ascribed him on the seventh day is to be understood but a cessation from creating, not a repose from labour: for all disproportionations to the power of created agents are so equally inconsiderable, in reference to one that is infinite, that omnipotence may make even the world without toil.

SECONDLY, To make this shadow, I neither use nor need colours, nor pencil; I dig no quarries, nor fell no trees to perfect this work, and employ no materials about it: as little had God any pre-existent matter to con-

trive into this vast fabrick: our creed proclaims him the Creator of heaven and earth; the angel, that holds the book, in the *Revelations*, describes him resemblingly; and the Apostle tells us, *That through faith we understand, that the worlds were framed by the word of God; so that things, which are seen, were not made of things, that do appear.* And indeed it became an omnipotent architect, not to be beholden but to himself for his materials. He that calleth things, that are not, as though they were, makes them by calling them; *He brought forth light out of darkness, by calling for light, and there was light; and he spake it, and it was done,* says the Psalmist: and the world was, if I may so express it, but the real echo of that productive *FIAT*.

THE next thing, I was considering, was, that, to destroy this shadow, I needed neither sword, nor pistol, the withdrawing of my self under the neighbouring trees being sufficient to make the shadow disappear, and leave behind as little shape of it, as if there never had been any. And thus, as the world could not have had a beginning, without having been provided by God, so for the continuance of the being it enjoys, it depends altogether, and every moment, upon the will and pleasure of its first author, of whom *St. Paul* tells us, *That in him we not only live, and move, but have our being;* and to the same purpose I think one may alledge that place, where the scripture says of God, not only, *that he has made heaven, the heaven of heavens with all their host, the earth and all things that are thereon, the seas and all that is therein;* but adds, *that he preserveth them all,* as our translators English it: for in the Hebrew I remember it is, *vivifies them all,* that is, sustains them in that improper kind of life, or that existence, which, whilst their nature lasts, belongs unto it. So that if God should at any time withdraw his preserving influence, the world would presently relapse, or vanish into its first nothing, as there are many notions of the mind such, as that of genus, and species, which are so the creatures of reason, that they have no longer an existence in the nature of things, than they are actually upheld therein, by being actually thought upon by some intellectual being; and God is so the preserver of all his creatures, that one may say of the rest, as the Psalmist speaks of many of them, where addressing himself to God, he says, *Thou hidest thy face, they are troubled; thou takest away their breath, they die, and return to their dust; thou sendest forth thy spirit, they are created, &c.*

I WAS also taking notice, (pursues *Eusebius*) that to produce what changes I pleased, in all, or any part of this shadow, I needed not employ either emissaries, or instruments, nor so much as rouse up my self to any difficult exertion of my own strength, since, by only moving this or that part of my own body, I could change at pleasure, in the twinkling of an eye, the figure and posture of what part of the shadow I thought fit: and thus, when God had a mind to work those miracles, we most admire, as when at *Joshua's* prayer he stopped

the course of the sun, and at *Hezekiah's*, made him go back; we men are apt to imagine, that these prodigious effects must needs cost their author much, and that he must strain his power, and be necessitated to a troublesome exertion of his omnipotence, to be able to produce them: whereas to that divine agent, those things, that would be to all others impossible, are so far from being difficult, and the creatures have so absolute and continual a dependence on him, that it is as easy for him to effect the greatest alterations in them, as to resolve to do so. And even those miraculous changes of the course of nature, that do the most astonish us, do so naturally and necessarily flow from the motions of his own will, that to decree, and to execute, (whether or no they require powers otherwise than notionally differing) are alike easy to him: and that irresistible agent finds as little more difficulty to produce the greatest changes among the creatures, than to produce the least, as I find it harder to move the whole arm of my shadow, than to move its little finger. And this consideration (subjoins *Eusebius*) might be, methought, consolatory enough to his church, who, by reposing an entire trust in her God, entitles her self to the protection of him, that can as easily produce changes in the world, as resolve on them, and can with the same facility destroy her and his greatest enemies, as decree their destruction.

I WAS also further considering, (says *Eusebius*) that though the little watry bodies, that make up this river, and consequently those, that glided along by me, were in a restless motion, the hindmost always urging on, and chasing those that were before them; yet my shadow was as compleat and stable upon the fugitive stream, as if it had been projected on the water of a pond, or rather as if all the parts of water, whereon it was visible, had been fixt and moveless; of which I made this application, that though we may say with *Solomon*, in a larger sense than his, *That one generation goes, and another comes*, the world being maintained by perpetual vicissitudes of generation and corruption, yet the wisdom and providence of God does so far confine the creatures to the established laws of nature, that though vast multitudes of individuals are always giving place to others, yet the particular creatures, which do at any time make up the world, do always exhibit the like picture of its divine original.

BUT yet lastly, (says *Eusebius*) I was considering too, that though this shadow have some kind of resemblance to that, whose shadow it is, yet the picture is but very superficial and obscure; and if we should suppose, the fishes, that inhabit this stream, to be endued with reason, they could even from *Lindamor's* shadow but collect, that the original is a man, and not a brute; but they could not hence make any discovery of what manner of man he is, nor know any thing of his virtues, or his thoughts, or his intention, nor consequently have that notion of him, that I (pursues *Eusebius*, turning to him, and a little smi-

ling on him) do harbour and cherish, who having the happiness to converse with him, have the opportunity and the justice to admire him. Thus, where I formerly ventured to call the world God's shadow, I did not forget, how imperfect a picture a shadow is wont to be: and though this dark representation, that God has vouchsafed men of himself in the universe, be sufficient to convince us, that it was not made by chance, but produced by a powerful and intelligent being; the eternal power and God-head of the great author of nature, as the scripture seems to teach us, being manifested to attentive and rational considerers, in the visible productions of his power and wisdom; yet how short and dim a knowledge must they have of him, that have no other than these corporal instructors? How many of his glorious attributes are there, for whose knowledge we must be beholden, rather to his written, than his created word? and how little will human intellects, without revelation, discover of that manifold wisdom of God, which the scripture teaches us, *That even to the angels it* Ephes. iii. *must be made known by the church.* And if those 10. illuminated persons, such as *Moses* and *St. Paul* himself, who had both extraordinary revelations from God, and intimate communion with him, confessed, that in this life they saw him but darkly, and, as it were, in a glass; sure the dim light of mere nature will give us but extremely imperfect, and detracting ideas of him, whom the like limitedness of our nature will allow us to know but very imperfectly, in heaven it self; though, as we shall there see him face to face, our apprehensive faculties will as well be enlarged, as the dazzling and ravishing object be disclosed.

BUT, (says *Eusebius*) though I forget, that I am not in the pulpit, I hope you remember, that I told you at first, how little I pretended these kind of reflections would endure a rigorous philosophical examen; and that I am not so indiscreet, as to expect, that they should work conviction in an infidel, though I hope they may excite good thoughts in a believer.

THESE last words of our friend being not followed by any other; *Lindamor*, having waited a while to ascertain himself, that *Eusebius* had ended his discourse, began another, by saying:

I PERCEIVE, *Eusebius*, with much more satisfaction than surprize, that the same subject, and at the same time, did, as it was fit, suggest very differing considerations to you and me; for whilst your shadow afforded you the rise of sublime speculations, I was making but a moral reflection upon mine: for taking notice, (continues he,) that the shade my body projected, near noon, was almost as much shorter than it, as in the morning it was longer, prompted me to think, how foolish it were for me, who know by sure ways of measuring my own stature, that it is moderate enough, not to be either proud of, or complained of, should imagine, that I am either as tall as a giant, or as low as a dwarf, because I see my shadow either exceeding long, or extremely short. And I was further considering, pursues *Lindamor*,

Lindamor, that if philosophers, as well as the vulgar, have rightly called fame or glory the shadow of virtue, it would be as irrational to estimate one's self not by the testimonies of one's conscience, which is the authentick standard of intrinick worth, but by the fickle opinions of others, (which oftentimes flatter, and oftener detract) but very seldom give a just and impartial estimate of merit: the fame may have its increase and decrements, whilst the person continues the same, and loses nothing of substance with the shadow. And for a man, that should examine himself, and judge of himself by his own designs, and actions, not other men's words, to suffer himself to be puffed up by vulgar applause, or dejected by unmerited censures, were to mistake a shadow for a standard.

DISCOURSE VII.

Upon a fall occasioned by coming too near the river's brink.

IT was not long after this, that *Eugenius* chancing to spy a little nook, which seemed to promise him a more convenient station for his angling, he invited *Lindamor* to share the advantage with him, and began to walk thitherward along the river's brink, which the abundant moisture of the waters, that glided by it, had adorn'd with a pleasant verdure; but he had not marched very far, when chancing to tread on a place, where the course of the water had worn off the bank, and made it hollow underneath, he found the earth falter under him, and could not hinder his feet from slipping down with the turf that betrayed him; nor could he have escaped so, had not his endeavours to cast the weight of his body towards the bank been assisted by *Lindamor*, who, though not so near the brink as to be in danger, was not so far off, but that he was able to catch hold of him, and to draw him to the firm land. The noise, that *Lindamor* made, when he saw his friend falling, quickly drew *Eusebius* and me thither; where, after I had a while made my self merry with the disaster, I found to have been so harmless; *Eusebius* (who arrived there a little later) asked him how he came to fall; and *Eugenius* answering, that he thought he had trod upon firm ground, because he saw the bank look to the very edge, as if it differed not from the rest of the field, which it terminated; *Eusebius* took occasion from thence to tell him, You may from this take notice, that it is not safe travelling upon the confines of what is lawful, and what is sinful, no more than upon the borders of two hostile nations: when we suppose, that thus far we may go towards that which is sinful, without committing it, we are wont with more boldness than considerateness to conclude, that we need not scruple to venture, or rather that we shall run no venture, having firm footing all the way. But it is much to be feared, that when we allow our selves to come as far as the utmost verge of what is lawful, and to do that, which, in the casuist's language, is *tantum non* to sin, the

natural proclivity of our minds to evil, which carries them downwards, as weight does our bodies, will some time or other make us find hollow ground, where we presume to find it firm. He that to day will go towards sin as far as he thinks he may, is in danger of going to-morrow further than he should; and it is far more easy for him to be secure than to be safe, that walks upon the brink of a precipice. He was a wise man, that as soon as he had forbidden his son to enter into the path of the wicked, and to go in the way of evil men, subjoins, as the best course to conform to the prescription, Avoid it, pass not by it, turn from it, and pass away. God's indulgence leaves us a latitude to comply with our infirmities, and necessities, and to give us opportunities of exercising a pious jealousy over our selves, and of shewing how much we fear to offend him. But a wary Christian will say in this case, as *St. Paul* did in almost a like, *all things are lawful for me, but all things are not expedient*: and he must often go further than he can with prudence, that will always go as far as he thinks he can with innocence.

DISCOURSE VIII.

Upon the good and mischief that rivers do.

THIS discourse being ended, we all, as it were, by common consent, applied our selves again to prosecute the sport that had invited us to the river: but we had not angled very long, before we were disturbed by a loud and confused noise, which we soon discovered to proceed from a ship, that, together with some barges, and other lesser boats, were, by the help of a favourable breath of wind, sailing up the river towards *London*. The sight of these laden vessels, together with the prospect of the *Thames*, which, (as it happened in that place) seemed, in various windings and meanders, wantonly to fly, and to pursue it self: this sight, I say, together with the rich and flourishing verdure, which the waters, in their passage, bestowed upon all the lands, that were on either side any thing near their banks, invited *Eugenius* to fall upon the praises of that excellent river, which not only imparts fertility and plenty here at home, by enriching all the places that have the advantage to be near it; but helps to bring us home, whatever the remoter parts of the world, and the Indies themselves, whether east or west, have of rare or useful.

LINDAMOR, having both applauded and recruited these commendations, Methinks, says he, that amongst other good things, wherewith this river furnish us, it may supply us with a good argument against those modern Stoicks, who are wont, with more eloquence than reason, to declaim against the passions, and would fain persuade others, (for I doubt whether they be so persuaded themselves) that the mind ought to deal with its affections, as *Pharaoh* would have dealt with the Jews-males, whom he thought it wise to destroy lest they might, one day, grow up into a condition

condition to revolt from him. But, because the passions are (sometimes) mutinous, to wish an apathy is as unkind to us, as it would be to our country, to wish we had no rivers, because (sometimes) they do mischief, when great or sudden rain swells them above their banks.

WHEN I consider, (says *Eusebius*) that of the immaculate and divine lamb himself, it is recorded in the gospel, that *he looked round about, upon certain Jews, with indignation, being grieved for the hardness of their hearts*; so that two passions are ascribed to Christ himself in one verse: and when I consider too the indifferency (and consequently the innocence) of passions in their own nature, and the use, that wise and virtuous persons may make of them, I cannot think we ought to throw away (or so much as wish away) those instruments of piety, which God and nature has put into our hands; but am very well content we should retain them, upon such conditions, as *Abraham* did those domesticks he bought with his money, whom, the Scripture tells us, *he both circumcised and kept as servants*.

BUT, (continues *Eusebius*) as I do not altogether disallow *Lindamor's* comparison between rivers and passions, so he must give me leave to add this to it, that as rivers, when they over-flow, drown those grounds, and ruin those husbandmen, which whilst they flowed calmly betwixt their banks, they fertilized and enriched; so our passions, (when they grow exorbitant and unruly) destroy those virtues, to which they may be very serviceable whilst they keep within their bounds.

INSTANCES of this truth, (pursues *Eusebius*) are but too obvious. It is said, that valour is anger's whetstone; and our being counselled by the apostle, *to be angry and not to sin*, argues that passion not to be incompatible with innocence, whilst it is confined within the limits of moderation. But when once anger is boiled up into rage, or choler into an habitual fury, or appetite of revenge, it makes more havock in the world than beasts and inundation: the greatest part of those rivers of blood, that are shed in battles, (though spilt by anger) do rather irritate than appease the unnatural thirst of that insatiate fury: the burning of cities, the sinking of fleets, and the desolations of provinces, and of kingdoms, make but part of the tragick effects of this inhuman passion, when it once thoroughly possesses those, that wield scepters, and handle swords.

I WILL not tell *Lindamor*, that even that noblest and best of passions, love, as gentle and amiable as it appears, when once it comes to degenerate by growing unruly, or being misplaced, is guilty of far more tragedies than those, that have the fortune to be acted on theatres, or to furnish the writers of romances; and that which (perchance at first) seems to be but an innocent love, being not duly watched, and regulated, may, in time, grow to disobey, or deceive parents, to violate friendships, to send challenges, and fight duels, to betray the honour of harmless virgins, and of the noblest families, to rebel against kings, procure the ruin of monarchies and commonwealths; and,

in a word, to make thousands miserable, and those it possesses most of all, and thereby to bring credit to, if not also to surpass, the fictions of poets, and the fabulous stories of romances.

AND as for the desire of excelling others, as great and noble things as it makes men undertake, whilst it aspires only to a transcendency in virtue, and in goodness, when that passionate desire, by making men too greedy of superiority in fame and power, degenerates into ambition; how many vices are usually set at work by this one passion! The contempt of the laws, the violation of oaths; the renouncing of allegiance, the breach of leagues and compacts, the murder of one's nearest relations, (if they be more nearly related to a crown) and all the other crimes and miseries, that are wont to beget or attend civil wars, are the usual as well as dismal productions of this aspiring humour in a subject. Nor does it less mischief when harboured in a prince's breast; for the undoing of his own people, the subversion of his neighbour's states, the sacking of cities, the slaughter of armies, the dispeopling of some provinces, and the peopling of others with widows and orphans, are sacrifices, that are more frequently offered up to ambition, than able to satisfy it. For what can quench his thirst of rule and fame, or hinder the attempts, to which it stimulates him, that can find in his heart to destroy armies, and ruin provinces, only that he may be taken notice of to be able to do so?

CERTAINLY (subjoins *Eusebius*) he knew very well the frame of human spirits, that said by the pen of an Apostle; *From whence comes James iv; wars and brawlings among you? Come they not hence, even of your lusts that war in your members*. And I doubt not, whether plagues, wars and famines have done more mischief to mankind, than anger and ambition, and some other inordinate passions; for these do frequently bring upon men those publick and other fatal calamities, either as judgments, which they provoke God to inflict, or as evils, which as proper consequents naturally flow from those mischievous practices, to which unbridled passions hurry the criminally unhappy persons they have enslaved.

WHEREFORE, (concludes *Eusebius*, casting his eyes upon *Lindamor*) as the usefulness of a river hinders us not from making good the banks, and, if need be, making dams, to confine it within its limits, and prevent its inundations; so the usefulness of the passions should not hinder us from watchfully employing the methods and expedients afforded us by reason and religion, to keep them within their due bounds, which they seldom overflow without shewing, to our cost, that, as it is observed of fire and water, they cannot be so good servants, but that they are worse masters.

DISCOURSE IX.

Upon the comparing of lands, seated at different distances from the river.

THIS last discourse, to which the river had afforded the occasion, inviting me to survey as much of it, as was within my view, a little

little more attentively, gave me the opportunity of taking notice of a manifest difference betwixt the lands that lay near it, and those whose situation was remoter from it; and having acquainted *Eusebius* with what I had observed, which his own eyes could not but presently bear witness to; One (says he) that should only consider how swiftly this stream runs along these flowery meadows, and how great a quantity of water passes through them, and from them, towards the sea, would be apt to conclude, that certainly these grounds retain none of the water, which runs from them so hastily, and so plentifully; especially since we can see no channels, nor other manifest inlets, and receptacles, that should divert and retain the fugitive water, so that the grounds confining on the river must be but little advantaged by its neighbourhood. But, (continues *Eusebius*) though these grounds have not any patent passages, whereby to derive water and fatness from the river, and therefore must suffer the greatest part of it to run by them undiverted; yet still some of the cherishing and fertilizing moisture is from time to time soaked in by the neighbouring ground, and (perhaps by blind pores and crooked channels) so dispersed thorough the whole fields, that they have thereby water, and in that vehicle fertility conveyed to them; which you will not doubt, if you do but with me take notice, how much the lands, that lie on both sides near the course of the river, are more verdant, and flourishing, and more rich, than those less happy grounds, to whom their remoteness denies the advantage of so improving a neighbourhood.

Thus (resumes *Eusebius*) many a pious person, that is an assiduous attendant on the means of grace, and has a care to place himself, as it were, in the way, by which the ordinances of God, especially those of reading and expounding of the Scriptures, are wont freely and copiously to flow, is (especially upon any fit of melancholy, or distress of mind) apt to be extremely discouraged from prosecuting that course of duties; and by looking upon the little, that he remembers of so many excellent sermons as he has heard, he is often inclined to conclude, that not only he has lost all the good sermons, that he has heard already, but that at least for such as he, there is little to be expected from them for the future.

But though to lose so much of a thing, so precious as the doctrine of salvation, be that, which is oftentimes a fault, and always an unhappiness; yet it is a far less mischief to forget sermons than to forsake them; the one may be but an effect of weak memory, the other is that of a depraved will, perverted by laziness, impatience, or some greater fault. We should scarce allow it for a rational proceeding, if one in a consumption, or dysentery, because he grows not fat with feeding, should resolve to renounce eating and drinking.

But this (says *Eusebius*) is not that, which I chiefly intended: for pious, but melancholy persons, are oftentimes too partial against themselves, to be competent judges of their own estate; they seem not to forget any sermon so

much, as that charity should begin at home; and they are much more careful not to accuse any body wrongfully than themselves: though they might remember, that in the estimate of Christ himself, all grounds are not equally fruitful, that are good; some bringing forth hundred, some sixty, some but thirty fold, and yet to all he vouchsafes the title of good. And though, as mad men, that have quite lost their wits, seldom or never complain of the want of them; so those, that have forfeited, or are devoid, of grace, rarely bemoan themselves of the weakness of it. And it is no mean sign of proficiency in piety, to be apt to deplore one's unproficiency in piety. It is true, that preaching is not always, and I fear not so much as often, the favour of *life unto life*; the perverseness of the hearers making it but too frequently the favour of *death unto death*. But yet, speaking in the general, though it aggravate the sins committed in spite of it, yet it usually hinders many others from being committed; and he, that twice a week is told of God, and duty, and heaven, and hell, has his conscience more awaked, than he, that never hears of any of these things. And if you but compare one of these despondent Christians, we are considering, with the careless sensualists, that fly a rousing sermon, as they should do what it would deter them from; you will easily discern a sufficient disparity between them, to invite you to conclude, that the instructiveness of preaching may, like the moisture of the river, be conveyed but by little and little at a time, and by unperceived passages, and yet be able to impart fertility. For though much run by, yet commonly something will stick; which we may safely conclude, if though we can discern it no other way, it disclose it self by the effects. For it is not always to those, that remember the most of them, that sermons do the most good, as water retained in ponds makes not the bottom flourishing, but the banks; and the efficacy of a sermon is better to be collected from the impression it has on the understanding and affections, than from that it leaves on the memory: whether we retain the particulars faithfully or no, and carry them home with us; yet if a sermon leave us devouter than it found us, if we go from God's ordinances, with a love to them, and a relish of them, and a purpose to frequent them, we may be despondents, but are not altogether non-proficients: that incorruptible seed, by which we are regenerated, being once thrown into an honest heart, may, as our Saviour intimates, grow up we know not well how, and though perhaps by insensible degrees, yet at length attain maturity. To dispatch, (concludes *Eusebius*) whether or no a man can orderly repeat all the particulars that composed the sermon, it does him good, if it either makes him good, or keeps him so; and its operation is to be estimated, not so much by what we remember, as by what we resolve.

WHAT you have been saying, (subjoins *Lindamor*, when he perceived that *Eusebius* had done speaking, suggests to me a reflection, that till now I did not dream of; and though

it differ from that, wherewith you have been pleased to entertain us, yet because it is applicable to the same purpose, and occasioned by the same river, I shall without scruple, though, after your discourse, not without blushes, tell you, that it is this; I, among many others, that live near it, have often resorted in hot weather to this river, to bathe my self in it; and after what I have been hearing, I now begin to consider, that though incomparably the greater part of the river run by me, without doing me any good, and though when I went out of it, I carried away little or none of it with me; yet whilst I stayed in it, that very stream, whose waters run so fast away from me, washed and carried off whatever foulness it might find sticking to my skin; and besides, not only cooled me, and refreshed me, by allaying the intemperate heat, that discomposed me, and made me faint, but also helped me to a good stomach for some while after.

THUS (resumes *Lindamor*) I have sometimes found, that a moving sermon, though it did not find me qualified to derive from it the advantages it questionless afforded better auditors; and when I went from it, I found I had retained so little of it, that it seemed to have almost totally slipt out of my memory, yet the more instructive and pathetick passages of it had that operation upon me, as to cleanse the mind from some of the impurities, it had contracted by conversing to and fro in a defiling world, without suffering pollutions to stay long, and settle, where they began to be harboured: and besides, I found that a course of such sermons, as I have been mentioning, did oftentimes (and if it had not been my own fault, would have always done so) both allay those inordinate heats, that tempting objects are but too apt to excite; refresh my drooping spirits, that continually needed to be revived, and raise in me an appetite to the means of grace, which are piety's (and consequently the soul's) true and improving aliments. So that, (concludes *Lindamor*) though I seldom let sermons do me all the good they may, and should, yet I dare not forsake them, because I forget them; since it is to do a man some good, to make him less bad than he was, and to give a value and inclination for the means of growing better than he is.

DISCOURSE X.

Upon a fish's running away with the bait.

THIS reflection of *Lindamor's* was soon followed by another of the same gentleman's, who seeing many fishes rise one after another, and bite at *Eugenius's* bait, which he let them sometimes run away with, that he might be the surer to be able to draw them up, as he afterwards did several of them; See, (says *Lindamor*, as one of the fishes had just swallowed the hook) how yonder silly fish, having at length seized the beloved bait he has been courting, posts away with it as his obtained wish, little dreaming of being himself taken. Thus (continues the same speaker) when greedy

mortals have an opportunity to obtain forbidden things, they joyfully run away with them as the goods they aimed at, and when they fondly think they have caught, they are so; and whilst they imagine themselves to carry away a booty, they become a prey: for that he is, in his judgment that never errs, who, whatever he gets into the bargain, loses himself.

THE Scripture (subjoins *Eusebius*) mentions, among other properties of vice, that which it calls the deceitfulness of sin. And the wise man tell us, that wine is a mocker; and it may be one of the reasons of these expressions, that when we think our selves possessed of a sinful pleasure, we are indeed possessed by it, as demoniacks are possessed by the devil, who serves many other finners, though less perceivedly, as he serves witches, whom he gets the power to command, by seeming to obey them, and to comply with their criminal desires: and, if we compare this with what I was just now observing to you, on the occasion of the counterfeit fly, we may add, that even when sin seems the kindest and most obsequious to us, and to answer, if not exceed our desires, our case may be but like the Canaanitish general's, who, though he had milk brought him by *Jael* instead of the water he only requested, was but thereby invited to *Judges iv.* *sleep the sleep of death*, and to have his fears *29.* more surpassed than his desires had been.

BUT, (pursues *Eusebius*) this may supply us with another reflection; for though this fish seems to have devoured the hook and bait it swallowed, yet in effect it is taken thereby: so the devil, when he had played the serpent and the lion, when he had brought the Jews and Gentiles to conspire against their common Saviour, and had made *Herod* and *Pilate* friends, to make them joint enemies to Christ, and when by these means he seemed to have obtained his end, by employing their hands to kill the formidablest of all his enemies; this pursued prey destroyed the seeming conqueror; and death appearing to swallow the Lord of life was, if I may so speak, choaked by the attempt, since he not only was quickly able to say in the Apostle's triumphant language, *O death, where is thy sting? O grave, where is thy victory? but did by death conquer* *2 Cor. xv.* *him that had the power of death, that is, the* *15.* *devil: nay, and made all his followers so much* *Heb. ii.* *14, 15.* sharers in the advantages of his conquest, as by the same way (which we are informed by the same text) to deliver those, whom the restless fear of death perpetually kept from relishing the joys of life.

DISCOURSE XI.

Upon a danger springing from an unseasonable contest with the steersman.

THIS discourse being ended, *Eugenius*, who was looked upon by us all as the most experienced as well as concerned angler among us, descrying at a good distance a place, which he judged more convenient for our sport, than that we there were in, where the fish began

gan to bite but slowly; he invited the company to this new station: but when we were come thither, finding in a short time, that either it was ill stocked with fish, or that the season of their biting in the places thereabouts was over, he thought it concerned him to provide us some better place. And accordingly, whilst we were yet, by the pleasure of mutual conversation, endeavouring to keep the fishes fullness from proving an exercise to our patience, he walked along the river, till he lighted upon a youth, that by his habit seemed to belong to some boat or other vessel; and having inquired of him, whether he could not be our guide to some place where the fish would bite quick, he replied, that he easily could, if we would take the trouble of coming to a place on the other side of the river, which his master, who was a fisher-man, had baited over night, and would questionless let us make use of for a small gratification. *Eugenius*, being very well content, called away the company, which were led by the youth to a boat belonging to his master; into which being entered, the old man, who was owner of the boat, hoisted up sails, and began to steer the boat with one of his oars, to a place he shewed us at a good distance off; but did it so unskillfully, that since a mariner of his age could scarce mistake so grossly for want of experience in the river, we began to suspect, that he had too plentifully tasted a far stronger liquor than that which was the scene of his trade: and as the old man was half drunk, so the youth appeared to be a mere novice, both which we had quickly occasion to take notice of. For some clouds that were gathering out of the sea, passing over our vessel, raised in their passage, as is usual enough, a temporary wind, that to such a slight boat as ours was might almost pass for a kind of storm: for then the old man gave his directions so ill, and the youth was so little able to execute them punctually, that two of the company, offended at their unskillfulness, began by angry and unseasonable expostulations and clamours to confound the already disordered boat-man; and being got up, with no small hazard to the boat, they would perchance, by crossing the watermen in their endeavours, have made it miscarry, had not *Lindamor*, whose travels had made him well acquainted with such cases, earnestly requested them to sit still, and let the watermen do their own work as well as they could; affirming, that he had seen more than one of those easily over-set boats cast away, by the confused and disagreeing endeavours of the watermen and passengers to preserve it. This counsel was thought very reasonable, since the greater the wind was, and the less the steerman's dexterity, the more necessary it appeared, that we should be orderly and quiet, and by leaning our bodies sometimes one way, and sometimes another, as occasion required, do what in us lay to keep the vessel upright: and herein we were so prosperous, that soon after the cloud was passed, and the shower it brought with it was over, the wind grew moderate enough to allow us to make some calm re-

lections on what had happened. This *Lindamor*, from the thanks that were given him for his advice, took occasion to do in these terms: Since statesmen and philosophers are wont to compare a commonwealth to a ship, I hope the reflection suggested to us by what had just now happened, will be the easier pardoned. The skill of ruling nations is an art no less difficult than noble; for whereas statuaries, masons, carpenters, and other artificers work upon inanimate materials, a ruler must manage free agents, who may have each of them interests or designs of their own, distinct from those of the prince, and many times repugnant to them: and the prizes, that are contended for in government, either are, or (which is in our case all one) are thought, so valuable, and the concurrents are so concerned, and consequently so industrious to drive on each his own design, that without mentioning any of those many other things, which make good government difficult, these alone may suffice to make it more our trouble than our wonder, that the rulers of states and commonwealths should oftentimes mis-govern them. But the publick infelicities of declining states are not always wholly due to the imprudence of the ruler, but oftentimes those, that most resent such imprudency, even by those very resentments increase the publick disorders they appear so much troubled at; and it may be a question, whether it be more prejudicial to commonwealths, to have rulers, that are mean statesmen, than to have a multitude of subjects, that think themselves to be wise ones, and are forward to censure what is done by their magistrates, either because it is done by their superiours, or because it is not done by themselves.

YET it may well be doubted, (says *Eugenius*) whether the reverence and submission we owe to senates, or princes extend to our very reasons, and our inward thoughts: for the right, and the skill to govern, are two very distinct things; nor does the one confer the other. A crown, how precious soever, adorns but the outside of the head, without enriching the inside; and its splendour will scarce dazzle a wise beholder's eyes, though it but too often does theirs that wear it. No, the tribunal of reason has a jurisdiction, that reaches to thrones themselves; and what you well observed just now, concerning the difficulty of avoiding faults in government, will, I presume, make you think it excusable, if I confess, that I think sovereigns do now and then do, what you confess it is so hard for them to avoid doing; nor is it more a breach of loyalty, not to think a weak governour a prudent one, than not to think him tall, or straight, or sharp-sighted, if nature have made him low, or crooked, or purblind. A senate or a monarch may indeed command my life and fortune; but as for my opinions, whether of persons, or things, I cannot in most cases command them my self, but must suffer them to be such, as the nature of the things I judge of requires; and therefore, the thinking all things done with wisdom, that are done by men in power, is too great an impossibility to be a duty;

duty; and besides, it would lessen the merit of obedience, which otherwise would not appear to be paid to the authority of the magistrate, since we readily obey the injunctions of lawyers and physicians, as long as we think them prudently framed for our good, though we acknowledge not these persons to have any right to command us.

BUT though (continues *Eugenius*) I take reason to be so supreme a thing, that as even the greatest prince's actions should be regulated by it, so they may be judged by it; yet I allow lawful authority a jurisdiction over my actions, that I deny it over my opinions: and though I can obey the orders, that have the impresses of wisdom, as well as the stamp of authority, with more hope and alacrity, yet I can obey those, wherein I think power is unguided by prudence, with no less punctualness and fidelity. I would not resist a magistrate, when I cannot esteem him; and though I dare discern folly even in the greatest princes, yet I can reverence authority in the weakest.

I KNOW *Eugenius* too well (says *Lindamor*) not to believe him. But though I confess, that to do what you say, is to do much, and to do that, which I fear is not usually done; yet methinks it were well if we did somewhat more. For whereas most human actions, especially about matters political, are attended with great variety of circumstances, according to some or other of which, they may be differinglly considered, and estimated; as it is not very difficult to make many, if not most actions appear politick or unwise, according as they are cloathed with those of their circumstances, that may be applied to excuse them, or with those, that are fit to discommend them; so I would take a care to put the favourablest constructions on those publick counsels, that are capable of more constructions than one, and use the parents of my country, as *Noah's* two dutiful children did their distempered father, whose nakedness when they had once discovered, they covered too; and that in such away, as shewed they were unwilling to see more of it, than was necessary to enable them to hide it. And I say this, (continues *Lindamor*) with relation to *Eugenius*, and such as he; for as to the vulgar, who yet make up the far greatest and loudest part of those, that would intrude themselves into state-affairs, upon the pretence of their being ill managed by their superiours; I cannot but think, that whatever the course of affairs be, these cannot but be incompetent judges of their being politick, or the contrary. For to judge of things barely by success, were somewhat to forget, that there is a supreme and absolute disposer of events, and has been a practice always rejected by the wise, as both discouraging wisdom, and affronting it. And as for the counsels, by which indeed the prudence or imprudence of publick actions is to be estimated, the vulgar is rarely admitted to have such a prospect into the true state of affairs, as is requisite to enable them to judge of the expedience or unadvisedness of them, being unacquainted with the frame and motives of the prince's counsels and designs. Ordinary men

may often think that imprudent, whilst they consider it only in it self, which its congruity to the rest of the prince's designs may make politick enough; and a private whisper, or the intimation from an unsuspected spy, or an intercepted letter, or divers other things unperceived, and perhaps undreamt of, by those, that are not of the state-cabal, may make it wise to do several things, which to those, that look only at the actions, without knowing the motives, may appear unpolitick, and would indeed be so, were it not for these reasons, which yet ought to be as little divulged as disobeyed. So that the people's forwardness to quarrel with the transactions of their prince, is usually compounded of pride and ignorance, and is most incident to those, that do not sufficiently understand either state-affairs or themselves; and whilst they judge upon incompetent information, even when their superiours are in the fault, they may be so, for censuring them.

I must not now dispute, (says *Eusebius*) whether such as you, gentlemen, whom their conditions, parts and opportunities qualify to discern the interests and designs of princes, may not be allowed to judge of their counsels, and see their errors; as our late astronomers, being assisted with good glasses, are allowed to tell us, that they discern spots even in the sun it self. But, certainly, the ambition of pragmatical inferiours to make themselves statesmen, upon pretence, that those, who sit at the helm, do not govern it as wisely as these would do, if they were in the same places, is a fault no less prejudicial to any state, than epidemical in some of them. For whilst the government is thus decried, the same disadvantageous representations embolden strangers and foreigners to attempt the subversion of a state, and make the despondent subjects despair of preserving it; little considering, that there are scarce ever any imprudences in a government, that can prove any thing near so prejudicial to the generality of the subjects, as would the subversion of it, whether by foreign conquest, or by intestine jars; such changes seldom doing less than entail upon unhappy countries the fears and mischiefs of war. And that though it be granted, that the right of governing does not confer the skill, yet it is much better to stick to the former, than oppose or desert it, because it wants the latter: for a right to a crown, is that, which for the most part manifestly belongs but to one, and is seldom plausibly pretended to by above two or three; whereas the skill to govern is so undetermined, and so uncertain a thing, that men's innate pride and self-love would incline almost every man to claim it for himself, especially, since by challenging that, he might put for no less than sovereignty. And in a state thus abandoned to the craftiest or the strongest, there would never want disturbing vicissitude of governments, as well as governours, since whoever could get interest enough in the soldiery, or the multitude, would quickly devise and impose such a frame of government, as may put the management of affairs into his and his party's hands, and give them the authority, that have the

the power. But (resumes *Eusebius*) I must remember, that not politicks, but divinity is my profession, and therefore without enlarging upon the confusion that is inevitable in a state, where the right of governing being not heeded, or at least not ascertained, every man would pretend to counsel or command, and none would think himself bound to obey; I shall only mind you, that magistracy having been instituted by God for the good of mankind, we may in obeying our lawful magistrates, though perhaps less wise than we could wish them, not only participate the advantages naturally accruing from obedience to superiors, but divers peculiar blessings, that God oftentimes vouchsafes to our obedience to his vicegerents, and his institutions. Let subjects therefore (says *Eusebius*) wish for wise princes, but submit to those, the providence of God, and the laws of their country, may have given them: let us, if by any just way we be called to it, assist a prince with the wisest counsels we can; if not, let us assist him to make the best of the unwise counsels he has taken, without adding our factiousness or our passions to his misgovernment; remembering, that, at least in my opinion, to the happiness of a commonwealth it is not only requisite, that the prince know how to command well, but that the subjects obey well; and that even weak counsels, faithfully assisted, and as much as may be rectified or repaired by those, that are to execute them, may less prejudice the publick, than the forward and jarring endeavours of men, that perhaps would be wiser rulers, if they had a right to be so. It may be (continues *Eusebius*) that affection and diligence in the publick service may, in spite of the government's miscarriages, prevent, or at least retard and lessen, the ruin of the state. But however, (concludes he) it will be no small satisfaction to an honest man, and a loyal subject, not to be conscious to himself of having contributed to the publick calamities, either by his own provocations, or his factious indignation at the prince's faults. If a man have done his utmost to hinder the ruin he comes to be involved in, the publick calamity will be far lighter to him, being not clogged by private guilt; and he will support the misfortune of it with far the less trouble, if he be to support nothing else. Nay, since the service we do to whatever prince is rightfully set over us, upon the score of his being God's vicegerent, is ultimately directed to that supreme, and, as the scripture calls him, only potentate, whose magnificence is as inexhausted as his treasure; we may safely expect, that whatever prejudice we here sustain upon the account of the prince's commands, will hereafter be advantageously considered to us in the reward of our obedience.

DISCOURSE XII.

Upon clouds rising out of the sea, and falling down in rain not brackish.

THIS discourse had already lasted so long, that as well my unwillingness, that one theme should detain us any longer, as my de-

fire to keep *Eugenius* from making any reply, which on such an occasion might, perchance, have begot some dispute, made me forward to divert the discourse, by inviting the company to take notice of a black cloud, that was coming towards us; which soon after, in its passage under the sun, interposed betwixt our sight and that gloriouslest object of it. *Lindamor* then having a while attentively enough considered it, took thence an occasion to say, This cloud, gentlemen, whensoever it shall fall down in rain, will sufficiently shew, that it was before but water, which whilst it lay mingled with the rest of the river, or sea, whence it is exhaled, may be supposed as clear and limpid as any of the rest; but now that the sun has by its powerful beams elevated this water in the form of vapours, and drawn it near it self, we see, it composes a cloud, which does no longer receive or transmit the light, but robs the earth of it, and eclipses the sun that raised it; and sometimes too produces dismal storms of rain, and wind, and hail. Thus (pursues *Lindamor*) there are many, who while they continued in a low and private fortune, were as blameless as others; and yet, when by a peculiar vouchsafement of providence, they are raised from that humble state to a conspicuous height, they seem to have as much changed their nature as their fortune; they grow as much worse than meaner men, as their condition is better than that of such; and the principal things, by which they make their exaltation be taken notice of, are, the prejudice they do to their inferiours, and the ingratitude they excuse towards that monarch of the world, that raised them above others. Of so perverting a nature is so high a station, that the gaining of an earthly crown is very far from being a furtherance to the acquiring of an heavenly one; and many, whom a humble condition of life kept as innocent as lowly, are, by the highest advancement in point of fortune, impaired in point of morality; and these supreme dignities, which the ambitious world so fondly courts and envies, do so often manifest those, that have attained them, to be unworthy of them.

I KNOW not whether *Eugenius* imagined, that *Lindamor* did in this discourse make some little reflection upon what we had lately said on the behalf of princes: but I afterwards suspected, that it was partly to reply to this observation, as well as entertain the company with a new one, that he subjoined; as this cloud has furnished *Lindamor* with one reflection, so that, which lately brought us the shower of rain, whose marks are yet upon our hats, may supply us with another, which may shew, that themes of this nature are applicable to very differing purposes, according as one or the other of their circumstances happens to be considered and employed: for as far (pursues he) as we can judge by the neighbourhood of the sea, and by that cloud's being driven hither by a wind blowing thence, it consisted of the sea-water raised in the form of vapours. But though the water of the ocean is salt and brackish, unpleasant and unwholesome, whilst it lies there unelevated; yet

yet that water, which has the advantage of being raised to the second region of the air, appears, when it is turned into rain, to have left all its brackishness behind it, and proves both wholesome for men's bodies, and fertilizing to their fields.

THUS (continues *Eugenius*) we sometimes see, that men, who in a private condition were subject to divers vices, divest them, when they are advanced to the honour of putting on royal robes; as silk-worms leave their husks behind them, when by acquiring wings they turn into (a nobler sort of creatures) flying animals. As most men change, so some improve their minds with their condition, and seem to have misbehaved themselves in a lower station; but because they were born to a higher, and were, whilst beneath it, detained out of their proper sphere. And indeed, as a throne exposes those, that sit on it to peculiar temptations to vice, so does it afford them peculiar engagements to virtue; as so elevated a station is apt to make men giddy, so is it proper to make them circumspect, by letting them see, that all the world sees them: the sublimity of such a condition would make any soul, that is not very mean, despise many mean things, that too often prevail upon inferior persons. If princes have any sense of shame and honour, it will be a great curb to them, to consider, that, as there are too many eyes upon them to let their vices be secret, so their faults can as little escape censure as discovery; and men will be the more severe to their reputations, because it is the only thing, wherein subjects can punish their sovereigns. If they have any thing of generosity in their natures, their very condition, by placing them above other objects, will make them aspire to glory; and that is a mistress, that even monarchs cannot successfully court, but with great and good actions. And if they have withal a sense of piety, they cannot but in gratitude to him, whose vicegerents they are, endeavour to promote his interests, that made them so; and so make themselves as like him as they can, in his other attributes of clemency, justice, and bounty, as he has vouchsafed to make them in his power and authority. And besides, that the actual possession of an earthly crown leaves them nothing worth aspiring to, but a heavenly one; the consideration of the great advantages they have above other men of doing good, and the exemplariness and influence as well of their vices as of their virtues, will make them tremble at the thoughts of the account they must one day render of so many thousands, perhaps of so many millions (of subjects) committed to their charge; if, as they are sure it will be a great one, they shall not make it a good one. Nor (pursues *Eugenius*) is history altogether unfurnished with examples of those, whom a throne has as well improved as dignified. *Saul* was not the only person, who, when he was created king, had another spirit, and became another man. That *Titus*, who was the head of it, was justly styled the darling of mankind, though his virtue and nobleness did, more than

his crown, keep the greatest part of posterity from taking notice of any thing in him, but an obligingness proportionate to his greatness; yet I find in some ancient writers, to whom truth was more dear than even this favourite of mankind, that before he came to that supreme pitch of human dignity, his course of life did not promise the Roman world the happiness it derived from his government; his life, before he came to be Emperor, having not been so free from blemishes of lust and blood: but that I may, in writing his character, invert what the Roman historian said of one of his predecessors, and say, that *Titus* had been thought *indignus imperio, nisi imperasset*. And, without going as far as *Rome*, our own history affords us a *Henry* the fifth, who, before he came to the kingdom, was scarce thought worthy to live in it, and did so degrade himself to the practices of the meanest malefactors, that a judge, that was then his father's subject, was fain to use him at that rate; and yet this prince, as soon as he had seated himself in the throne, did as suddenly, as if the place itself had some secret virtue to improve those it admitted, behave himself as a person worthy of it; and not only conquered *France*, but, which was a nobler, as well as a more difficult victory, his own resentments too, by preferring that judge, when king, that had imprisoned him, when prince; and evincing by so memorable an action, that he preferred virtue above himself, and renouncing the pleasure of revenge, he scrupled not to promote one, whom he could not commend without condemning himself; were it not, that in this prince, according to what I was saying, the king was become another man than the subject. And perhaps, (concludes *Eugenius*, a little smiling) I could proceed to give you other examples enough to keep it from being improbable; that one main reason, why there are but few good princes, is, because there are but few princes; were it not, that I see the waterman prepare to land us. And in effect, we are now come so near the place, where the fisherman designed to set us ashore, that whether or no *Lindamor* had a mind to return any thing to what *Eugenius* had said, it would then have appeared unseasonable, either to resume the debate, or prosecute the discourse.

DISCOURSE XIII.

Upon drawing the boat to the shore.

WHEN we were now come to the place, where we were to be landed, lest the boat should be carried away by the stream before we could step ashore, the owner of it reached out his long pole, and by means of the crook, taking fast hold of the bank, he drew the pole towards him with all his might, and thereby brought the boat to shore. This endeavour of the water-man's, and the effect of it, inviting *Eusebius* to smile a little, gave me the curiosity, as soon as we were landed, to inquire, why he did so. It is almost as ordinary, (answers *Eusebius*) for men to think themselves

1 Sam. x.
6, 9.

themselves wiser than God, as it is impossible for them really to be so. Those, that study nothing but to obtain their ends, and that scruple at nothing they judge conducive to them, do oftentimes lay their designs and plots with so much artifice and subtilty, that they do not doubt, that, whatever may become of God's designs, and of his promises, and threats, those, which themselves have laid so politickly, cannot but succeed. And even pious and well-meaning persons, that have the opportunity to discern the politick ways, that these men take to compass their ends, are oftentimes tempted to needless fears, that divine providence will be puzzled and distressed by them; and to think, that, for reasons secret, though just, providence may be put by these men's craft to play an after-game in the world to come. But in such cases, it often fares with these grand designers, as it did just now with our water-man: he had fastened his grappling-iron to the shore, and putting to his utmost strength, did so forcibly endeavor to draw it towards him, that one, that did not know that the shore was fixt, might expect this lusty fellow's endeavours capable to put into motion whatever he so forcibly drew towards him: but the shore being fixt, and immovable, instead of making that come to him, his very strainings drew him and his boat to that. Thus the contrivers of the proud pile of *Babel*, whereby they meant (not as most imagine, to secure themselves against a second flood; the text being silent as to that aim, and a plain being a very improper place for such a purpose, but) to make themselves a name, and prevent dispersion; these ambitious contrivers, who had laid their plot so hopefully, that they had engaged no less than mankind, and who probably had designs as raised as their intended fabrick, since those expressions of him, that knew their hearts, (*And this they begin to do, and now nothing will be restrained from them, which they have imagined to do*) seemed, methinks, to warrant my conjecturing, that those had designs very aspiring, that intended but to make a rise to their soaring flight of a tower, whose top should reach unto heaven. But the policy of these ambitious builders being contrary to the charitable decree of God, to have the earth peopled, he made use of that very conspiracy, that brought them together, to effect that, which they conspired to prevent; so that now the remotest parts of the inhabited world are but the colonies of *Babel*, whose scattered architects have indeed made themselves a name, but upon a quite contrary account than they intended or expected. Thus the purblind envy of *Joseph's* brethren, having made them resolve to prevent his future dreams of superiority over them, made them think, that, by selling him for a slave, they had taken sufficient order he should never come to be their master. And yet we see, that *Joseph's* being sold into *Egypt* was made use of by the wise orderer of human affairs, to make him in effect Lord of that rich and populous kingdom, and thereby, of his envious brethren, *Pharaoh's* dreams having advantage-

Gen. xi.
6.

ously made him amends for the hardships his own had exposed him to. So the proud favourite of *Abasuerus*, questionless, thought he could scarce miss his ends, when, by the counsel of his friends, and, as he fondly thought, of his gods too, he provided for *Mordecai* that fatal gibbet, which probably he might have escaped, if he had not erected it. Thus the high priest, and the sanhedrim of the Jews, seemed to act with much policy, though no justice, when they resolved upon the death of our Saviour; lest, as the Gospel tells us, the Romans should come and destroy their temple, and nation; which, whether indeed it did not rather procure, than divert the coming of the Romans, the church-history can inform you. Nay, the old serpent himself, that arch-politician, that was the instructor of those others I have been naming, even in his chiefest master-piece, found himself the most over-matched by him, to whom the Scripture ascribes the taking of the wife in their own craftiness. For, questionless, he highly applauded his own subtilty, and seemed to have taken the directest, and most prosperous way to his impious ends, that could be devised; when, having made *Herod* and *Pilate* friends, upon such terms, that the Lamb of God should be the victim of their new confederacy, he had engaged both Jews and Gentiles in a ruinous and tragick conspiracy, to kill the prince of life, and, by that unparalleled crime, at once destroy the devil's chief enemy, and make God their's. And yet the event has sufficiently manifested, that the Apostle might well affirm, that Christ, by his death, destroyed him, that had the empire of death, the devil; and that Satan's kingdom never received so deadly a wound, as that which pierced our crucified Saviour's side. Wherefore, in short, (concludes *Eusebius*) the decrees of providence are too solid and fixed, to have violence offered them by human attempts, how specious soever they be; and those, that think to bring God to their bent, will find, at long running, that they have to do with one, whose power and wisdom are so over-ruling, that not only he can frustrate their utmost endeavours, but make those very endeavours frustrate themselves, and employ men's subtlest policies, to accomplish those very things they were designed to defeat.

DISCOURSE XIV.

Upon catching store of fish, at a baited place.

AS soon as we were come to the place the fisherman told us of, we found it as plentifully stored with fish, as he had foretold us; and caught more in some few minutes, than we had taken in a whole hour before: but we did not half so much marvel at this, as we were pleased with it, because the fisherman informed us, that he had liberally baited the place over-night with corn, as well as worms. Whilst this pleasant exercise lasted, *Eusebius*, marking how great a resort of fishes there was in that place, and how fast we drew them up, upon comparing what he saw happen with the occasion of it, thus acquainted

us with the thoughts thereby suggested to him. Those (says he) that yesterday in the evening might see this man (pointing at the fisherman) throw in his baits by handfuls into this place, and then depart, as minding them no more, were probably, if they knew not his design, and the custom of fishers, tempted to think him a wasteful prodigal, or, at best, a venturesome fool, to bury his corn in the river, and throw his baits to be caught up by fishes, that, for aught he knew, would never come back to thank their host. But those, that know (what we now find) how profitable a course this is wont to prove, would, instead of thinking such a practice a piece of folly, look upon it as a piece of providence: for though he be sure not to recover, in kind, the things he cast upon the waters, yet such a loss is wont to prove very gainful unto him, whilst he loses but a grain of corn, or a worm, to obtain fishes of far more value. Thus, though the purblind world may think a liberal alms-giver, or a generous confessor, a fool, or a prodigal, whilst they only consider him as one, that throws away what he has in present possession, and seems not so much as to hope for the recovery of the same goods, or any of the like nature; yet those, whose eyes being illuminated with a heavenly light, are thereby enabled to look into the vast and distant regions of the future, and to descry there the final issues of all temporal things, will be so far from thinking him unwise, for parting with unsatisfying trifles, to procure the highest and most permanent goods, that they will think his proceedings far more justifiable, in point of prudence, than we now think the fisherman's: nor will the parting with a greater fortune, as freely as with a lesser, any more alter the case, than the fisherman's throwing in his bigger worms, and grains of corn, with no more scruple than his lesser. For heaven does as well incomparably out-value the greatest, as the least goods, poor mortals can lay out for it; and he, who has all things to give, and is infinitely more than all himself, has promised, that those that sow plentifully, shall reap so too; and though the least of future acquits would incomparably transcend the greatest price, that can be here given for it, yet the future rewards will, betwixt one another, bear a proportion to the occasions of them. And, as the fisherman is sure to lose what he throws into the water, and is not sure to get by it any thing of greater value than some fishes, the Christian adventurer (if I may so call him) may hope, though not confidently promise himself, in this world, the hundred-fold mentioned by our Saviour, as well as in the world to come life everlasting. And therefore, if we do indeed, in *St. Paul's* language, look, not to the things, which are seen, which are but temporary, but to the invisible ones, which are eternal, we shall think that exhortation of his very rational, as well as very pious, where, having discoursed of the future and glorious state of the true Christians, he concludes, *Wherefore, my beloved brethren, be ye steadfast, immoveable, always abounding in*

the work of the Lord; for as much as you know, that your labour is not in vain in the Lord.

DISCOURSE XV.

Upon the magnetical needle of a sun-dial.

WE had not yet dismissed the waterman, when *Eugenius*, chancing to express a curiosity, to know what o' clock it was, when we had freshly begun to angle at our new station; as *Lindamor* and the rest drew their watches to satisfy his question, so the boat-man took out of his pocket a little sun-dial, furnished with an excited needle, to direct how to set it, such dials being used among mariners, not only to shew them the hour of the day, but to inform them from what quarter the wind blows. Upon the sight of this dial, my natural curiosity invited me, after it had told me the hour, to try, whether the magnetick needle were well touched, by drawing a little penknife out of a pair of tweezers I then chanced to have about me, and approaching it to the north point of the needle, which, according to the known custom of such needles, readily followed it, or rested over-against it, which way soever I turned the penknife, or whereabouts soever I held it still. *Eusebius* seeing me give my self this diversion, came up to me to be a sharer in my sight, which no familiarity can keep from being a wonder: but, after a while, he looked upon it in a way, that made me think it presented him somewhat else than the hour of the day, or the corner of the wind; and I was confirmed in that thought, by seeing him apply to it the case of *Lindamor's* watch, and then a diamond-ring, plucked from his own finger, and, in effect, he soon began to tell me; *Methinks, Philaretus*, this needle may afford us a good direction in the choice of companies; and that is a matter of such moment, that some divines perhaps would question, whether or no the direction it gives navigators, to find the poles, be of much greater importance. For not only it has been truly observed, that the choice of one's company does exceedingly discover, whether a man be good or bad, wise or foolish; but I shall venture to add, that it does very much contribute to make him what others say it declares him: for an assiduous converse does insensibly dispose, and fashion our minds and manners, to a resemblance with those we delight to converse with; and there are few, that have so much resolution, as to disobey customs, and fashions, especially when embraced by persons, that we love, and would be esteemed by, and from whose opinions, and practices, we can scarce dissent constantly, without impressing a dislike, that threatens to make them dislike us. For my part, (says *Lindamor*) I have always thought, there is great difference betwixt keeping company with some men, and chusing to do so; for, whilst we live in this world, we must often have to do with the lovers of the world: but though to be cast, by the exigencies of our callings, upon bad company, be an infelicity without being a fault, yet certainly, to chuse such company,

and prefer it before that of wise and good men, is, in a high degree, both the one and the other. And I confess, (continues he) I cannot think, that the proper use of conversation is but to pass away our time, not to improve it.

YOU are certainly much in the right (subjoins *Eusebius*;) for though too many of those, that are now cried up for good company, do either so dissuade us from good and serious things, or so divert us from them, that it is oftentimes counted a piece of indiscretion, to say any thing, that may either enrich men's understandings, or awaken their consciences; yet I cannot but think, that conversation may be, as well as ought to be, rescued from being an instrument to promote idleness and vice; and, if men were not wanting to themselves, I doubt not, it may be so ordered, that conversation, which so often robs men of their time, and so frequently of their devotion, might be made a great instrument of piety, and knowledge, and become no less useful, than it is wont to be pleasant.

To make companies (replies *Lindamor*) such as you think they may be, they must grow very different from what most commonly they are: for, not to speak of those loose and profane ones, where virtue and seriousness are openly derided; and any thing, how contrary soever to piety, or right reason, may be used, not only with toleration, but applause, if men can bring it out, I say not in jest, (for they are seldom more in earnest) but neatly wrapt up in raillery; even in those civiler sorts of company, where vice is not professedly maintained, you shall seldom, during a long stay, hear any thing, that is really worth carrying away with you, or remembering when you are gone. And, to discourse of any thing, that is grave enough, either to exercise men's intellects, or excite their devotion, is counted a piece of indiscretion, that is wont to be more carefully avoided, than almost any thing that is really such; so that, even in such companies, the innocentest use, that we are wont to make of our time, is to lose it. And really (continues *Lindamor*) when I consider, how ensnaring the worse sort of companies are, and how little even those, that do not openly defy piety and knowledge, are wont to cherish either of them; I begin to be reconciled to hermites, who fly from such conversations, as are so apt to make men either vicious, or at least idle, into those solitudes, where they are not like to be tempted, either to renounce their devotion, or to suppress it, to entertain idle thoughts, or stifle good ones. Nor could I, without much scruple, as well as impatience, allow my self to spend some part of my time in such kind of entertainments, as many spend most of their's in, were it not, that looking upon civility as a virtue, and hospitality, as in some cases a duty, and upon both of them as things of good report, I can think those hours, they make me spend, may be justly cast upon their account, and that the ceremonious and insignificant conversations, whereto they oblige me, may be undergone upon some such account, as that, on which serious parents converse, and often-times play with their children.

For as, though the things they do, are in themselves trivial, and useless, yet they may be justifiable effects of a paternal care to still a child; or keep him from harming himself; so the duty of exercising of civility makes me look upon as justifiable, though unpleasent, those expressions of it, which, in themselves considered, I could not reflect on without indignation, and could not but think very much below any man, whom education has fitted for the exercise of reason, or whom religion has elevated to the hopes of heaven.

BUT it may (says *Eusebius*) on the other side be represented, that since it is scarce possible not to meet sometimes with companies, that are not of the best sort, we should look upon those necessities, as calls of providence, to improve those opportunities for the advantage of them we are engaged to converse with: for nature, as well as Christianity, teaches us, that we are not born only for ourselves, and therefore, as we ought often to converse with the best men, to acquire virtue and knowledge; so we must sometimes converse with others, that we may impart them, and learn how much we are beholden to God's goodness, that has so much discriminated us from other men. And though we do not find, that our conversation does immediately and visibly reform those we converse with, yet it will not presently follow, that it is altogether ineffectual on them: for, besides that the seeds of virtue and knowledge, as well as those of plants, may long seem to lie dead; even in these soils, wherein they will afterwards flourish and fructify, there may be at present a good, though not a conspicuous, effect of your discourse and example. For when men are hastening to hell, he does them no small service, that does so much as retard their course; as cordials, and other medicines, may do good even to decrepid old men, whom they cannot perfectly cure.

AND trust me, *Lindamor*, it is no such useless performance as you may think it, for a man of known piety and parts, by conversing with the children of this generation, to dare to own religion among those that dare to deride it; to keep alive and excite a witness for God and good things in their consciences; to let them see, and make them (at least inwardly) acknowledge, the beauty of a pious, industrious, and well-ordered course of life; to convince them, that it is not for want of knowing the vanities they doat on, that he despises them; to shew, that a man that denies himself their sinful jollities, can live contented without them: and, (to dispatch) to manifest, by a real and visible demonstration, that a virtuous and discreet life is no unpracticable, no more than melancholy thing, even in bad times, and among bad men. And, says *Eusebius*, to me it seems very considerable, that our Saviour himself, the great author of our faith, and exemplar of our piety, did not chuse an anchorite's, or a monastick life, but a sociable and affable way of conversing with mortals, not refusing invitations, even from publicans, or to weddings, and by such winning condescensions gained the hearts, and thereby a power to reform

form the lives, of multitudes of those he vouchsafed to converse with.

OTHER considerations (pursues *Eusebius*) might be represented to the same purpose with these: but since I promised you something of direction, I suppose you will expect I should tell you not what I *could* say, but what I *do* think. I will tell you then in few words, that though I think it as well possible as fit for men of radical virtue, and fine parts, to make sometimes a good use of bad company, especially when their lawful occasions cast them into it; yet, for others to be often engaged in such company, though it may be but an infelicity, is a very great one; and to chuse such company, is, what is worse than an unhappiness, a fault. But generally speaking, I would distinguish three sorts of companies: for there are some, that not only are unable to improve me, but are unwilling to be improved themselves. A second sort there is, that are as well ready to learn, as able to instruct: and there are others, that, though they are not proficient enough to teach me things worth my learning, are yet desirous to be taught by me the little, that I know, and they ignore. Now, as the magnetick needle we were looking on, and which affords us the theme of this discourse, if you should apply a load-stone to it, would be most powerfully attracted by that, because it can receive fresh virtue from it; and even, if you approach a piece of steel to it, the needle will, though not so studiously, apply itself to it, from which, though it receives no magnetick virtue, it can impart some to it; but if you offer it the silver case of your watch, or the gold, that makes up your ring, or the diamonds, that are set in it, none of all these, how rich or glittering soever, will at all move the needle, which suffers them to stand by it unregarded: so I shall, with the most of cheerfulness, and application, seek the company of those, that are qualified to impart to me the virtue or the knowledge they abound with. Nor shall I refuse to entertain a society with those few, that being such small proficient as to need to learn of me, are also forward to do so. But those, that can neither teach me any thing, that is good, nor are disposed to let me teach them, how great a shew soever they make among those, that make choice of their companions by their eyes; I may be cast upon their conversation, but shall very hardly chuse it.

DISCOURSE XVI.

Upon the quenching of quick-silver.

I HAD almost forgot to relate, that not far from the place, where we went on shore, and which we had not yet quitted, we saw divers heaps of quick-lime, some smoking, and some, that had not yet been drenched in water; and upon inquiry of those, that looked to it, we were soon informed, that the conveniency of the neighbouring river, both for slacking of lime, and conveying mortar, had made the owners bring their lime thither, to be tempered and made fit for the reparation of some houses, that we saw a little way off:

but while we were talking, one of the workmen began to throw water upon one of the heaps, that had not yet been slacked, and afterwards poured on so much more as served quite to drown the lime; and *Eusebius* marking, both what he did, and what ensued upon it, took thence occasion to say to us; he, that should see only the effect of the first effusion of cold water upon quick-lime, would think, that by a kind of antiperistasis, the internal heat of the lime is rather increased than suffocated by the coldness and moisture of the water: for that, which before was not taken notice of, to manifest any sensible warmth, as soon as its enemy, the water, begins to invade it, acquires a new heat and new forces in the conflict, and not only shews a great impatience, or enmity, to that cold liquor, by acting furiously upon it, and throwing off many parts into the air, but prevails so far as to heat that cold element itself, to that degree, as to make it smoke and boil. But this conflict is seldom near so lasting as it is eager; for if you have but the patience to stay a while, you shall see the lime, after it has spent its occasional ardour, and after its fire is quenched, lay quietly with, nay under, the water, as cold and as moveless as it. Thus, when a devout man, (especially if his fervour be adventitious from education; or custom, as the fire in the lime from the calcination) first falls into the company of persons, either profane, or otherwise grossly vicious, we often see, that his zeal, instead of being smothered by such a rude and unaccustomed opposition, seems rather to be excited and kindled thereby, and possibly seems more likely to impart the warmth of his devotion to its enemies, than to lose any of it himself; but when he is constantly, or at least frequently, surrounded with such company, you will too often see him lose as well his own ardour as the endeavours of communicating it; and with those very persons, that did at first kindle and exasperate his zeal, you shall at last see him live very quietly, and perhaps manifest as little of religious warmth as they; and that, which at first did so strangely exasperate and discompose him, becomes after a while so familiar, as not at all to move him.

DISCOURSE XVII.

Upon one's talking to an echo.

WE had possibly dwelt longer upon such reflections, had I not been suddenly diverted by the repeated clamours of a voice, which each of us imagined he had very often heard: whereupon, as it were by common consent, we began to look round about us, to see if any of our little company were missing; and finding that *Eugenius* was so, we readily concluded the voice we heard, though somewhat altered by distance, and other circumstances, to be his; and accordingly we hastened towards the place, whence we judged the voice to proceed, that in case he were in any distress, or had met with any disaster, we might rescue or relieve him: but when we came near, we could now and then distinctly hear him speak
some

some words so loud, and yet so incoherent and unable to complete a sense, as if he meant, that all thereabouts should hear him, and no body understand him. This made us double our curiosity, and our pace, till at length we descried him all alone in a solitary corner, wherein yet his loudness kept us from believing he sought privacy: but as soon as he discovered us, he seemed both surprized and troubled at it. Coming to meet us, he first begged our pardon, if having been louder than he thought, he had put us to a trouble he did not intend; and then laughing, asked us, if we did not think him mad: but *Eusebius* smiling told him, that before we could answer that question, we must ask one of him, which was, what he had been doing? Whilst you, (answers *Eugenius*) were (I doubt not) better employed, my natural curiosity seduced me to spend some time in ranging about the places near the river-side; and as I was passing by this field, the accidental lowing of an ox made me take notice, that this neighbouring hill and wood furnish this place with an excellent echo, which I at first tried only by whooping and hollowing; but afterwards diverted my self by framing my questions so, as to make that babling nymph (for so you know the poets will have echo to be) to discourse with me.

FOR my part, (says *Lindamor*) I should by no means like her conversation, because that two qualities she has, which to me would very much discommend it: and to prevent our asking him what those qualities were, one of them, (says he) is, that she vouchsafes to discourse indiscriminably with all comers that talk to her, provided that they make noise enough.

You are much in the right, (says *Eugenius*) for that easiness of admitting all kind of company, provided men have boldness enough to intrude into ours, is one of the uneasiest hardships, (not to say martyrdoms) to which custom has exposed us, and does really do more mischief, than most men take notice off; since it does not only keep impertinent fools in countenance, but encourages them to be very troublesome to wise men. The world is pestered with a certain sort of praters, who make up in loudness what their discourses want in sense; and because men are so easy-natured, as to allow the hearing to their impertinencies, they presently presume, that the things they speak are none; and most men are so little able to discern in discourse betwixt confidence and wit, that like our echo, to any that will but talk loud enough they will be sure to afford answers. And, (which is worse) this readiness to hazard our patience, and certainly lose our time, and thereby incourage others to multiply idle words, of which the Scripture seems to speak threateningly, is made by custom an expression, if not a duty, of civility; and so even a virtue is made necessary to a fault.

FOR my part, (subjoins *Eugenius*) though I think these talkative people worse publick grievances than many of those, for whose prevention, or redress, parliaments are wont to be assembled, and laws to be enacted; and though I think their robbing us of our time as much a

worse mischief than those petty thefts, for which judges condemn men, as a little money is a less valuable good, than that precious time, which no sum of it can either purchase or redeem; yet I confess, I think, that those of our great lords and ladies, that can admit this sort of company, deserve it: for if such persons have but minds in any measure suited to their qualities, they may safely, by their discountenance, banish such pitiful creatures, and secure their quiet, not only without injuring the reputation of their civility, but by advancing that of their judgment. And I fear, (continues *Eugenius*) that those, who decline this employment (and indeed improvement) of their titles, or other kinds of eminency, do, by their remissness, more harm than they imagine; for though the judgment and company of such persons be not always the best grounded, or the best chosen, yet their quality or station in the world makes it usually the most conspicuous, and the most considered. And I doubt not, there is no such multitude of disinterested lovers of good things, but that there will be the fewer found studious to express wit and virtue in conversation, when they see, that in the estimate of those, that are looked upon as the chief judges of what is or is not good company, the most empty and impertinent prattle with confidence, or loudness, procures a man at least as good a reception, as the best and most rational discourse without it. And, which is yet worse, that tyrannous thing, which we mis-name civility, has so degraded reason, as well as displaced piety, in conversation, that if there be never so many persons together, entertaining themselves with rational or instructive discourse, in case there come in but one impertinent creature, that is below it, all these shall sink themselves to his level, and as much debase their discourse, as if they believed it fitter, that all the rational conversers should forego the exercise and the benefit of their wit and virtue, than that a fool should not appear to talk as wisely as any of them. And thus they seem ashamed of their attainments, instead of making him ashamed of his ignorance, and reducing him to improve himself into a capacity of being fit for their company; whereas, from a contrary practice, they might derive the great advantage, either of freeing themselves from uninvited companions, or of making them worth the having.

BUT, (subjoins *Lindamor*) I remember I told you there was a second quality, that I disliked in the nymph I found you entertaining, and that is, that, when I will, I can make her speak to me, just what I please. I know (replies *Eugenius*) that a moderate degree of complaisance is not only in many cases allowed us by discretion, but necessary to keep up the pleasantness, not to say the very peace, of human societies; for if all men, at all times, speak their minds freely; and did not soften one another by concealing their mutual dislikes, and dissents, and by certain outward expressions of kindness, or respect, made by compliments and gestures, men have so many imperfections, and so much self-love withal, that scarce any

two of them would endure one another; nay, and in spite of that indulgence, which provident nature has implanted in all animals, for the preservation of their species, in that of the individuals that compose it, and as much as our own faultiness has added to that fondness; yet, I doubt, we shall scarce find one man of a thousand, that would endure so much as himself, if we did not for the most part exercise complaisance within our own breasts, and did not as much flatter our selves, and disguise our selves, to our selves, as we flatteringly disguise our selves to others.

BUT, (continues *Eugenius*) when all this is said, I may endure, but I shall scarce chuse and prize a companion, that, like an echo, uses no liberty of his own, but allows me to direct whatever I would have to be answered me: and I know not whether I could not better like one, that would ever dissent from me, than one that would never do so. I cannot look upon him either as my friend, or as a person worthy to be made so, who never evinces his being more concerned to advantage me, than to please me, by making use of the liberty of a friend, and thereby shewing, that he considers not barely himself, but me: besides, that as there is no true friendship, where there is not an union of affections, so methinks there can be no good company, where there is not sometimes a dissent in opinions.

EUSEBIUS, that was a friend to seriousness, without being an enemy to pleasantness, gathering from the long pause made by his friends, that they designed not the prosecuting of this discourse any further; Methinks, gentlemen, (says he, smiling) you are very severe to a harmless nymph, who is so modest, and reserved, that she will never put you upon beginning a conference with her, and so complaisant in it, that it is your own fault, if ever she says any thing to you, that displeases you: and for my part, (continues he) I have that opinion of human things, that as I think there are very few so perfect, but that we may find something in them fit to be shunned, so there are not many so imperfect, but that they may suggest to us somewhat or other, that may not be unworthy of our imitation; and as *Linda-mor* has taken notice of two qualities in our echo, which discommended it to him, so I have observed as many, that I rather approve than dislike.

FOR, in the first place, it is evident, that our nymph (however *Eugenius* has been pleased to mis-call her a babler) is much less talkative than most of her own sex, or indeed of ours; for she never begins to talk with any body, not speaking unless she be spoken to. He that considers how much of the discourse, that wastes men's time, and entertains the most companies with the most applause, consists of talk, that tends either to flatter those that are present, or detract from the absent, or to censure our superiours, or our betters, or to express our own profaneness, or to excite the pride or carnality of others; and he that shall consider, that though by these and many other ways we are extremely apt to offend in words, yet we must

give an account for that kind of words, what sort soever be meant by them, which our translators render idle ones; and that the judge himself tells men, that they shall by their words, as well as by their actions, be justified, or condemned; will easily believe, that if silence were as much in fashion, as it is charitable to mankind to wish it, the regions of hell would be far thinnier peopled than now they are like to be.

I COULD tell you, that silence discovers wisdom, and conceals ignorance; and it is a property, that is so much belonging to wise men, that even a fool, when he holdeth his peace, may pass for one of that sort; and I could easily add I know not how much in the commendation of this excellent quality, if I knew how at the same time to praise silence, and to practise it: so that it may well pass for an excellency in the nymph, whose apology I am making, that she does not speak, but when it is necessary she should, I mean, when she is spoken to, in such a way as does exact her answer.

BUT this is not all the good qualities of our echo; for as she rarely speaks, but when it is expected she should, so she seldom repeats above a small part of what is said to her: this I account a very seasonable piece of discretion, especially in such treacherous and fickle times as ours, where, almost as if he thought himself fit to be an universal statesman, such a one concerns himself very needlessly for almost all the publick quarrels in Christendom; and shews himself zealous for a party, which will receive no advantage by his disquiets; and not content like a merchant-venturer, his passion may upon this account make him a sufferer by what happens in the remotest parts of the world. In our own fatal differences, (which it is almost as unsafe to speak freely of, as it is unhappy to be involved in them) he will on needless occasions declare, with his opinion, his want of judgment, and perhaps ruin himself with those, under whose protection he lives, by spreading reports, and maintaining discourses, that rendered him suspected among those, who think, that a man must wish their forces should be beaten, if he can think they may have been so: nay, I have known some, that, though put into considerable employments, could not hold talking of their own party, at a rate of freedom, which those that have so much innocence as not to deserve it, will scarce have so much goodness as to support it. So that methinks, these men deal with their fortunes as children oftentimes do with their cards, when having taken a great deal of pains to build fine castles with them, they themselves afterwards ruin them with their breath.

IT may be a greater, without being a more prejudicial piece of folly, to believe all that one hears, than to report all that one believes; and especially, those are to be censured for want of our nymph's reservedness, by whom it loses that name: for though those kind of men make sure, by their way of talking, to make others take notice, how much they are confided in by their own party, yet sure they would take a discreeter

discreeter discourse, if they did but consider, that the proof they give, that they are trusted with secrets, is, that they are unfit to be so.

DISCOURSE XVIII.

Upon a giddiness occasioned by looking attentively on a rapid stream.

THESE thoughts of *Eusebius* suggested so many to *Lindamor*, and me, that to entertain our selves with them, we walked silently a good way along the river side; but at length, not hearing any more the noise his feet were wont to make in going, turning my self to see what was become of him, I perceived him to be a pretty way behind me upon the river's brink, where he stood in a fixt posture, as if he were very intent upon what he was doing. And it was well for him, that my curiosity prompted me to see what it was that made him so attentive; for, before I could quite come up to him, methought I saw him begin to stagger, and though that sight added wings to my feet, yet I could scarce come time enough to lay hold on him, and, by pulling him down backwards, rescue him from falling into the river. The shriek I gave at the sight of my friend's danger, was, it seems, loud enough to reach *Eusebius's* ears; who, turning his eyes towards the place whence the noise came, and seeing *Lindamor* upon the ground, made hastily towards us, and came up to us by that time I had helped *Lindamor* up, and before I had received from him the obliging acknowledgments he was pleased to make for a piece of service, that I thought had in it more of recompense than merit. *Eusebius* hearing what passed betwixt us, joined his thanks to *Lindamor's*, and at the same time congratulated my friend for his escape, and me for having, to use his expressions, had the honour and satisfaction to be such a person as *Lindamor's* deliverer. But after our expressions of joy for his escape were over, *Eusebius* and I had both a curiosity to learn particularly the occasion of his danger, which he told us in these words: As I was thinking, *Eusebius*, on your last reflection, I was diverted from prosecuting my walk in *Philaretus's* company, by happening to cast my eyes on a part of the river, where the stream runs far more swiftly, than I have all this day taken notice of it to do any where else, which induced me to stop a while, to observe it the more leisurely: and coming nearer, I found the rapidness of the current to be such, notwithstanding the depth of the water, that I stood thinking with my self, how hard it were for one to escape, that should be so unlucky as to fall into it. But whilst I was thus musing, and attentively looking upon the water, to try whether I could discover the bottom, it happened to me, as it often does to those that gaze too steadfastly on swift streams, that my head began to grow giddy, and my legs to stagger towards the river; into which questionless I had fell, if *Philaretus* had not seasonably and obligingly prevented it. Something like this (*says Eusebius*) does not unfrequently happen in the unwary

consideration of some sorts of sinful objects, especially those suggested by atheism and lust: for not only we oftentimes consider atheistical suggestions, and entertain libidinous fancies, without any intention to quit our station, or the secure and solid basis of religion and chastity; but we are often inclinable to think, that we converse with these objects only to discern their formidableness the better, and fortify our resolutions to shun them. And yet such is the pernicious nature of atheism, and of lust, that they turn our brains, and oftentimes, if providence, or Christian prudence, do not seasonably interpose, we may unawares fall into the mischief, even by too attentively surveying its greatness, and may be swallowed up by the danger, even whilst we were considering how great it is. To parley with such fascinating enemies, though with a design to refuse them, and strengthen our aversion to them, is against the laws of our Christian warfare; and though it be not as criminal, may often prove as fatal, as to hold intelligence with the enemy. It is true, that the deformity of both these sins is such, that all their ugliness cannot be taken notice of at first sight; but the discovery is more dangerous than necessary, since a little knowledge of their hideousness is enough to make every honest heart abhor them. And since their less obvious deformities are more dangerous to be pried into, than necessary to be known, let us fear to learn of these deluding sins, more than we need know to hate them; and remember, that even those, that are frightened by seeing faces recently marked with the small pox, may, notwithstanding that fear, catch the disease with that sight.

DISCOURSE XIX.

Upon one's drinking water out of the brims of his hat.

WE were by this time come back to the baited places we had left, when *Eugenius*, to whom his rambling up and down, added to the heat of the day, had given a vehement thirst, spying a place, where the banks were low, and almost level with the surface of the water, left us for a little while to repair thither; and kneeling upon the ground, he took up with his hat, which by cocking the brims he turned into a kind of cup, such a proportion of water, that he quenched his thirst with it; and carelessly throwing the rest upon the ground, quickly returned towards the company, which he found he had not left so silently, but that our eyes had been upon him all the while he was absent: and that sight afforded *Eusebius* an occasion to tell us, our friend *Eugenius* might, if he had pleased, by stooping lower with his head, have drank immediately out of the entire river. But you see he thought it more safe, and more convenient, to drink out of a rude extemporary cup; and that this way sufficed him fully to quench his thirst, we may easily gather, by his pouring away of some remaining water as superfluous: and if he should tell us, that he could not have quenched his thirst with a sufficient

ficient quantity of water, because he drank it not out of the river, but out of his hat; I doubt not, you would think him troubled with a more formidable distemper than thirst, and conclude him in a greater need of physick than of water.

Thus (resumes *Eusebius*) to a sober man, provided he have a competency of estate suited to his needs and conditions, it matters not very much, whether that competency be afforded him by a moderate or by an exuberant fortune, and oftentimes it is more safe and convenient, and no less satisfactory, to receive this competency out of that, which is but a little, than out of that, which is a great deal more than enough; for not only the necessities of nature are few, but her capacities are limited. And therefore, how much soever you have of meat, and drink, and the like accommodations; the body of a man can enjoy but a certain, and that too no very great measure of them, proportioned to the craving of our stunted nature, by more than which it is not the body, but the unruly fancy, that is gratified; as when the stomach is satisfied, a table full of untouched dishes feeds but a man's eye, or his pride; and if he should cram a little part of it into his stomach, it would be but nauseated at first, and afterwards breed ill humours and diseases. And accordingly, it is no less than *Solomon* that says, *when goods increase, they are increased that eat them; and what good is there to the owners thereof, saving the beholding of them with their eyes?* I dare not absolutely (pursues he) condemn those, that think not the necessities of nature the only measures of a competency of fortune; for though he, that wants not them, wants a just cause to quarrel with providence, yet custom has so entailed some ways of expence upon some stations in the world, that since a man can scarce live without them, and yet without disgrace, there are but few who are so great Stoicks, or such mortified Christians, as not to think, that what is more than enough for one, may be less than enough for another, and as to not estimate their having or wanting a competency, not only by the exigencies of nature, but by those of a man's particular quality, or station. But (subjoins *Eusebius*) he, that has, in this liberal sense, a sufficiency of outward goods, is, methinks, but ill advised, as well as unthankful, if he repine at his portion, because it is inferiour to those of the famously rich: For though an unwieldy affluence may afford some empty pleasure to the imagination, (for to the body it scarce affords any at all) yet that small pleasure is far from being able to countervail the embittering cares, that attend an overgrown fortune: for whatever the unexperienced may imagine, the frequent and sad complaints of the rich themselves sufficiently manifest, that it is but an uneasy condition, that makes our cares necessary for things, that are merely superfluous; and that men, whose possessions are so much spread and displayed, are but thereby exposed the fairer and wider marks, that may be hit in many

many places by misfortune. Nor will carelessness secure them, since a provident concern of a man's estate, though it be great, being by the generality of men looked upon as a duty, and a part of prudence, he cannot suffer himself to be wronged or cheated of that, without losing, with his right, his reputation.

For my part, (says *Lindamor*) I do the more wonder to see men so greedy of lading themselves, as the Scripture speaks, with thick clay, that they hoard up their treasures from those uses, which alone make riches worthy the name of goods, and live by a temper quite contrary to that of saint *Paul*, *As having all things, and possessing nothing*. When I consider the things they pretend to by this as mean as unchristian appetite; the two chief of these are wont to be, the keeping of a great house, and the leaving their children great matches. As to the former, though others are too much advantaged by it not to extol it, and though it be sometimes indeed in some cases a decent, and almost necessary, piece of greatness; yet it is in my opinion one of the most unhappy attendants that retain to it; for the laws of hospitality, and much more those of custom, turns him, that keeps a great table, into an honourable host, subjects him to comply with the various and oftentimes unreasonable humours of a succession of guests, that he cares not for at all, and that care as little for him; it brings him in a world of acquaintance, to whom he must own himself obliged, because they come to eat his meat, and must really requite them by giving them the pretiouslest thing he has to part with, his time: and a full table, together with the liberties that custom allows at it, if not exacts there, tempt him both to indulgence to his appetite, prejudicial to his health, and if they do not prevail with him to speak, do often at least to dispose him to hear, and to connive at, such free discourses, as are prejudicial to his interests. So that there is more than one account, upon which a great entertainer may be involved in *David's* curse against his mortal enemy, of having his table become a snare.

And for the design (continues *Lindamor*) of laying up vast estates for a man's children; if they be sons, he thereby but increases their temptation to wish the father dead, and provides incentives to their vice, and fuel for their excesses, when he is so. And if they be daughters, not to repeat the newly-mentioned inconveniencies; how many unhappy young women have we seen, who, upon the score of the vast portions left them by their parents, have been betrayed, and sold by their guardians, or by those relations, that should have been, as they were called, their friends? And how often have we also seen, that an unwieldy fortune has been so far from purchasing the heir to it a good husband, that it has procured her a bad one, by making her think her self obliged and qualified to match with some high title, and procuring her to be haunted by some, whose vices perhaps alone have reduced him

him to sell himself to redeem his fortune, and to make an address which aims but at the portion, not the person? And accordingly, when he has got the one, he slight the other, and despises her for the want of that high extraction she prized in him, and perchance hates her too, for confining him from some former and more than pretended passion.

I perceive then, *Lindamor*, (says *Eusebius*) that you are, as well as I, disposed to think him not a meer fool, that prayed God to give Prov. xxx. 8. *him neither poverty, nor riches, but to supply him with things suitable to his condition*: (that seeming to be the meaning of the Hebrew phrase;) a pinching poverty, and a luxuriant fortune (though different extremes) being liable to almost equal inconveniences, and a competency affording us enough to engage us to thankfulness, without administering such temptations to sensuality and pride.

DISCOURSE XX.

On seeing boys swim with bladders.

THE sun was yet so near the meridian, that if the attention *Eusebius's* discourses excited, had not diverted us from minding the heat of the weather, we should have found it troublesome; and in effect, soon after we had left shining to the conferences I have been repeating, we begun to feel a heat, uneasy enough to oblige us to retire from it: but taking several ways, as chance or inclination directed us, to shun the same inconvenience, it was my fortune to hold the same course with *Lindamor*, and both of us, by following no guide, but the design of shunning all beaten paths, and unsheltered grounds, that being the likeliest way to reach our double end of coolness and privacy; after we had a while walked somewhat near the river-side, we were at length brought to a shady place, which we should have found, as well as we wished it, a solitude, if others had not concurred with us in the same hopes: for the expectation of privacy had brought thither divers, whom the sun's scorching heat invited to that cool and retired part of the river, where they hoped to shun all other eyes, as well as that of heaven; among those swimmers we observed some novices, who to secure their first attempts, had bladders tied under their arms, to keep them from sinking any lower. This sight (says *Lindamor*, after he had a while mused upon it) hath circumstances in it, that, methinks, are applicable enough to the education of many of the young ladies of these times; of whose faults, the excellent *Celia*, and all the others, that you and I can think worth our concern, are free enough to let me entertain you without rudeness of them; the commonness of these blemishes ennobling those few, that are exempted from them. You cannot then (continues *Lindamor*) but have observed with me, that many of those young ladies, whose parents, out of a mistaken zeal, condemn that, which at the court was wont to be called good

breeding, and principles of honour, as things below a Christian, and insufficient to bring their possessors to heaven, are so unluckily bred, and so ill-humoured, as well as fashioned, that an almost equally unhappy education is requisite to make their company tolerable. Civility, which is almost as essential to a compleat lady, as her sex, they are perfect strangers to, or rude despisers of it; and not only their minds are not imbued with those principles of friendship, generosity, and honour, which make some of their sex so lovely, and so illustrious in story, and of which more ladies would be capable, if more were taught them; but these are utterly uninstructed in the laws of what the French call *Bienveillance*, and are altogether unpractised in that civility and suppleness of humour, which is requisite to endear conversation, and is so proper to the softer sex. I must confess, (pursues *Lindamor*) that I never have been more puzzled how to behave my self than in their company: the serious sort of discourse, (even such as is to be found in our fresher and more polished romances) they are utterly incapable of; and in the trifling and pitiful prattle, that alone is not above them, they are so unfociable, so indiscreet, and oftentimes so bold, that in spite of the respect, such as *Celia* gives me for her sex, I find in their conversations as much exercise for my patience as my chastity; and being tempted to put off the respect that belongs to ladies, as they do their modesty, I find it more difficult to retain my civility than my liberty. The bladders (resumes *Lindamor*,) which young swimmers use, are, it is confessed, but light and empty things, that are easily made useless; nay, though they help beginners, they are clogs to skilful swimmers; and yet these trifles are they, that hinder novices from sinking into the mud. Thus honour, though it be an airy unsolid thing, nay, though it oftentimes proves a hinderance to great proficients in Christianity, yet to persons, that have not yet attained to higher principles, it is an excellent support, and hinders them from sinking into many meannesses and miscarriages, into which those especially of the fairer sex, that want a due sense of honour, are too apt to be precipitated: you know what lord told his accused lady, that he knew she was too proud to be a whore. And certainly, though principles of gallantry include not all virtues, yet they avert those they sway from grosser vices: and though to be well bred be not to be a faint, but incomparably inferiour to it, yet to be both, is more desirable than to be the latter only: and they are very unwise, who, before they are sure their children will admit the higher and more perfect principles of religion, neglect to give them that education, that may render moral accomplishments acceptable to them, and them to well bred company, lest by proving indisposed to spiritual graces, their not having been taught the moral ornaments of the mind leave them destitute of all good qualities.

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The TRANSITION.

Containing a DISCOURSE upon the sports being interrupted by rainy weather.

NOTWITHSTANDING the serenity and promisingness of the morning we came out in, we have already upon the water had one proof of the unsettledness of the weather, and now upon the land, we meet with another: for, by that time *Lindamor* was come somewhat near the end of this discourse, he was obliged to hasten to it by the approach of a cloud, whose largeness and blackness threatned us with an imminent shower; nor did it give us a false alarm, for by that time we could recover the next shelter, the shower we fled from began to fall violently enough upon the trees, we were retired to. And this unwelcome accident reducing us all to look about us, we quickly saw, to our grief, that not only the rain but the clouds were increased, and the sky being almost every where overcast, left us no way to escape the inconveniencies it threatned us with, but the making with what haste we could towards the place, over which we perceived smoke enough, to conclude there was some village beneath it; and finding at our arrival thither as good an inn, as we could reasonably expect in such a place, after we had a while dried our selves by the fire, *Eugenius* (to whom exercise and the time of the day had given a good stomach) moved the company, that in spite of the meanness of the house, we might rest our selves there, till we had dress'd the fish we had taken, to make up the best dinner the place would afford. This motion I did not alone readily assent to, but seconded it, by representing, that probably by that time we had dined, we should either recover some fair weather, or lose the hopes of regaining it for that day. To which I added other considerations, to persuade the company; though, that indeed, which prevailed with me, was, the expectation of having an opportunity, while dinner was providing, to retire, as I soon after did, into another room, and set down in short hand what I have hitherto been relating, lest either delay should make the particulars vanish out of my memory, or they should be confounded there by the accession of such new reflections, as, in case a fair afternoon should invite us to return to the river, *Eusebius* would probably meet with occasions of presenting us. But before I could handsomely sink away, I happened to be entertained a while with some things of the like nature with those I was about to set down: for this unwelcome change, after so glorious and hopeful a morning, did naturally suggest to all of us, some thoughts of the mutability and fickleness of prosperity, how easily, as well as quickly, we may be deprived of that we cannot easily part with. But whilst the rest of us were entertaining themselves with these thoughts, *Eugenius*, who was more concerned than any other of us, for the sport he came for, having a good while looked with melancholy eyes upon this change, began to repine and murmur at

the interruption, which the persisting rain continued to give him in it. Whereupon *Lindamor* took occasion to say, For my part, if I could dissipate these clouds with a wish, I should scruple at the ridding my self of them, even at so easy a rate: for I see, that the gaping clefts of the parched ground do, as it were with so many mouths, proclaim its need of the rain you repine at. And I always (continues he) am ready to join with the husbandman in his wishings, as well for rainy as for fair weather, and am so much a commonwealth's man, that I had rather at any time not escape a shower, than let him want it.

You are I confess, (says *Eugenius*) now I think a little better on it, in the right, and have more reason to be discontented at my impatience, than I at the weather: for we should, even in these lesser occasions, as well as on greater, exercise self-denial, and prefer a publick good to our private conveniences: and indeed it were far better, that I should miss some fishes, than thousands of families should miss of bread.

EUSEBIUS, that had hitherto listened to what was said, being unwilling, that his friend's ingenuity should make him any longer accuse himself, told him, (to divert the discourse) This accident, *Eugenius*, was suggesting to me a thought, wherewith I shall not scruple to acquaint you, and the company. For (continues he) as pleasant, and as much desired, as fair weather is wont to be, and as much as we use to be discontented at a lowering and dropping sky, yet the one is no less necessary nor useful in its season, than the other. For too uninterrupted a course of heat, and sun-shine, would make the season fruitful in nothing, but in caterpillars, (or such kind of vermin) and in diseases, and is far more proper to fill graves, than barns: whereas seasonable vicissitudes of clouds, and cloudy weather, make both the ground fruitful, and the season healthful. Thus in our outward condition, too long and constant a prosperity is wont to make the soul barren of all, but such wantonneffes, as it is ill to be fruitful of, and the interposition of seasonable afflictions is as necessary, and advantageous, as it can be unwelcome. But (pursues *Eusebius*) the consideration, that chiefly entertained me, was this, that as here, to make the earth fruitful, the face of heaven must be now and then obscured, and overcast, we must be deprived of the welcome pleasure of the sun to receive the fertilizing benefit of the rain; so such is our condition here below, that our perverseness makes it necessary, that God should oftentimes appear to frown upon us, to make us fruitful in those works, to which he is pleased to vouchsafe his smiles. But, oh! (concludes *Eusebius*, lifting up his eyes and hands towards heaven) how happy shall we be in that glorious and everlasting day, when our condition shall be as blessed in not requiring vicissitudes as in not being subject to them! When the sun-shine alone shall perform all that is wont to be done here both by it, and by the rain; and the soul, like *Egypt*, being fruitful without the assistance of the clouds, we shall not need to have our joys eclipsed,

eclipsed, to have our graces kept from being so, or to make our light shine the brighter: but each blessed soul shall be emblem'd by that vision in the revelations, where St. *John saw an angel standing in the sun*; we shall not then need to have our love weaned from inferiour or undue objects, by any experience of their imperfections; since the clear discovery, that God will vouchsafe us of his own excellencies will abundantly suffice to confine our affections

to them; and since the works, wherein we are to be fruitful in heaven, will be but to admire and thank him, that is infinite in beauty and in goodness, the perfecter sight and fruition we shall have of his astonishing as well as ravishing attributes, will but proportionably increase our wonder, and our praises, and will naturally make us as grateful for such a state as happy in it.

OCCASIONAL REFLECTIONS.

SECT. V.

REFLECTION I.

Upon the sight of N. N. making of syrup of violets.

ONE, that did not know the medicinal virtues of violets, and were not acquainted with the charitable intentions of the skilful person, that is making a syrup of them, would think him a very great friend to Epicurism: for his employment seems wholly designed to gratify the senses. The things he deals with are flowers and sugar, and of them he is solicitous to make a composition, that may delight more than one or two senses; for in one syrup he endeavours to please the eye, by the loveliness of the colour; the nose, by the perfume of the scent; the taste, by as much sweetness as sugar can impart. But he that knowing, that violets, though they please the palate, can purge the body, and notwithstanding their good smell, can expel bad humours, knows also, that the preparer of these fragrant plants, in making their juice into a syrup, is careful to make it acceptable, that its pleasantness might recommend it, and invite even those to prove its virtues, who had rather continue sick, than make trial of a disgusting remedy; will not blame his curiosity, but commend his prudent charity; since he doubly obliges a patient, that not only presents him remedies, but presents him allurements to make use of them.

If I see a person, that is learned and eloquent, as well as pious, busied about giving his sermons, or other devout compositions, the ornaments and advantages, which learning or wit do naturally confer upon those productions of the tongue, or pen, wherein they are plentifully and judiciously employed; I will not be forward to condemn him of a mis-expenditure of his time or talents; whether they be laid out upon speculative notions in theology, or upon critical inquiries into obsolete rites, or disputable etymologies; or upon philosophical disquisitions or experiments; or upon the florid embellishments of language; or (in short) upon some such other thing, as seems extrinsic to the doctrine, that is according to godliness, and seems not to have any direct tendency to the promoting of piety and the kindling of de-

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votion. For I consider, that as God hath made man subject to several wants, and hath both given him several allowable appetites, and endowed him with various faculties and abilities to gratify them; so a man's pen may be very warrantably and usefully employed, though it be not directly so, to teach a theological truth, or incite the reader's zeal.

AND, besides what I have been alledging, there is a further and more principal consideration, which belongs to this matter. For even wise men may prosecute the same design, without doing it all of them the same way; and the several means and methods they employ, notwithstanding a great difference in other particulars, may agree in this, that the respective chusers of them had each of them a good aim, and proceeded in a rational way. Though therefore I see a man of good parts, studious of learning, or of practising, the precepts of eloquence, and spend much time in reading florid compositions, or in making such; I dare not be forward to censure him for an effeminate or useless writer. For there are so many things pious or laudable, and so many ways, whereby some or other of them may either be directly promoted, or indirectly served, by removing objections, or other impediments, that it is not easy to be sure, that a rational man cannot have as well a rational as a well-meant design to instruct, if not reform, in those very compositions, that seem fitted only to delight. There being a nicer sort of readers, which need instruction (and to whom it is therefore a charity to give it) who are so far from being likely to be prevailed on by discourses not tricked up with flowers of rhetoric, that they would scarce be drawn so much as to cast their eyes on them.

A WHILE before *Esther* made that generous attempt, wherein, to rescue the people of God, she hazarded a throne, to which above an hundred other peoples paid homage, and ventured at once the greatest crown and the fairest head in the world; one, that had seen only what she was doing, without knowing why she did it, would perchance have thought her employed, more like a disciple of *Epicurus* than of *Moses*, whose people and her own was then in a forlorn and gasping condition. For the

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the Scripture telling us, that *she put on her royal apparel*, and the tenour of the story intimating with what aim she did it, we may well suppose, that she was not sparing in jewels, and other of the richest ornaments, on an occasion, where her quality exacted, that she should appear with a magnificence befitting the greatest princess in the world; and that she was very curious in a dress, that was to heighten her beauty, when by that, with the giver's assistance, she was upon her knees, to dazzle the world's greatest monarch on his throne, and make him pay homage to her charms, to whom above an hundred nations had presented their fairest productions, (the brightest nymphs of the East.) And those, that have read any thing of the Asiatick luxury, will easily believe our pious queen to have been also very sollicitous about the choice and ordering of her sweetmeats, when she was to treat an Asian monarch, who had treated the whole people of the chief city of the world for many days together, and as many princes, as made up the noblest part of mankind, for above twenty times as long: and yet this magnificent queen, that seemed busied about none but sensual employments, had so commendable a design both in her ornaments, and in her banquets, that so meritorious an employment of her greatness shewed her to be worthy of it; and, as it appeared in the event, that her banquets did cooperate with her fasts, and her royal robes with *Mordecai's* sack-cloth and ashes, to that happy rescue of her nation, for which, after so many ages, it doth to this day yearly celebrate her memory: so whilst she seemed busied to gratify others sensuality and her own pride, her disposition of mind was so worthy the success, that crowned her attempt, that at the same time she was providing all that pomp and those delicacies, she was also providing to give them, and sacrifice them, for the interest of God's church, and her people; generously venturing for the service of heaven a height of prosperity, for whose loss nothing but heaven itself could make her amends.

REFLECTION II.

Upon the sight of a paper-kite in a windy day.

EUGENIUS, LINDAMOR.

EVG. **I**F the air were calm and quiet, this kite would lie unregarded even by those very youths, that now look at nothing else. But the wind, that blows away straws and feathers, and throws down leaves, does even by its being contrary, help to raise this paper-engine to that admired height, which makes it be gazed at by many others, than boys, and not only attract our eyes, but sometimes soar out of their reach. Thus, if a great person, for courage, or parts, or both, have the ill fate to live in quiet, and peaceful times, he may long enough languish unregarded in an age that needs him not. But if the times grow troublesome and dangerous, his generous spirit will not only surmount the difficulties, that are wont to attend them, but be raised by them,

and turn them into steps to glory and preferment.

LIND. Methinks, *Eugenius*, these kites may affords us no less fit a resemblance of the fate of some errors about religion, especially if they chance to be maintained by men, that are resolute, and viceless. For there are some of these conceits so fond, and groundless, that they could not long subsist of themselves, and would soon cease to tempt a solemn opposition, if they did not too soon meet with it. And as you were observing to another purpose, that these artificial kites, which men take no notice of in calm weather, are both elevated and kept aloft by the blasts of contrary winds; so these erroneous opinions I speak of, would, if they were let alone, grow quickly unregarded, whereas needless or ill-managed persecutions of doctrine, not prejudicial to government, (for it is only such, that I mean) bring them into every body's eye, and give them a repute, that nothing else would have procured them, and make them be looked upon as things of a sublime and celestial nature, that lead to that heaven, they seem to aspire to. To thrive by persecution, though it be a great advantage, yet it is not the incommunicable prerogative of divine truths; and though it be certain that they get most by it, yet even errors do often gain by it too, there being certain advantages, that accrue to opinions, by being persecuted, without distinguishing, whether they be true, or false. For men, that are persecuted for their religion, are generally careful to instruct themselves thoroughly in it, and furnish themselves with arguments to defend it. The frowns of the magistrate, and the watchful eyes of their adversaries, are strong dissuasives to them from doing any thing, that may arm his hand, or provoke other's tongues against their sect, to which they know their personal faults will be imputed. And above all this, their sufferings intitle them to popular commiseration, which is a thing, that distress does so much invite, that even condemned malefactors seldom want a share in it. And to some of these men persecution is the more favourable, because it puts them upon fighting with the weapons they can best handle. For some are far better at suffering, than at disputing, and can more easily endure a prison, than answer a syllogism. And as this constancy is often their best argument, so is it an argument, that the generality of men best understand, and consequently is likely to be most wrought on by; so that the more harsh than effectual way, wherein they are dealt with, gives them the opportunity to display a resoluteness, that makes most men think them well meaning, and in earnest, and their own party cry them up for martyrs, or at least confessors; which, in case that (as it happens in most states) scandalous sins be left unpunished at the same time, that harmless errors are so severely dealt with, gives them the fairer opportunity to insinuate into the minds of the people, that their persecutors had rather see men vicious, than inquisitive. And, generally speaking, any personal sufferings, that a well-meaning man undergoes for what he judges his con-

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science, is but such a kind of burden to his mind, as feathers are to an eagle, or a falcon, which, though in themselves considered they have a weight, yet instead of clogging him, they not only help him to support himself, but enable him to soar towards heaven, and reach a height, that makes him praised or wondered at.

REFLECTION III.

Killing a crow (out of a window) in a hog's trough, and immediately tracing the ensuing reflection with a pen made of one of his quills.

LONG and patiently did I wait for this unlucky crow, wallowing in the sluttish trough, (whose sides kept him a great while out of the reach of my gun) and gorging himself with no less greediness, than the very swinish proprietaries of the feast, till at length having guzzled and croaked enough, when by hovering over his beloved dainties, he had raised himself high enough, to prompt me to fire at him, my no less unexpected, than fatal shot, in a moment struck him down, and turning the scene of his delight into that of his pangs, made him abruptly alter his note, and change his triumphant chant for a dismal and tragick noise. This method is not unusual to divine justice towards brawny and incorrigible sinners, whose souls no less black, than this inauspicious bird's feathers, do wear already the livery of the prince of darkness, and with greediness do the works of it, whose delights are furnished (as the feasts of crows are by carrion) by their own filthy lusts, or other people's faults, and who by the oaths and curses, wherewith they offend Christian ears whilst they live, and by the ill odour they leave behind them when they are dead, do but too much justify my resembling them to these hateful creatures. Such sensual and obdurate Epicures, I say, God oft times suffers to run on their long career, in paths of their own chusing, without checking them in the fruition of those joys, which are to be their only portion, till at length *their iniquity filling up the determinate measure*, he cuts them off, in the height of their enjoyments, and employing oft-times their own sins for their executioners, or at least instruments of their destruction, precipitates them headlong from the pinnacle of their delights, into the bottomless pit, which one of their predecessors (the rich man in the parable) called, as he sadly found it, the *place of torment*, where the luscious sweets of sin are so dearly reckoned for, and afford so much *bitterness in the latter end*, that their sense sadly convinces them, of (what their sensuality kept them from believing) the folly of gaining any thing at the rate of losing their own souls. Thus the Israelitish prince found a Nemesis bold enough to violate the sanctuary, even of his mistress's arms, and (regardless of its charms) enter that lovely circle, their kindness closed him in, to snatch him thence, and extinguish the lustful flames, that lighted him thither, with the cold blasts of death. Thus the mutinous loa-

thers of manna, and lusters after flesh, had their wish severely granted, for they had indeed quails served in by fields-full, but attended with so sudden and sharp a reckoning, that *whilst the flesh was yet between their teeth, ere it was chewed*, death hindered them to swallow it, choaked them with it, and devoured them as greedily, as they did those birds. Thus the insolent Philistines found themselves ill protected by their vainly celebrated God, and his (much stronger) temple, though in the latter there were thousands of them, without any other enemy, than one, they had sent for to be a friend to their mirth. For in the very midst of all the triumphs of a solemn festival (which had more properly been kept to *Dalilab*) whilst they were insulting over captive *Sampson's* blindness, they could not see their own approaching destiny, though it were then so near, that the next fit of laughter had not time to pass to their mouths, ere an unexpected vengeance (the provoked Deity lending an omnipotent arm to *Sampson's* hand) confounded in one ruin) the idol with the worshippers, and suddenly turned the whole temple into an altar, with which the priests themselves fell surprised sacrifices to that tragical solemnity. And thus (to hasten from so sad a theme) the reveling *Belshazzar*, in the midst of his magnificent and royal feast, saw an intruding hand, which by its manner of appearing, as well as by what it wrote, was able to mar the supper, without impairing the dainties. And that monarch, whom even a siege could not reduce below a condition of feasting, though he were carousing in the consecrated cups, had such a brimmer of trembling put into his hand, as both presaged and, perchance, began the destiny approaching him under the ensigns of the noble *Cyrus*, whose conquering sword, guided by providence, and made the sword of justice, did that very same night let out his wine, and blood, and life together.

Upon the same subject.

IT is hard on such an occasion to avoid making some reflection upon the mutability of worldly conditions! How little did this crow imagine, a quarter of an hour since, that in so short a time, his body should be as senseless, and as stinking carrion, as that he was wont to feed it with; that his feathers should wear so unlucky a kind of mourning for his destruction, and that I should write his epitaph with one of his own quills! Sure, since a few minutes can turn the healthiest bodies into breathless carcases, and put those very things into the hands of our enemies, which were they, that we principally relied on for our safety, it were little less than madness, to repose a distrustless trust in these transitory possessions, or treacherous advantages, which we enjoy but by so fickle a tenure. No; we must never venture to wander far from God, upon the presumption, that death is far enough from us; but rather in the very height of our jollities, we should endeavour to remember, that they, who

Gen. xv. 16.

Luk. xvi. 28.

2 Sam. ii. 26.

Num. xxv.

feast

feast themselves to-day, may themselves prove feasts for the worms to-morrow.

REFLECTION IV.

At Lees. Upon a glow-worm, that he kept included in a crystal phial.

IF this unhappy worm had been as despicable as the other reptiles, that crept up and down the hedge, whence I took him, he might, as well as they, have been left there still; and his own obscurity, as well as that of the night, had preserved him from the confinement he now suffers. And if, as he sometimes for a pretty while withdrew that luminous liquor, that is as it were the candle to this dark lanthorn, he had continued to forbear the disclosing of it, he might have deluded my search, and escaped his present confinement.

RARE qualities may sometimes be prerogatives, without being advantages. And though a needless ostentation of one's excellencies may be more glorious, yet a modest concealment of them is usually more safe: and an unseasonable disclosure of flashes of wit may sometimes do a man no other service, than to direct his adversaries, how they may do him a mischief.

AND as though this worm be lodged in a crystalline prison, through which it has the honour to be gazed at by many eyes, and, among them, by some, that are said to shine far more in the day than this creature does in the night; yet no doubt, if he could express a sense of the condition he is in, he would bewail it, and think himself unhappy in an excellency, which procures him at once admiration and captivity, by the former of which he does but give others a pleasure, while in the latter he himselfresents a misery.

THIS ostentimes is the fate of a great wit, whom the advantage he has of ordinary men in knowledge, the light of the mind exposes to so many effects of other men's importunate curiosity, as to turn his prerogative into a trouble: the light, that ennobles him, tempts inquisitive men to keep him, as upon the score we do this glow-worm, from sleeping: and his conspicuousness is not more a friend to his fame, than an enemy to his quiet; for men allow such much praise, but little rest. They attract the eyes of others, but are not suffered to shut their own; and find, that by a very disadvantageous bargain, they are reduced for that imaginary good, called fame, to pay that real blessing, liberty.

AND, as though this luminous creature be himself imprisoned in so close a body as glass, yet the light, that ennobles him, is not thereby restrained from diffusing it self: so there are certain truths, that have in them so much of native light or evidence, that by the personal distresses of the proposer, it cannot be hidden, or restrained; but in spite of prisons, it shines freely, and procures the teachers of it admiration, even when it cannot procure them liberty.

REFLECTION V.
Upon a court's being put into mourning.

PART I*.

Hague
1648.

GENORIO, EUSEBIUS, LINDAMOR.

GENOR. **M**ETHINKS, you look, *Eusebius*, as if the change, that blacks have made in this place, since I last saw you here, tempts you to question, whether or no this be the court.

LIND. Yet, I fear, *Eusebius* will scarce doubt, that you, and these other gentlemen are courtiers, whilst he sees, how much you dissemble in personating sadness: for though your clothes look mournful, your faces do not, and you talk to one another as unconcernedly, as when you wore lighter colours; and your grief is so slight, that it has not an influence so much as upon your looks, and words, which yet are things, that courtiers are said to be able to disguise without an over-difficult constraint.

GENOR. But, I hope, *Lindamor*, I need not labour to persuade such as you, that, when we seem to mourn, without doing it, we may be thought guilty of dissimulation, without being so: for what duty is there, that you and I should be really troubled for the death of a prince, whose subjects we were not, who never obliged us, and who perhaps did only keep the power of doing good, which himself never used, from a successor, that had the will to employ it? But you will demand, why then we put on black; to which the answer is easy, that custom having established that ceremony in the courts of princes, in amity with each other, the omission would be looked upon as an affront, and be a provocation. And therefore, the blacks we wear, are not meant to express a grief for the dead, but a respect to their living relations: and thus, this as heartless as solemn shew of mourning is not put on by hypocrisy, but by prudence, or civility. And in this case, I would appeal to *Eusebius* himself, but that I perceive some object or other has, ever since we began to talk, engrossed his attention, as well as sealed up his lips.

LIND. I have taken notice of it, as well as you, *Genorio*, and I confess, I would give much to learn his thoughts.

EUSEB. It is odds then, *Lindamor*, that you would over-purchase so worthless a knowledge: and to satisfy your curiosity at an easier rate, I will tell you, that I was observing, how a gentleman, who, it seems, does not much frequent the court, chancing to come in a coloured suit, that, but last week, would have been thought a fine one, was stared at by all in the room except your selves, whose faces chanced to be turned from him, like a man of another country, (not to say of another world;) which the poor gentleman at length perceiving, he soon grew so sensible of it, that in spite of the richness and newness of his clothes, with many blushes he slunk out of the court, to which he found

* For there was a second part of this reflection, but when it was to be sent to the press it could not be found, nor would the press's haste, and the author's occasions, allow him either to stay till it were found, or write a new one.

found men's gazing at him concluded him to be a stranger.

LIND. But this, *Eusebius*, is only to tell us, what you observed, not what reflections you made upon it; and you know, that which I was inquisitive after, was your thoughts.

EUSEB. I will add then, *Lindamor*, since you will have it so, that I was considering, that there has been no law made by the state to forbid any, much less strangers, to appear in this court in coloured clothes: and those, which the gentleman I was speaking of, had on, were such, both for fineness, and fashionableness, as would very well become a greater court, if it were not in mourning. But, now the prince, and those, that have the honour to belong to him, or to frequent this place, have put themselves into blacks, to appear in another, though in a finer habit, is, to betray one's not belonging to the court, nor using to come to it; and among so many, that think they have a right to give laws in point of clothes, a laced, or an imbroidered suit, though last week in request, would, now they have laid them by, make a man look not so much like a courtier, as a player. And this reflection invited me to consider further, what a strange influence fashions have on mankind, and what an happy change might be easily made in the world, if they, who have it in their power to introduce customs, would make it their endeavour to introduce good ones.

LIND. I am so much of your mind, *Eusebius*, that I confess, I envy not princes so much for the splendour and the pleasures; that they live in, nor for the authority of raising armies, nor, perchance, for the happiness of making them victorious, as for the power of imposing and reforming of fashions. And I think it a less improvable prerogative, to be able to coin any metal into money, or call it in at pleasure, than by the stamp of their authority to introduce good customs, and make them current.

GENOR. But, do not princes enough, when they take care to make good laws, and see them well executed?

LIND. I will not dispute, whether by that, they do all they ought, but sure I am, they do not all they may: for human laws being made for the civil peace of human societies, they are wont to be framed not for the making men virtuous, but the restraining them from being mischievous; they consist far more of prohibitions than commands, and even their prohibitions reach but to a little part of what is ill; the business of laws being to provide, not against all evils, but those grosser ones, that are prejudicial to civil societies: so that there are a thousand rules of reason, or Christianity, which states have not thought fit to turn into laws. For pride, envy, covetousness, gluttony, intemperance, effeminatefulness, oaths, idleness, and I know not how many other sins, contrary to the laws of nature, and of Christ, are so little provided against by human sanctions, that one may be a bad Christian, and a bad man, without being a bad citizen; there being nothing more easy, nor, I fear, more usual,

than for multitudes to pass uncited before man's tribunal, to receive their condemnation at God's. But though a prince can scarce, as a legislator, prevent, or suppress such sins, yet, as a pattern, he may do much towards it: for by his example, his opinions, his encouragements, and his frowns, he may reform an hundred particular things, which the laws do not (and perhaps cannot) reach. His declared esteem of such and such practices, joined with his particular actions suited to it, and his profest dislike of those sinful or dishonourable courses, he finds the richest, backed with a steady and resolute discountenance of those, that do not decline them, will, in a short time, bring those, that are about him, to conform their actions and behaviour to what men are fastidious, he desires, or likes. And those, whom their nearness to him, or their employments, make the conspicuous and exemplary persons, being thus modeled, their relations and dependants will quickly be so too; and then that which is in request at court, being upon that very account looked upon as the fashion, it will by degrees be imitated by all those, on whom the court has influence; since, as we just now saw in the instance of *Eusebius's* gaudy gentleman, men will be ashamed to be unlike those, whose customs and deportments pass for the standards, by which those of other men are to be measured.

REFLECTION VI.

Upon hearing of a lute first tuned, and then excellently played on.

THE jarring strings made so unpleasant a noise, whilst the instrument was tuning, that I wonder not at the story, that goes of a Grand Signior, who being invited by a Christian ambassador to hear some of our musick, commanded the fiddlers to be thrust out of his seraglio, upon a mis-apprehension, that they were playing, when they were but tuning. But this rare artist had no sooner put an end to the short exercise he gave our patience, than he put us to the exercise of another virtue; for his nimble and skilful fingers make one of the innocentest pleasures of the senses to be one of the greatest, and this charming melody (for which *Orpheus* or *Orion* themselves might envy him) does not so properly delight as ravish us, and render it difficult to moderate the transports of our passions, but impossible to restrain the praises, that express our satisfaction: so that if this musician had been discouraged by the unpleasant sounds, that were not to be avoided, whilst he was putting his lute in tune, from proceeding in his work, he had been very much wanting to himself, and to save a little pains, had lost a great deal of pleasure and applause.

THUS, when the faculties and passions of the mind, either through a native unruliness, or the remissness of reason and conscience, are discomposed, he, that attempts to bring them into order, must expect to meet at first but an uneasy task, and find the beginning of a reformation more troublesome, for the time, than the

past disorders were: but he is very little his own friend, if he suffers these short-lived difficulties to make him leave his endeavours unprospered; for when once they have reduced the untuned faculties and affections of the soul to that pass, which reason and religion would have them brought to, the tuned or composed mind affords a satisfaction, whose greatness does even at present abundantly recompence the trouble of procuring it, and which is yet but a prelude to that more ravishing melody, wherein the soul (already harmonious within itself) shall hereafter bear a part, where the harps of the saints accompany the glad voices, that sing the song of the lamb, and the allelujahs of the rest of the celestial choir.

REFLECTION VII.

Upon being presented with a rare nosegay by a gardener.

LINDAMOR, EUSEBIUS.

LIND. **H**ERE is indeed a present, for which I must still think myself this fellow's debtor, though he thinks I have overpaid him. It is pity these rarities were not more suitably addressed, and worn by some of nature's other master-pieces, with whom they might exchange a graceful lustre, and have the ornament they confer reflected back upon them. But one, that had never been a lover, would perhaps say, that that wish were more civil to the flowers, than the ladies, of whom there are few, which these soft polished skins, and orient tinctures, would not easilier make foils, than prove such to them: for (not to name the rest) this lovely fragrant rose here wears a blush, that needs not do so, at any colour the spring itself can, amongst all her charming rarities, shew. Yes, here are flowers above the flattery of those of rhetorick; and besides, two or three unmingled liveries, whose single colours are bright, and taking enough to exclude the wish of a diversity, here is a variety of flowers, whose dyes are so dexterously blended, and fitly chequered, that every single flower is a variety. I envy not *Arabia's* odours, whilst that of this fresh blusher charms my sense, and find my nose and eyes so ravishingly entertained here, that the bee extracts less sweetness out of flowers; which were they but less frail, I fear would make me more so than yet I am. Surely this gardener leads a happy life! He inherits nothing of *Adam*, but that primitive profession, that employed and recompenced his innocence, and such a gay and privileged plot of his *Eden*, as seems exempted from the general curse, and instead of the thorns and thistles, that are the unthankful earth's wonted productions, brings him forth lillies and tulips, and gratefully crowns his culture (for toil I cannot think it) with chaplets of flowers.

EUSEB. I perceive, (*Lindamor*) that you judge of the delightfulness of this man's calling, only by these lovely and fragrant productions of it. And you see these curious flowers in their prime, without seeing by what

practices, and degrees, they have been brought from despicable seeds to this perfection and lustre. And perhaps, if you considered, that a gardener must be digging in the violent heats of the summer, and must be afraid of the bitter cold of the winter, and must be watchful against surprizing frosts in the spring, and must not only prune, and water, and weed his ground, but must, to obtain these gaudy and odoriferous flowers, submit to deal with homely and stinking dung: if (*Lindamor*) you would take notice of these and of some other toils, and hardships, that attend a gardener's trade, you would (I doubt not) confess, that his employments, like his bushes, bring him thorns as well as roses.

AND now give me leave (*Lindamor*) to tell you, that this may be applied to the condition of some studious persons, that you and I know. For when we hear a learned or eloquent sermon, or read some book of devotion, or perhaps some occasional discourse handsomely written, we are apt to envy the preacher or the writer, for being able to say some things, that instruct or please us so much. But alas, (*Lindamor*) though we see not these productions of the brain till they are finished, and consequently fitted to appear with their full advantages abroad; yet to bring them to that pass, the author may perhaps undergo many a trouble, that we dream not of. For he, that has to do with difficult or weighty subjects, cannot present us a good book, or a fine discourse, with the same ease, that a rich man can present us a fine pair of gloves, or a fine collation, which may be had at an hour's warning from the next milliner's or confectioner's. For to be able to write one good book on some subjects, a man must have been at the trouble to read an hundred: to grow capable to give a better rendering of a Greek text, he must, perchance, have perused *Suidas*, *Stephanus*, *Hesychius*, and I know not how many lexicographers and scholiasts: to be qualified to make a translation of an Hebrew word or phrase, that shall illustrate a dark text, or clear a difficulty, or more fitly agree with his notion, or accommodation of a place in Scripture, a man must have not only, like a school-boy, learned an Hebrew grammar, and turned over *Buxtorf's*, *Schindler's*, and other dictionaries, but (which is worse) he must, in many cases, hazard his eyes and his patience in conversing with such Jewish writings, not only as *Elias* his *Tisbibi*, and *Kimchi's Michlol*; but to gain a little rabbinical learning, and find out some unobvious signification of a word or phrase, he must devour the tedious and voluminous rhapsodies, that make up the Talmud, in many of which he can scarce learn any thing, but the art of saying nothing in a multitude of words; and in others, which are not so uselefs, the most he will find in I know not how many dull pages, (written with as little wit as truth) will perhaps be an account of some wild opinion, or some obsolete custom, or some superstitious rite of a generation of people, whose fancies and manners scarce any thing makes worth our inquiring after, but their having lived many ages since. And even when

when a man sets himself to write those smooth composures, where eloquence is conspicuous, and seems to be chiefly designed, the author seldom comes by his contentment on as easy terms as the readers come by theirs. For, not to mention, that sometimes periods, that in a well-printed book look very handsomely, and run very evenly, were not in the written copy without interlining and transcriptions; those, that are scholars themselves, can hardly write without having an ambition, or at least a care, to approve their discourses to them that are so too. And in the judgment of such perusers, to be able to write well, one must not only have skill in the subject, but be well skilled in the way of writing, lest the matter be blemished by the manner of handling it. And although to shew one's self a master, in treating of variety of themes with a florid style, and even in those composures, that are designed chiefly to express wit and move affections, one may think, that nature may be well let alone to supply any she has been kind to, with all they need, yet even in these cases there are some toils and uneasinesses, that are scarce to be avoided; since a discreet man, though never so rich in nature's gifts, will think himself obliged to study rhetoric, that he may be sure he does not transgress the laws of it. For though an author's natural parts may make his book abound with wit, yet without the help of art he will scarce make it free from faults. And to be well stocked with comparisons, which, when skilfully managed, make the most taking passages of fine pieces, one must sometimes survey and range through the works of nature and art, which are the chief warehouses, where variety and choice of similitudes is to be had; and to obtain those pleasing ornaments, there is oftentimes required no less pains than to devise useful notions. As one must search the ditches amongst briars and weeds, not only to find medicinable herbs, but to gather primroses and violets. So that (*Lindamor*) to conclude, if we consider the trouble, that applauded composures do oftentimes cost their authors, we should be sensible we owe more, than most men think we do, to those, to whom we owe good books. But then unless they find some recompence for their labours, in the satisfaction of promoting piety, or in the well-natured pleasure they feel themselves in pleasing others, I should scarce doubt, but that some of the writers, we think so happy, may rather deserve our esteem than our envy.

REFLECTION VIII.

Upon a child that cried for the stars.

I REMEMBER *P. S.* did once, upon just the like theme, discourse to the following purpose.

AMONGST those numerous eyes, that these fair lights attract in so clear a night as this, there are not perhaps any, that are more delighted with them, than this child's seem to be. And those Persians, that adored the rising sun,

could not be more charmed with that glorious object, than this child is with these twinkling lights, that need his absence to become so much as visible. But his is a pleasure, that is not more great than unquiet, for it makes him querulous, and unruly; and because he cannot by his struggling, and reaching forth his little hands, get possession of these shining spangles*; that look so finely, their fires produce water in his eyes, and cries in his mouth, that are very little of kin to the musick the Platonists fancied in the spheres he looks at. Whereas, though my inclinations for astronomy make me so diligent a gazer on the stars, that in spite of my great obnoxiousness to the inclemency of the nocturnal air, I gladly spend the coldest hours of the night in contemplating them; I can yet look upon these bright ornaments of heaven itself, with a mind as calm and serene, as those very nights, that are fittest to observe them in.

I KNOW divers men, for whom nature seems to have cut out too much work, in giving them, in an unconfinedly amorous disposition of mind, strong appetites for almost all the fair objects, that present themselves to their sight: these amorous persons may be, I grant, very much delighted, when they first gaze upon a constellation of fair ladies; but the heart commonly pays dear for the pleasure of the eye, and the eager desires, that beauty creates, are in such men excited too often not to be frequently disappointed, and are wont to be accompanied with so many jealousies, and fears, and repulses, and difficulties, and dangers, and remorse, and despairs, that the unhappy lovers (if those, that love more than one, can merit that title) do rather languish than live, if you will believe either their own querulous words, or their pale and melancholy looks, which would make one think they were just entering into the grave, or had been newly digged out of it. Whereas a person, that has his affections and senses, at that command, which reason and religion require and confer, can look upon the same objects with pleased but not with dazied eyes: he considers these bright and curious productions, as fair animated statues of nature's framing, and contenting himself to admire the workmanship, adores only the divine artificer, whose infinite amiableness is but faintly shadowed forth even by such lovely creatures. And therefore what has been said of mistresses, may be more justly applicable to all the other objects of men's too eager passions. To be short, looking upon these curiousest productions of nature, with a philosopher's and a Christian's eyes, he can cast them on those bright objects with pleasure, and yet withdraw them without trouble, and allowing beauty to contribute to his delight, without being able to create him any disquiet; though it afford him a less transporting pleasure than it sometimes does the amorist, yet, all things considered, it may afford him a greater pleasure, by being more innocent, more untroubled, and more lasting; and there may be such a difference betwixt the contentment of this calm admirer

* Thus in a starry night fond children cry
For the rich spangles, that adorn the sky. Mr. W.

mimir of beauty, and that of a greedy and unconfined profligator of his heart to it; as there is betwixt the unquiet pleasure, that the sight of the stars gives to this child, and the rational contentment it may afford to an astronomer.

REFLECTION IX.

Upon my lady D. R. her fine closet.

LINDAMOR, EUSEBIUS.

A. D.
1651.

LIND. **I**S not this closet strangely fine, *Eusebius*? Here is such a variety of pretty and taking objects, that they do as well distract the eye as delight it; the abundance, the choice, and the order, do as well disclose the fair possessor's skill, as her magnificence, and shew at once, that she both has plenty, and deserves it, by knowing so well how to make use of it. Those things, that are here solitary, or single, will scarce be elsewhere matched; and all the rest are so pretty, and so excellent in their several kinds, that the number of fine things, that make up this curious collection, cannot hinder any of them from being a rarity. And in a word, the embellishments, that adorn and ennoble this delightful place, are such, that I believe the possessor of them, as welcome as she is unto the best companies, scarce ever looks upon finer things, than she can see in her closet, unless when she looks into her glass. But, methinks, *Eusebius*, you hear and view all this with a silent seriousness, which begins to make me suspect, that what I thought might be an effect of your wonder, may be so of your dislike.

EUSEB. The collection, *Lindamor*, is, I confess, very curious in its kind, and such as if the mistress of it were less handsome than she is, might give her as well cause to be jealous of these fine things, as to be proud of them, since a beauty, that were but ordinary, could not divert a spectator's eye from objects, whereof many are not so. But, *Lindamor*, I must freely tell you, that I like both the lady, and the closet, much better than the custom such sights as these are introducing among ladies of furnishing such kind of closets: I know, that youth may in certain cases, excuse some of the impertinencies it is wont to occasion; and it is not strange to me, that persons of the fairer sex should like, in all things about them, that handsomeness, for which they find themselves to be the most liked; nor would I forbid, even such of them, as are not of a very high quality, to have a retiring place so neatly adorned, as may invite them to be alone, and withdraw to it, to read, or meditate, provided these ornaments be not so costly, as to rob charity, or so gaudy, as to distract the devotion they should but accommodate. And in case circumstances should so conspire, as that youth and quality should be attended by such a plentiful fortune, as that after all, that either justice, prudence, or decency can challenge, there remains yet enough, both to relieve the poor, and purchase rarities themselves; I will not be so severe, as to condemn persons so circumstanced, nor fall out

with those, that are able to reconcile sumptuousness and charity. But the number of such ladies, especially so soon after a long civil war, must needs be but small, and I fear much inferior to that of those, who will consider more what they see done before their eyes, than they will the disparity of circumstances betwixt their own condition, and that of those they emulate: and the greater appearance of ingeniousness, as well as innocence, there is in the practice I am disapproving, the more dangerous it is, and the more fit to be examined and decry'd. For as the old serpent has variety of wiles, so he fits them to the various tempers of the persons he assays to work upon; and when he meets with ladies virtuously disposed, since he cannot quite eradicate their inclinations to the best part of religion, charity, he will at least blast and render them fruitless; and he justly thinks, he has reached no small part of his end, if though he cannot seduce them to do ill, he can at least hinder them from doing good. And this he has of late attempted but too prosperously, by persuading us to take those for the standard and examples of our expences, that making none of the score of piety, have the more left for their vanities and their appetites; which they gratify at such high rates, that those, that think themselves bound to imitate them in those excesses, that are misnamed gallantry, shall have as little ability as the other have will, to apply any considerable part of their estates to those uses, which chiefly God granted them those estates for; and by that time, the lady her self, and the house, and the closet, are furnished with all the ornaments, that vanity and emulation call for, there is nothing left for charity to dispose of, nay, perhaps not for justice; the creditor being oftentimes turned back empty as well as the beggar, if not also made a beggar by ruinous delays. And greater fortunes, than most ladies have, may be exhausted, by gratifying such an ambition, as that of a closet, to whose costliness nothing can put limits, till discretion do; custom it self having not yet regulated a piece of vanity, which, as imposing as custom is wont to be, it has not yet dared to enjoin.

LIND. Methinks, *Eusebius*, you are somewhat forward to accuse those fair creatures, that though they should want innocence, would scarce want advocates; and you are too good a casuist to ignore, that they are wont to alledge, that the bravery you are so severe to; is no where expressly prohibited in the Scripture; and this unforbiddenness they think sufficient to evince, that the sumptuousness you so condemn, is not absolutely, and in its own nature, sinful.

EUSEB. I can readily believe, that *Lindamor* has wit and amorousness enough to make him find it more easy to defend fair ladies, than to defend himself against them; and I know, it is said, that these sumptuous closets, and other vanities, are not simply unlawful in their own nature: but I know too, that divers things, not in their own nature unlawful, may be made so by circumstances; and if so, then I fear, that that can be no other than ill, which makes a man needlessly disable himself to do good. The
Apostle,

Apostle, that discountenanced women's wearing of gold, or precious things upon their bodies, would sure have opposed their having more sumptuous ornaments upon their walls: these cannot pray for us, but the poor and distressed, they keep us from relieving, may either successfully pray to God for us, or cry to him against us. The Scripture, that represents *Dives* in hell, without saying, that he oppressed or defrauded any, gives no other account of his doom, than that living at a high rate, and going richly dressed, he neglected to relieve the starving poor. A few such closets as this lady's might be easily enlarged, and contrived into an hospital: a small part of these superfluities would relieve the necessities of many families, and a liberal heart might purchase heaven at an easier rate, than the furniture of his closet cost the owner of it. Nor is this practice so unallied to a fault, as to escape a punishment even in this world; these courtiers of applause being oftentimes reduced to live in want, even in the midst of a plentiful fortune; these costly trifles so engrossing all that they can spare, that they must sometimes deny themselves things convenient, and, perhaps, almost necessary, to flaunt it out with those, that are neither the one nor the other, and being frequently enough fain to immolate their own inclinations and desires, though, perchance, strong and innocent, to their vanity. And those, that have once found the happiness there is in making others happy, will think their treasure better bestowed in feeding hungry mouths, than idle eyes: the costly practice I am yet censuring, does not only offend charity, but starve it, by subtracting from it that, which should feed it, and enable it to act like it self. And for my part, I think, he, that devises, and by his example brings credit to, a new expensive way of vanity, does really destroy more poor, than if he usurped an alms-house, or ruined an hospital. And by the ill precedent he leaves, he takes the way to be uncharitable, even after death, and so do harm, when misers and usurers themselves are wont (by their legacies) to do some good. To conclude, it is no very Christian practice to disobey the dictates of piety, without having so much to plead for so doing, as the pretence of following the dictates of custom: and it is a great deal better to be without a gay closet, than to be without charity, which loveliest of Christian virtues she must sure very much want, that will needlessly begin a new example to give a bad one.

REFLECTION X.

Upon his seeing a lark stoop to, and caught with, day-nets.

EUSEBIUS, LINDAMOR.

EUSEB. **P**OOOR bird! thou wert just now so high upon the wing, that the tired gazers feared thou hadst lost thy self in heaven, and in thy fatal stooping seemest to have brought us thence a message, that so relishes of that place, that I should be troubled to see thee so rudely entertained, if that circumstance were not necessary to the instructions

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of thy message. Some birds, you know, *Lindamor*, we usually beguile with chaff, and others are generally drawn in by appropriated baits, and by the mouth, not the eye. But the aspiring lark seems composed of more sprightly and refined materials; she is ever a natural, though no native, Persian; and the sun makes not a cloudless visit to our horizon, which that grateful creature gives not a welcome to, both by notes, which, could he hear them, he would think worthy of him, and by a flight as aspiring, as if she meant he should hear them; and, in a word, so conspicuous is this creature's fondness of light, that fowlers have devised a way to catch her by it, and pervert it to her ruin: for placing broken looking-glasses upon a moveable frame betwixt their nets, the unwary bird, while she is gazing upon that glittering light the glass reflects, and sporting herself in those beams, which derive a new glory from their very being broken, heedlessly gives into the reach of the surprizing nets, which suddenly cover her, and which the light it self kept her from seeing. The devil is like this fowler, *Lindamor*; and you, or I, had perhaps resembled the unhappy lark, if sometimes providence did not both graciously, and seasonably, interpose, and even when we were come near enough to have been covered by the nets, rescued us from them; for it has ever been that old serpent's policy, and practice, to take the exactest measure of our inclinations, that he may skilfully suit his temptations to them; well knowing, that that dexterity gains him a devil within us, that conspires with him without us, to make us instances of that truth, which represents things divided against themselves as ruinous. If therefore the tempter find by experience, that you are indisposed to be wrought upon by common temptations, to forget the practice of religion, that you have unconcernedness enough not to be much distracted with the empty and trifling chaff, youth is wont to be caught with, (which perhaps seldom employ any of your thoughts so much as those of scorn, and pity) that the very gain and silder goods of this world (for which many, thought wise men, lose those of the next) cannot make you so greedy, nor so fond of them, as he desires: If, I say, the devil have sufficiently observed, how uneasy it were to intice you with common baits, he will alter his method strait, and attempt to catch you with light. He knows as well as I do, that you have a curiosity, or rather a greediness of knowledge, that is impatient of being confined by any other limits than those of knowledge it self; and accordingly, seldom, or perhaps never disturbing or frightening you, he will let you freely sport your self about the glittering intellectual glass, men call philosophy, and suffer you not only to gaze upon all its pieces, and survey a pretty number, but, peradventure, pry into more than one: and among so numerours, and delighting objects, I fear, that if you will frankly own what my own guilt makes me suspect you of, you must confess, that he had made you so share your time, that you should scarce have left your self any

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any for heavenly themes, and the meditation of death, (which consequently, might have then surprized you, had it invaded you) if providence had not mercifully snatched you out from between the nets you were allured to, before you were quite involved in them; and by sickness, or else, by means (in other cases) so unlikely, as outward distractions, called your thoughts home by driving them away from those enchanting studies, whose light might much likelier have betrayed you into the net, than have shewn it you.

LIND. Though I am not surprized to hear *Eusebius*, yet I am glad to hear a scholar talk at this rate, and believe with you, that many, a one, that was neither crow, nor woodcock, has perished in this snare; and we have known but too many great scholars so intirely taken up with writing, and reading of books, with learning this science, and with teaching that, that by setting themselves such tasks, as required and employed the whole man, death has undiscernedly stolen upon them, and unawares intruded into their studies, where their restless ambition to enrich the mind never left them the leisure to prepare it to leave the body, but either made them surprized instances of that sad (but true) observation of *Seneca*, *plerisque in ipso vite apparatusu vita destituit*; or else made their condition like that of *Archimedes*, who was so busy in tracing his circles, that he took no notice of that victorious enemy, that came to dispatch him.

EUSEB. I allow, that it is the innocence, as well as pleasure of knowledge, that deceives those learned men; but they, as well as others, must remember, that even the wholesomest meats may be forfeited on, and there is nothing more unhealthy, than to feed very well, and

do but very little exercise. And I take it to be as true of the intellectual, as the material world, that *it profits not a man, if he gain the whole world, and lose his own soul*. Whatsoever therefore philosophers do tell us of a wise man, that he is no where banished, because he is a citizen of the world; I must think a Christian every where an exile, because he is a citizen of the heavenly *Jerusalem*, and but a *stranger and a sojourner here*. It was not absolutely in the capacity of the *father of lies*, that the devil boasted, that the earth was his dominion; for, as our Saviour stiled him, *the prince of this world*, I find, that he has all things here so much at his devotion, that there is no place, that he cannot lay an ambush in, since he can pervert even light itself, to hide his snares. Let us, therefore, hereafter endeavour still to stand upon our guard, as remember our selves to be in an enemy's country, where distrust is the only mother of safety; and since providence has so graciously presented us a lesson, our books would not have taught us, against such a fondness of them, as is injurious to piety, and dangerous to the soul; let us justify, better than this silly lark has done, that saying of *Solomon*, *surely in vain the net is spread in the sight of any bird*. Let not philosophy any more take up our life so, as not to leave us leisure to prepare for death, and study a science, which shall most benefit us in another world, and which alone will do so there. No, we may visit *Athens*, but we should dwell at *Jerusalem*; we may take some turns on *Parnassus*, but should more frequent mount *Cabvary*; and must never so busy our selves about those *many things*, as to forget that *unum necessarium, that good part, which shall not be taken away from us*.

OCCASIONAL REFLECTIONS.

The Last SECTION.

REFLECTION I.

Seeing a child picking the plumbs out of a piece of cake his mother had given him for his breakfast.

EUSEBIUS, LINDAMOR.

EUSEB. **T**HIS child is so much one in his humour, that despising meer bread, though never so nourishing and wholesome, his mother is fain to disguise the materials of it into cake, out of a belief, that the toothsome would make the nutritive part go smoothly down. But this liquorish chit, I see, defeats her plot, and knows already how to nibble off the bait from the hook, and casting by the meat, makes his whole meal of what was meant only for sauce, to give a relish to what he rejects for it. This puts me in mind of the unwelcome fate those papers of mine, that treat of devotion, have met with; for when I first was so unacquainted with the

world, as to expect, that piety and virtue were able, by their native charms, so much to endear my dress, as to win themselves adorers in a plain, or even a severe one; I ventured some of them abroad, though not in print, yet among my acquaintance, in a careless matron-like habit, in which I soon found they almost frighted most of those I had designed them to work the quite contrary effects on. But when my acquaintedness with the genius of the age had sadly taught me, that I was to alter my method, that the eloquence of virtue's sermons was that, which must attract an auditory, and engage attention to them; and that those orders of hers, in which she employed not rhetorick for her secretary, could not be so much as listened to, much less obeyed, I endeavoured to clothe virtue, though not in a gaudy, in a fashionable habit, and divesting her not only of her sackcloth, but her blacks, where I saw she appeared in them with disadvantage, I endeavoured to give

give her as much of the modern ornaments of a fine lady, as I could, without danger of being accused to have dressed her like a courtesan. This attempt having not proved so unsuccessful, but that many were pleased to assure me, I had not been unlucky in it, I spent some time in the self-denying exercise of minding words, and improving a style, I hoped to be able to improve to virtue's service, and subduing my inclinations to be fit to teach, as I had done to learn, her precepts; I sometimes, for her sake, tired my pen in a smoother, and more florid style, than that, which the nature of the studies I was most addicted to, made the most familiar to me, flattering myself with a belief, that since my writings had usually the good fortune not to be ill approved, I might so happily mingle and interweave instructions with delight, as to necessitate my readers to swallow both together, or at least bribe them by the latter to entertain the former.

LIND. You have better luck, as well as better skill, than many others, if you find it not often to fare with the fishers of men, as it did with those other fishers, that first were honoured with that glorious title, when they complained to our Saviour, that *we have toiled all the night, and have taken nothing*. For I see, that men are grown witty enough to elude what they cannot despise, and resemble the deaf adder, that stops her spiritual ears from hearkening to the voice of charmers, be the charmer never so cunning. And the best reception, that the movingest eloquence, that pleads for piety, can obtain of them, is but such as may serve to make that applicable to the preacher, which GOD once said to a prophet, *Lo, thou art unto them as a very lovely song of one, that hath a pleasant voice, and can play well upon an instrument; for they hear thy words, but they do them not*. But the best is, that you serve a master, that is as inclinable to reward, as able to discern intentions; and does not make his estimates by events, but judges of our performances, not by the effects they produce, but the affections they flowed from, and the ends they aimed at.

EUSEB. *The disciple is not above his master, nor the servant above his lord*. And therefore, Lindamor, as I dare not repine at the unsuccessfulness of my endeavours, so I dare think, that whilst it proceeds but from the obstinacy of others, it is not likely to be imputed to me by him, that complained himself, *that all the day long he had stretched forth his hands to an unpersuadable and gain-saying people*. Otherwise, I confess, I should not have much cause to be satisfied with the return, that all my endeavours have hitherto brought me home. For I see, that men can read a book of devotion as unconcernedly as they do a romance or a play, in both of them culling out only what they call wit, and making no better use of it than either to exercise or improve their own. They hear the most pathetick sermons, not as Christians, but orators; and if in such discourses they have been so just as to praise the rhetoric, they think they may well be excused, if they over-look the divinity: in short, nothing but

what gratifies their fancy can leave any impressions on their memory: and that itself, if it tend to reform them, makes none on their affections. And some, whose happier pens allow them to do it far more justly than I can, do complain, that if a devout book have not good store of witty passages, they will not mind it at all; and if it have, they will mind nothing else.

So that, Lindamor, I should sometimes be discouraged from prosecuting endeavours, which though they now and then succeed, are oftentimes so unprosperous, if I did not think with you, that they, who labour to win souls to God, are set on work by him, that having no need of our performances, seeks in our services but the opportunities of exercising his own goodness.

REFLECTION II.

Upon the sight of sweet-meats very artificially counterfeited in wax.

THE shape and colours of the best sweet-meats of these kinds are here so luckily represented by a skilful hand, that art seems to have designed rather to rival nature, than barely to imitate her; and a lover of junkets, that approaches not too near to these, must have much quickness of sight, or but little of appetite, if such inviting objects do not tempt him both to mistake and to desire them. But, though at this distance these alluring sweet-meats appear very pleasing, yet if one should be so unadvised, as to endeavour to eat them, instead of enjoying them more fully by the taste than he did by the sight, he would both spoil and disfigure them, and perhaps be so near choaking himself, that he would more earnestly wish them out of his mouth, than ever he wished them in it.

THERE are some pleasures and conditions too in the world, which make so fine a shew at a distance, that in those, that gaze at them aloof off, they frequently beget envy at them, and wishes for them; and yet he, that calmly beholds them, takes the best way of enjoying them: since that, which, whilst it is but aimed at, is expected to be but very satisfactory upon a nearer and fuller fruition, would be so far from proving so, and would so little be as sweet to the palate as specious to the eye, that it would not only cease to afford them any delight, but would make them wish they had let those deluding sweets alone, and would make attainments more uneasy and troublesome, than even desire was.

REFLECTION III.

Upon the eating of oysters.

EUGENIUS, LINDAMOR.

EUG. **W**HILST everybody else is commending these oysters, either with his tongue or with his teeth, so that one of the company sticks not to say, that they are as much worth, as if they contained each of them a pearl; you only seemed as unconcerned a spectator,

spectator, as if you thought their proper use, like that of flowers, were rather to be looked on than to be eaten.

LIND. I confess, *Eugenius*, that I found my self more inclinable to reflect on what you are doing, than to keep you company in it; and whilst I saw such persons so gustfully swallow these extolled fishes, that sight led me to take more notice than perhaps you have done of the strange power of education and custom.

EUG. And what, I pray you, has custom to do with oysters?

LIND. You will soon know that, if I tell you, that I was considering, on this occasion, how forward we are to think other nations absurd or barbarous for such practices, that either the same, or little better, may be found unscrupled at among our selves; and I acknowledge it to be one of the chief advantages I account my self to have obtained by my travels, that as I do not easily admire, so I am not forward to deride, the practice of any people for being new, and am not apt to think their customs must be therefore worse than ours, because they widely differ from them.

I COULD give you store of instances to justify this impartiality; but because the circumstances of eating and drinking are those, which make men, with the greatest confidence, term other nations brutish and barbarous, I will confine my self to some examples of that nature.

WE impute it for a barbarous custom to many nations of the Indians, that like beasts they eat raw flesh. And pray how much is that worse than our eating raw fish, as we do in eating these oysters? Nor is this a practice of the rude vulgar only, but of the politest and nicest persons among us, such as physicians, divines, and even ladies. And our way of eating seems much more barbarous than theirs, since they are wont to kill before they eat, but we scruple not to devour oysters alive, and kill them not with our hands or teeth, but with our stomachs, where (for aught we know) they begin to be digested before they make an end of dying. Nay sometimes when we dip them in vinegar, we may, for sauce to one bit, devour alive a shoal of little animals, which, whether they be fishes or worms, I am not so sure, as I am, that I have, by the help of convenient glasses, seen great numbers of them swimming up and down in less than a saucer full of vinegar.

WE detest and despise some other nations, for feeding upon caterpillars, grasshoppers, and other insects; and others, for feeding upon carrion, and stinking food.

AND do not many of us do as bad, when we not only eat, but extol, rotten cheese, whose livid colour sufficiently betrays its putrefaction, and whose odious smell offends most men's noses, and turns some men's stomachs? Nay, when this cheese is grown to that high degree of rottenness, that our critical palates like it best in, we then devour whole hundreds of mites, which are really crawling insects, bred out of putrefaction, and these too are so numerous and little, that our greediness makes us swallow many of them alive.

AMONG the savagest Barbarians we count the Cannibals; and as for those among them, that kill men to eat them, their inhuman cruelty cannot be too much detested; but to count them so barbarous, merely upon the score of feeding upon man's flesh and blood, is to forget, that woman's milk, by which alone we feed our sucking children, is, according to the received opinion, but blanched blood; and that mummy is one of the usual medicines commended and given by our physicians, for falls and bruises, and in other cases too. And if we plead, that we use not mummy for food, but physick, the Indians may easily answer, that, by our way of using man's flesh, we do oftentimes but protract sickness and pain; whereas they by their's maintain their health and vigour. And there is no reason, why it should be allowable to eat broth, for instance in a consumption, and be condemnable to feed upon it to maintain health.

BUT lastly, as the highest degree of brutishness, our travellers mention the practice of the Soldanians, at the *Cape of Good Hope*, who not only eat raw meat, but, if they be hungry, eat the guts and all of their cattle, with the dung in them. I will not answer, that I know several among us, (and perhaps some fair ladies too) that, to prevent the scurvy and the gout, drink their own or boy's urine: nor that women themselves do oftentimes take parmacetty inwardly, though the Latin name (*Spermacetti*) sufficiently declare what excretion of a whale it is (though perhaps mistakenly) believed to be: nor yet, that under the name of *Album Gracum*, dog's dung is commonly given to patients of all sorts and qualities, against fore throats: nor will I mention, that in *Holland* it is usual, as I have seen my self, to mingle sheep's dung with their cheeses, only to give them a colour and a relish. But I will rather demand, how much less we do ourselves, than what we abominate in those savages, when we devour oysters whole, guts, excrements, and all? nay, when not for physick, but only for delicacies, our courtiers and ladies themselves are wont to make sauce for the bodies of lobsters of that green stuff, which is indeed their dung. And to these I could add other examples, if I were not afraid to divert you too long from so much pleasure, as the company seems to take, in eating raw fish.

EUG. You put me in mind of a fancy of your friend Mr. *Boyle*, who was saying, that he had thoughts of making a short romantick story, where the scene should be laid in some island of the southern ocean, governed by some such rational laws and customs, as those of *Utopia*, or the *New Atlantis*; and, in this country, he would introduce an observing native, that, upon his return home from his travels made in *Europe*, should give an account of our countries and manners, under feigned names, and frequently intimate in his relations, (or in his answers to questions that should be made him) the reasons of his wondering to find our customs so extravagant, and differing from those of his country. For your friend imagined, that by such a way of proposing many of our

our practices, we should ourselves be brought unawares to condemn, or perhaps laugh at them, and should at least cease to wonder, to find other nations think them as extravagant, as we think the manners of the Dutch and Spaniards, as they are represented in our travellers books.

LIND. I dislike not the project, and wish it were prosecuted by somebody, that, being impartial, were more a friend to fables. For when I consider, that the name of Barbarian was given by the two noblest people of the earth, the Greeks and Romans, not only to all the rest of the world, but to one another, though both those nations were highly civilized, and the courtly Persians, and other voluptuous Asiatics, were perhaps no less so than they; I doubt, that most nations, in styling one another's manners extravagant and absurd, are guided more by education and partiality, than reason; and that we laugh at many customs of strangers, only because we never were bred to them, and prize many of our own, only because we never considered them. And we may well believe, that custom has much a larger empire, than men seem to be aware of, since whole nations are wholly swayed by it, that do not reckon themselves among its subjects, nor so much as dream, that they are so.

REFLECTION IV.

Upon a lanthorn and candle, carried by on a windy night.

AS there are few controversies more important, so there are not many, that have been more curiously and warmly disputed, than the question, whether a publick or a private life be preferable? But perhaps this may be much of the nature of the other question, whether a married life or a single ought rather to be chosen? that being best determinable by the circumstances of particular cases. For though, indefinitely speaking, one of the two may have advantages above the other, yet they are not so great, but that special circumstances may make either of them the more eligible to particular persons. They, that find themselves furnished with abilities, to serve their generation in a publick capacity, and virtue great enough to resist the temptations, to which such a condition is usually exposed, may not only be allowed to embrace such an employment, but obliged to seek it. But he, whose parts are too mean to qualify him to govern others, and perhaps to enable him to govern himself, or manage his own private concerns, or whose graces are so weak, that it is less to his virtues, or to his ability of resisting, than to his care of shunning the occasions of sin, that he owes his escaping the guilt of it, had better deny himself some opportunities of doing good, than expose himself to probable temptations. For there is such a kind of difference betwixt virtue, shaded by a private, and shining forth in a publick life, as there is betwixt a candle carried aloft in the open air, and inclosed in a lanthorn; in the former place it gives more light,

but in the latter, it is in less danger to be blown out.

REFLECTION V.

Upon the first audience of the Russian extraordinary ambassador, at which he made his emperor's presents.

I See the general expectation, that there will be here this night a magnificent appearance, has produced one. And, as it often happens in publick shews, that the chief part of them is made by those, that come to see them; so here, besides them, whose duty obliges them to attend at the solemnity, there is a greater concourse of fine people of either sex, than any thing of this nature has for these many years occasioned. And not only many of the ladies wear in their ribbands little less vivid colours, than those of their faces, and are set out with jewels almost as sparkling as their eyes, (which yet the courtiers think were able to warm the Russian hearts, though all the ice and snow of their country guarded them) but the men themselves are many of them as finely and as richly dressed, as if even they came as well to be seen as to see. And if the ambassador be, what a man of his employment should be, (and what some say he is) a person acquainted with the manners of men, he cannot but know, that we, as other nations, value our own fashions enough, to look upon men disguised by the Russian dress, as little better than anticks, if not as some new kind of northern animals. But for all this gazing throng of gaudy spectators, that were able to put an ordinary stranger out of countenance, to appear in a habit differing from their's; the ambassador, and those, that come along with him, think it not fit to decline the Russian habit or ceremonies for the English, but keep to the ceremonies used in *Muscovy*, as strictly, as if the monarch of it, that sent him hither, saw them here; and are not discouraged from this manly proceeding, by seeing themselves stared at for it by a number of gaudy spectators, that wear clothes, and use ceremonies, so differing from their's. And whatever those may think of the ambassador, that are wont to estimate men by the fashionableness of their clothes; yet the wiser and more intelligent do not blame him, for refusing to disparage the fashions of his own people, by appearing ashamed of them; but do rather think it prudent in him, to prefer the pleasing of his master, and his own countrymen, before the gratifying of strangers, since it is not here, but at home, that he expects the recompence of his behaviour, and embassy.

Thus, when a Christian, who belongs to a celestial king, and whose citizenship is in heaven, being but a stranger upon earth, converses among the men of the world, though in matters indifferent, there is oft-times required by prudence as much of compliance, as is allowed by innocence; yet, when there happens an occasion, wherein he cannot comply with the depraved customs of those, among whom he

lives, without disobeying him, for whom he lives, and whose servant he is, or doing something, that would derogate from the dignity of a person related to such a master, he will then less consider, what may be thought of him by a multitude, than what account he is to render to him, who has forbidden men *to follow a multitude to do evil*. And as he knows, that his reward would be much less than he reckons upon, if it were a thing to be received on earth, not in heaven; so, how strange and unfashionable soever his conformity to the orders of his own sovereign may appear, he chuses rather to displease men than God, and acts, as both *seeing*, and being seen by, *him that is invisible*.

A continuation of the DISCOURSE.

AND this ought to be more easy to him, than their singularity is to the Russians, I have been mentioning; for whereas these, if they be knowing, and impartial, refuse our modes and rites, not because they are worse, but only because they are other than those of their country; he refuses to conform to the forbidden fashions of this world, not for their being different from those of the kingdom he belongs to, but for their being bad, and condemned by him, that cannot err: whereas, of the opposite practices, the same infallible judge pronounces, by the mouth of a person by him inspired, that *these are the good things, and the profitable unto men*. And whereas these strangers see nothing in this magnificent assembly, whose fashions they decline, fit to be despised, but see some persons in it, to whom they pay a great respect, and who deserve it upon another account, than that of their wearing crowns; those, that are loyal to virtue, have cause to look upon those they refuse to be like, with a noble, and just indignation, as persons that have degraded themselves, and by unworthy practices blemished, and almost forfeited, the dignity of their nature, and the nobler title of Christians. And, whereas these Muscovites are morally certain, that we shall never prefer their fashions to our own, the Christian has as great an assurance, that those, whose practices he differs from, will one day repent, that their's differed from his, and will wish they had imitated what they now seem to scorn. And however, when he shall come to the celestial city he belongs to, he will be in no danger to be derided for the sake of piety, since those, that deride piety, will not be admitted there. And as these Russians could not take a better way, than that of not sneaking, to avoid the having their rites and persons undervalued; so for a Christian not to blush at his unfashionable practices, seems the hopefulest way to keep them and him from being scorned, especially with those, who having themselves no quality better than confidence, value it most in others. And sure it were a very unlikely way, to keep others from despising the customs of the heavenly *Jerusalem*, for him, that belongs to it, to appear ashamed of them himself. Nor have pious persons cause to be out of countenance, at the singularity even of a strictly virtuous de-

portment, since, being (as the Scripture tells us such men in general are) *fellow-citizens with the saints and domesticks of God*, they cannot justly be blamed, if they aspire to be as like as they can here, to those, whom they desire and hope to be perfectly like hereafter. And if the angels (as the Scripture in several places seems to intimate) are witnesses of our actions, the smallest number of unfashionable good men may, upon that score, say to one another, as the Prophet did to his servant, upon the account of the heavenly host that surrounded him, *Fear not, for they that be with us are more than they that be with them*. And the approbation of these illuminated, happy, and glorious spirits, is sure more considerable than that of mortal, and, which is worse, of sensual men, whether we consider their number, or their judgments. And however, the day will come, when those, that despise their singularity, will envy his happiness; one welcoming smile from Christ will make him amends for all the scornful smiles of sinful men; and the sentence of absolution, and bliss, solemnly pronounced before God, angels, and men, will not only recompense him for the world's dis-esteem, but shew, that he did not deserve it.

REFLECTION VI.

Upon the sight of roses and tulips growing near one another.

IT is so uncommon a thing to see tulips last till roses come to be blown, that the seeing them in this garden grow together, as it deserves my notice, so methinks it should suggest to me some reflection or other on it. And perhaps it may not be an improper one, to compare the difference betwixt these two kinds of flowers, to the disparity, which I have often observed, betwixt the fates of those young ladies, that are only very handsome, and those that have a less degree of beauty recompensed by the accession of wit, discretion, and virtue: for tulips, whilst they are fresh, do indeed by the lustre, and vividness, of their colours, more delight the eye than roses; but then they do not alone quickly fade, but as soon as they have lost that freshness, and gaudiness, that solely endeared them, they degenerate into things not only undesirable, but distasteful; whereas roses, besides the moderate beauty they disclose to the eye, (which is sufficient to please, though not to charm it) do not only keep their colour longer than tulips, but when that decays, retain a perfumed odour, and divers useful qualities, and virtues, that survive the spring, and recommend them all the year. Thus those unadvised young ladies, that because nature has given them beauty enough, despise all other qualities, and even that regular diet, which is ordinarily requisite to make beauty it self lasting, not only are wont to decay betimes, but as soon as they have lost that youthful freshness, that alone endeared them, quickly pass from being objects of wonder, and love, to be so of pity, if not of scorn; whereas those, that were as solicitous to enrich their minds, as to adorn their faces,

faces, may not only with a mediocrity of beauty be very desirable, whilst that lasts, but notwithstanding the recess of that, and youth, may, by the fragrantcy of their reputation, and those virtues and ornaments of the mind, that time does but improve, be always sufficiently endeared to those, that have merit enough to discern and value such excellencies; and whose esteem and friendship is alone worth their being concerned for. In a word, they prove the happiest, as well as they are the wisest, ladies, that whilst they possess the desirable qualities, that youth is wont to give, neglect not the acquit of those, that age cannot take away.

REFLECTION VII.

* An unpublished piece of the author's. (Taken out of the 2^d book of the * martyrdom of Theodora, and turned into an Occasional Meditation.)

Upon the sight of a branch of coral among a great prince's collection of curiosities.

THE present and future condition of a Christian, especially of a martyr, is not ill represented by what we take notice of in coral; for whilst that shrub yet lives, and remains fastened to its native earth or soil, it grows in an obscure region of the world, and is perpetually surrounded, and over-flown, by the brackish and unpleasant waters of the sea, and oftentimes exposed to the irregular agitations of its waves. Besides, the substance of this plant (as those that should know inform us) is but soft and tender under water, and its colour but sad and unlively: nor is it, like the tulip or the rose-bush, adorned with any pleasant verdure, and much less does it flourish with gaudy colours. And whilst it remains under water, the excellency of it does so little disclose it self, that men sail over it without suspecting or dreaming they have any thing of precious under their feet; and by the fishes, in whose region, or rather element it grows, it is passed by wholly unregarded: but when this unheeded coral comes to be torn off from its root, and plucked out of his soil, and so is killed in the capacity of a plant, it then exchanges the dark and unquiet place it was confined to, for a more elevated and lightsome region; and instead of sharing the fate of common shrubs and flowers, first to degenerate into fading colours and offensive smells, and then to perish, either by rottenness or fire, our coral, by the violence offered to it, acquires a delightful redness, together with a solidity and a durableness, that makes it a thing so lovely and immortal, that it serves for an ornament for the cabinets of the curious; and what stupid fishes do not at all regard, those nobler creatures, men, do so highly prize, that oftentimes it finds place even among the rarities of princes.

Thus, a true Christian, whilst he is yet confined to the region of the animal life, lives oftentimes in an obscure and low condition, and far from that prosperous state, wherein the world's favourites are wont to flourish: he is al-

most perpetually exposed to pressures and afflictions; and either most men consider him not at all, or those, that look at his outside only, are apt to despise him, because it is so homely. And he is not only in such a (seemingly forlorn) condition, as made the Psalmist complain of himself, that *all the waves passed over him*; but (like those plants of coral, that, not growing so near the shore, are constantly covered with water, as well as sometimes disordered by storms) the calamities, that do, as it were, overwhelm him, are never altogether removed, even in the intervals of those tempestuous fits, which increase his distresses: but when the violence of sickness, or the fury of a persecutor shall have taken away his life, he must be then translated into a higher and happier region, afflictions and distresses will be all left behind. And when the sensual idolizers of their bodies shall be condemned to have those as loathsome as were their minds, and as restless as their guilty consciences, his body will obtain new and glorious qualities like that of his redeemer, and his soul shall find no less happy a transfiguration; the mortal part will be swallowed up of life, that perfection, which is but in part, shall be done away. And these newly acquired excellencies of the whole man will never after vanish or decay. And he, that lived unregarded by the stupid inhabitants of the earth, shall be joyfully welcomed into the blest society of celestial spirits; and, what is infinitely more, be graciously welcomed and dignified by the Son of God himself. Men should not therefore, by a Christian's present state, take their measures of his future fate, but rather should remember, that he, who said of such, *They shall be mine in the day when I make up my special treasures*, is one, whose estimate of persons and conditions we may safely rely upon, since he is able to make any of them infallibly such as he pleases to pronounce them, and consequently we may look upon the constant Christian's differing condition, with his eyes, that said, *We are now the sons of God, and it does not indeed yet appear what we shall be, but we know, that when he shall appear, we shall be like HIM*; who would be like himself alone, did not his goodness vouchsafe to exalt those that love him, to a likeness, which makes them very unlike the gloriouseth things we here admire, by incomparably transcending them.

REFLECTION VIII.

Upon the sight of the effects of a burning-glass.

IT is a fault incident to many good men, to be too much indisposed to entertain the precepts of virtue, as such excellent things deserve, in case, those, that teach them, do not practise them. There are too many, that do not think themselves obliged to take even the wholesomest advice from those, whom they see more careful to give it others, than to follow it themselves. And some of them are so nice, that they will scarce read a book of devotion, unless it come, like that St. John eat in the *Apocalypse*, from the hand of an angel. But for my part, though I hope I both value and de-

fire

fire religious preachers as much as the rest of my brethren, yet I think it would be much to the injury of Scripture and of reason, if we should suffer the personal faults of men to keep them from doing that good, their nature fits them for. The etymology of the gospel importing its being welcome news, it is pity, that any one that teaches it should not have a title to the character *David* gave *Abimaaz*, of whom he said, that *he is a good man, and brings good tidings*. But my desirousness of piety in a preacher is more for others sake than mine. For I know not why truth, which is an intellectual thing, should lose its nature by any moral viciousness in the proposer. I know there is something extraordinary in the case of *Noah*, who awoke from his wine, and immediately prophesied, and yet the event verified his predictions. Our Saviour instructing his disciples about the Scribes and Pharisees, who sat in *Moses's* chair, at the same time commands them to conform to their doctrine, when he forbids them to imitate their example. The wise-men did not the less find Christ at *Bethlehem*, though the priests and Pharisees sent them without accompanying them thither. And the Assyrian general was cured of his leprosy by following the Prophet's prescription conveyed him by that *Gebazi*, who, by his unworthy carriage in that business, transplanted (if I may so speak) that foul disease into himself and his posterity. I will therefore consider sermons more than preachers: for as in a burning-glass, though the sun-beams do but illustrate, not heat, it in their passage, they may yet, by its assistance, kindle subjects, that are more disposed to receive their action: so those very truths and notions of a learned preacher, which do but enlighten him, may inflame his hearers, and kindle in their hearts the love of God. And as if a perfume be set on fire by the beams projected through a burning-glass (which they do not so much as warm in their passage) the scent is no less odoriferous and grateful, than if it had been produced by an actually burning coal. So neither is that devotion, which is kindled by the eloquence of an indevout preacher, any whit the less acceptable to God for their not being themselves affected with the zeal they beget in others. And what the book of *Kings* relates of *Elisha's* bones, contains a far greater miracle in the historical, than in the allegorical sense, in which it is no such wonder to see a man raised to life by a dead prophet.

REFLECTION IX.

Upon the finding a horse-shoe in the high-way.

THE common people of this country have a tradition, that it is a lucky thing to find a horse-shoe. And though it was to make my self merry with this fond conceit of the superstitious vulgar, I stooped to take this up; yet now I observe in it a circumstance, that may, for aught I know, somewhat justify the tradition. For I take notice, that though horse-shoes are by travelling worn out, yet if they had a sense of their own condition,

it might afford them some consolation in it, that the same journies, that waste them, make them both useful and bright. Whereas, though the horse-shoe I have taken up have not been consumed upon the account of travelling, it has been eaten up by rust, which wastes it as well as attrition would have done, but does not give it the lustre it would have received from that. I meet with many, who, very unmindful, that he, who was justly styled the wiseman, whose counsel it was, that *what ever our hand finds to do, we should do it with all our might, &c.* make it the main business of their life merely to lengthen it, that are far more solicitous to live long, than well, and would not undergo the least labour, or endure the least hardship, to do the greatest good, but had rather lose an hundred opportunities of serving God, or obliging men, than an entertainment, or an hour's sleep, and all this under the pretence of minding their health, and complying with the dictates of self-preservation. But I have often observed too, that even these jolly people, that seldom have a serious thought, but how to avoid serious employments, may, by making their whole lives a succession of diversions, or rather a constant diversion from the true end of them, make their lives indeed thereby useless, but not at all immortal. And truly, fevers, pleurisies, and other acute diseases, that are home-bred, besides those numerous fatal ones, that are caught by contagion, and a multitude of casualties, do cut off so many before they reach old age, in comparison of those, that the diligence, and industry, imposed by religion, or curiosity, destroy, that I think so great a fear of using the body for the interests of the soul, and of him to whom we owe both, does very little become his disciples, who said, that it was *his meat to do the will of God that sent him, and to accomplish his work*. The trouble of John iv. thirsting, and sweating, and undressing, would³⁴ to an ingenious man be but just recompensed by the bare pleasures of eating, and drinking, and sleeping: to confine an honest and inquisitive person from those, which he looks upon as the almost only manly employments, the exercise of virtue, and the pursuit of knowledge, by telling him, that such a forbearance may protract his life, is to promise a thing upon a condition, that destroys the end and use of it; and he will look upon it, as if you should offer him a horse, provided he will not ride him, or a perspective-glass, upon condition he shall not draw it out, for fear the air should, as it sometimes does, impair the glasses. A heaven-born soul would scarce think it worth while to stay here below, if its work must be, not to employ the body, but to tend it. Those, that are so unreasonably afraid to spend their spirits, are in some regards less excusable than misers themselves; for though both hoard up things, that cannot be better enjoyed, than by being parted, with, the chief uses for which they were intrusted with them; yet in this, those I blame are more censurable, than the covetous themselves, since these, by their niggardliness, can avoid spending their money, but the others,

by their laziness, cannot avoid the consumption of their time. I know a man may be prodigal of himself, as well as his estate; and that both those profusions are faults, and therefore fit to be declined. But if I could not shun both the extremes, certainly, since we all must die, and the question is not, whether or no we will live for ever, (for the most, that can be hoped for, is not to be privileged from death, but only to be longer reprieved) but whether we will rather endeavour to lead a life, mean, and unprofitable, a few more days, or a glorious life, for a somewhat less number of them? I should rather chuse to spend my life quickly, than uselessly; for he, that lays out himself for eternity, if he lose any portion of his time upon that account, is the sooner put into possession of an inexhaustible stock of it; whereas those, who, that they may live long, meanly forgo the ends of living, and seek, by laziness, to protract an insignificant stay on earth, would, should they reach their aim, add rather to their years than to their life.

REFLECTION X.

At the Hague.

Upon the shop of an ugly painter rarely well stored with pictures of very handsome ladies.

GENORIO, LINDAMOR, EUSEBIUS.

GENOR. **H**ERE is a deceitful shop of beauty, where many, that come but to wonder, meet with love, and even when they buy not what they like, pay their hearts for it; the shop being so well furnished, that beauty seems here to have assumed all the variety of features, and complexions, she can be dressed in, and so exquisitely to have fitted all gazers with proportionate and attractive objects, that nothing but an absolute incapability of love is here able to protect them from that passion, which, not to resent among so many inspiring wonders, were one. If in these faces, the originals equal the transcripts; if art have not flattered nature, and attempted more to instruct than imitate her; and if the painter have not elected, rather to have his pieces liked, than like, here are apologies for love, that can procure it, not only pardons, but profelytes. I must (in that case) add, that there are more suns than one, whose brightness, even by reflection, can dazzle; here are princeesses more illustrious for the blood, that lightens in their cheeks, than for that, which runs in their veins, and who, like victorious monarchs, can conquer at a distance, and captivate by proxy.

EUSEB. I fear, *Genorio*, that you are so transported with your text, that you will quite forget (if ever you intended it) to make a homily upon it: for you talk at such a rate, as if you were about to lose, to the pictures of ladies, the liberty, your friend *Mr. Boyle* would be thought to have ever defended against their originals, and fancied, that it might add to the other resemblances you so admire betwixt them, if both of them were made enemies to seriousness.

VOL. II.

LIND. I presume, *Genorio* will willingly allow me to serve him at this turn; for whether or no he meant us a reflection, some charms or other he has met with in these pictures, seem to have so arrested his thoughts, as well as his looks, that we shall not have them hastily delivered from so pleasing a captivity; and the knowledge I alone, of us three, have of the drawer of these pictures, supplies me with a circumstance, without which, I should not, when *Eusebius* is by, offer at an occasional meditation. But upon this advantage, I shall venture to tell you, that the thing I was considering, was, that though the limner have drawn some pieces, as handsome as lovers think, or wish their mistresses, and some (as they tell me) so like, that an actual confrontation of the artist's works, and nature's, would scarce distinguish them, (since the former would appear to differ from the later, but in that silence, which the later's admiration, to see themselves so perfectly represented, would impose) yet is the painter himself so deformed a creature, that he might draw a lovelier face even than any here, by drawing one perfectly unlike his own. Alas! this discloses the difference there may be betwixt the being able to write fine characters of virtue, and the possessing of it. How ridiculous should I esteem this limner, if with all this ugliness, he should esteem himself handsome, because his pencil can draw faces that are so! As absurd were it for us, to grow proud of our devout compositions, and fancy piety ours, because our discourses can possibly inamour others of it. The devil sometimes does unmoletedly suffer us to write well, if he can but persuade us we need do no more, and that good pens may dispense us from good actions. Our paper-wars against vices are oftentimes like *Alexander's* against the neighbouring nations, not out of hatred, but glory, not to extirpate, but to conquer them, and manifest to the world the sufficiency of our parts, by a victory, after which we often treat the vanquished enemy with greater courtesy, than those, whose quarrel we undertook. Discourses against vices may be as well indited by vanity, as by zeal, and meant to express wit, not persuade piety. And if (as it chanceth but too frequently) we grow proud of them, we do, like witches turning exorcists, only comply with Satan to cast out the devil.

EUSEB. To second your pious reflection, *Lindamor*, with some thoughts suitable to my profession, I will add, that in the case you put, Judg. viii. 24, 25, 26, &c. it happens to us as it once did to *Gideon*, who, of the spoils of God and *Israel's* conquered enemies, made an idol, which proved, in the end, his, and his house's snare. It was a most instructive check, and divine admonition, that our Saviour gave his Apostles, when, in the account they brought him of their embassy, they joyfully related their exercised power, of dispossessing devils; *notwithstanding* (answered Christ) *in this rejoice not, that spirits are subject to you, but rather rejoice, that your names are written in heaven.* In effect, though *Judas* were one of the persons, invested with this miraculous

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raculous power of casting devils out of others, yet we read, that *Satan afterwards entered into Judas, and that it had been good for him, that he had never been born.* And though, as *Solomon* tell us, *he that winneth souls, is wise,* yet it is he only, that shall do, as well as teach, the commandments, *that shall be called great in the kingdom of heaven.* And the judge himself informing us, that, at the world's last day, many will plead their *having in his name not only prophesied or preached, but cast out devils,* and shall yet be disclaimed by him, sufficiently intimates, that it is as possible, as unavailable, to do many wonderful works (for religion) and to be workers of iniquity. The true Christian should, *Lindamor,* be willing to impart any useful discoveries, that God shall please to vouchsafe him; but he will ever consider the takingest notions he can frame of virtue, more as engagements to it, than arguments of it: and since there is not any thing, in which charity ought more to begin at home, than in devout instructions, he will endeavour to make himself as much piety's votary, as advocate; to imitate those truly wisemen, that, as they informed those of *Jerusalem* of the star they had seen in the east, did themselves follow it, till it brought them unto Christ; to entitle himself to that of our Saviour, *a good man out of the good treasure of his heart, brings forth good things:* and (finally) to take his celebrations of virtue from his experience, not his fancy; as nurses first feed themselves, to nourish their sucking infants, to whom they give no meat, which they have not in their own breasts first digested into milk, lest (like the carpenters, that toiled to build the ark to save *Noah* from the deluge, themselves perished in,) *when he has preached to others, he himself should prove a cast-away.*

A continuation of the discourse.

GENOR. **S**URE, gentlemen, it is a happy thing to be able to convert the meanest things to the noblest uses, and make whatever one pleases subservient to piety, by skilfully employing even slight and unpromising occasions, to represent her, with the advantages of a varied and surprizing dress, whereby you may procure that virtue lovers, and your selves friends: for her votaries are so ingenuous and disinterested in their amours, that they have

as well a kindness for their rivals, as their mistress.

LIND. I will not deny, but that there may be persons so inflamed with heavenly love, that their devotion is able, like the last fire, that is to refine or destroy the world, to turn all things into fuel for its victorious flames; and who, when they are once engaged in meditation, can make their pious thoughts excite themselves and flame up higher, and higher, without the assistance of other incentives, than what their own fervency procures them; as it is observed, that when the fire has seized upon a town, by how small a spark soever it have been kindled, if the flame come to be very great, though the air be very calm, the fire it self will produce a wind, that without the help of bellows shall strongly blow it, and make it blaze the more, and aspire towards heaven. But, *Genorio,* whenever (for I answer but for my self) I shall meet with any such happy contemplators, I shall have the justice to be one of their admirers, without having the vanity to pretend to be one of their number.

EUSEB. And I, for my part, shall tell you, *Genorio,* that though there may be divers charitable persons, besides your self, that by the expressions it becomes me to use in some of my meditations, and other composures of the like nature, may be apt to fancy that I am my self as devout as I endeavour to make my readers, yet you must not imagine that my mind, like one of those writings, has no other thoughts than religious, or at least moral ones; for those may be the productions, not of a constant frame of mind, but of occasional fits of devotion: and you may read a greater number of such reflections in an hour than, perhaps, I have made in a month, not to say in a year. And I must ingenuously confess to you, that I think it more easy to make ten good sermons than to practise one, and to declaim against all sins than to relinquish any: there goes much less self-denial to conform to the precepts of *Cicero,* than to those of Christ; and I find it so much less difficult to excite other men's passions, than to command my own, that if you will not suffer your charity too much to injure your judgment, you must look upon the devouter passages you may have met with among my composures, as expressions of what I aim at, rather than of what I practise.



An Account of a very odd monstrous Calf; printed first in the Philosophical Transactions, N° I. p. 10. Anno 1665.

BY the same noble person [Mr. Boyle] was lately communicated to the Royal Society an account of a very odd monstrous birth, produced at *Limington* in *Hampshire*; where a butcher, having caused a cow (which cast her calf the year before) to be covered, that she might the sooner be fatted, killed her when fat, and opening the womb, which he found heavy to admiration, saw in it a calf, which had begun to have hair, whose hinder legs had no joints, and whose tongue was, *Cerberus*-like, triple, to each side of his mouth one, and one in the

midst: between the fore-legs and the hinder-legs was a great stone, on which the calf rid: the sternum, or that part of the breast, where the ribs lie, was also perfect stone; and the stone, on which it rid, weighed twenty pounds and a half: the outside of the stone was of greenish colour, but some small parts being broken off, it appeared a perfect free stone. The stone, according to the letter of Mr. *David Thomas*, who sent this account to Mr. Boyle, is with Doctor *Haughteyn* of *Salisbury*, to whom he also referred for further information.

An Observation imparted to the noble Mr. Boyle, by Mr. David Thomas, touching some particulars further considerable in the Monster, mentioned above; printed first in the Philosophical Transactions, N° II. p. 20.

UPON the strictest inquiry, I find by one, that saw the monstrous calf and stone, within four hours after it was cut out of the cow's belly, that the breast of the calf was not stony (as I wrote) but that the skin of the breast and between the legs of the neck (which parts lay on the smaller end of the stone) was very much thicker, than on any other part; and that the feet of the calf were so parted, as to be like the claws of a dog. The stone

I have since seen; it is bigger at one end than the other; of no plain superficies, but full of little cavities. The stone, when broken, is full of small pebble stones of an oval figure: its colour is grey like free-stone, but intermixt with veins of yellow and black. A part of it I have begged of Dr *Haughteyn* for you, which I have sent to *Oxford*, whither a more exact account will be conveyed by the same person.

NEW
EXPERIMENTS
 AND
OBSERVATIONS
 TOUCHING
COLD,
 OR,
 An Experimental History of COLD begun.

To which are added,

An EXAMEN of *ANTIPERISTASIS*, and an
 EXAMEN of Mr. *HOBBE S*'s Doctrine about COLD.

Whereunto is annexed an *Account of Freezing*, brought into the
 ROYAL SOCIETY by the learned Dr. *C. MERRET*, a Fellow of it.

Together with an *APPENDIX*, containing some promiscuous *Experiments* and
Observations relating to the precedent History of COLD.

Non fingendum, aut excogitandum, sed inveniendum, quid natura faciat, aut ferat. BACON.

The Publisher to the Reader.

A GREAT progress having been made at the press in the second edition of the *History of Cold*, before the author was acquainted with it, he did not think fit to make any alteration of the former edition, but left it to come forth this year, just as it was printed seventeen years ago, *viz.* in the year 1665.

FOR the same reason, the author declined making any alteration in the introductory preface; whose prolixity seemed very excusable, because it was not barely a preface to the particular book, whereunto it was prefixed, but (as the title was designed to intimate) contained divers considerations introductory to the *History of Cold* in general, and superadded divers experiments and observations to those, that were delivered in the history itself.

THE author thinks he may justly hope, that equitable readers will not look upon the thermometrical discourses, that are premised to the *History of Cold*, as unfit to appear again with it; though some of the particulars, that are there delivered as paradoxal, are now acknowledged for truths by most of the Virtuosi; and others, that are proposed as new observations and practices, are, at present, come into common use among the curious. For the ancient

date of these discourses will easily make it appear, that the things they mainly consisted of, were then novelties. And he hopes it will not disparage them among the equitable readers, that many have since thought fit to embrace the opinions, and make use of the practices, there proposed.

BUT it will be now expected, that somewhat should be said about the following Appendix, wherein the author is very sensible, that he stands more in need of the reader's equity and favour. For, not being solicited to make a second edition, (after men's curiosity and the fire of *London* had dispersed or destroyed the first) till want of leisure made him unwilling, and want of health almost unable, to revise and prosecute that work; he threw aside the particulars he intended to add among other loose papers, where for many years they lay neglected, and probably there were divers of them lost: so that when the stationer and several other persons were pressing to have a new edition of the former *History of Cold*, and gave the author notice, that a good part of it was already printed off, and waited for some additions, that they earnestly desired, he had much ado to retrieve any considerable

considerable number of notes; most of which too being occasionally written, when he could not get one exemplar to collate them with, (the Stationer himself having not so much as one book left) it was almost necessary, that many of them should be so written, as to be easily and smoothly joined to the titles of the formerly published history. So that the author (who at that time was much indisposed) having neither health nor leisure to put this chaos of loose memoirs into some order, desired a learned friend to take upon him the trouble of doing it for him: yet it was not possible, for all that ingenious person's care and diligence, to give a good method and smooth connexion to so confused an heap of particulars; all that the difficulty of the attempt permitted him to do, being to refer the particulars, as near as might be, to the respective titles they seemed most to belong to.

It remains, that the reader be told, whence the materials have been taken, whereof the following Appendix doth consist: some few of them have been drawn out of printed books, because cold (in itself, a subject barren enough) has been left so uncultivated by classick authors, that, according to our judicious *Verulam's* advice, it was not thought fit to cast away any credibly-related matter of fact, that might add to the history of it. But the greater number by far of the following particulars was taken from the relations of navigators and travellers, whom the author had the curiosity to consult about the phænomena of cold, they had met with. And for the better gaining of such informations, he became an adventurer in that, which is commonly called the *Company of Hudson's Bay*; to which those that are from time to time sent from *London*, do, either in their voyages thither and back again, or in their stay in that frozen country, not unfrequently meet with considerable, though unwelcome effects of cold. But two persons there are above the rest, from whose answers the author drew the considerablest part of the following Appendix. One was an ingenious English physician, dead many years since, that was archiater to the then Russian emperor; for whom our author having furnished this physician with some pleasing, and yet effectual, chymical medicines, that were very well liked, and nobly rewarded by the Czar, the author desired, as his recompense, to have some observations about cold (whereof he sent a list) made in *Russia*, and especially at the city of *Moscow*, where the physician, attending his master, resided. The answers to Mr. *Boyle's* queries were, by misfortune, not sent by themselves, but in several letters intermingled with so many other passages, relating to the Russian monarch's government, religion, &c. that to put them in the writer's own words (which was thought the fairest and surest way to prevent mistakes) some of them must be dismembered from the context, and so must appear as torn and incoherent rags, and consequently to the great disadvantage of the papers they are made parts of. The other principal informations to be met with in this Appendix, the author received in divers

conferences he procured with an ancient sea-captain, who was looked upon as the greatest navigator into the Northern seas, that has been known; upon which account his majesty himself had the curiosity to send for him, and discourse with him. This lusty old man had made above thirty several voyages into the frigid zone; and being then (as he still is, if he be yet alive) in the service of the company of *Hudson's Bay*, was, upon that account, the more willing, and the more free, to make answer to the author's questions, even when it required the discovery of his most secret observations. And, that this preface may not be altogether useles to the design of the history it belongs to, I shall add, on this occasion, that the author having been visited by the principal person, that ventured to winter in *Hudson's Bay* (where the ingenious captain *James*, often mentioned in the foregoing history, found it almost, if not quite, as rigorously cold, as the *Hollanders* found *Nova Zembla*) he was particularly inquisitive to learn of this person, how he was able to support the extreme rigours of the cold all the winter long: to which inquiry the navigator answered, that the cold was scarce sufferable the first year he settled there; but that afterwards they had found an expedient to make their wintering not only tolerable, but comfortable enough. And being pressed to name this expedient, he ingenuously confessed it to be this; that they dug so deep into the earth, where they thought fit to erect their wintering-house, that about one half of their mansion, and that part, wherein they dwelt themselves, was built under ground; by which means the cold air could not laterally pierce into it, so that they slept warm enough, and in the day-time could keep themselves from excessive cold, as long as they continued in that subterranean part of their house.

THE following papers having been sent away to the press, without being reviewed by the author after the particulars, that compose this Appendix, were ranged in the order they now appear in; when afterwards he received them all at once as they now stand printed, he found (not without being troubled at it) that to comply with the design of referring particulars to their proper heads, some passages in this new model of them had lost their dependencies, or the connexions they had in the papers whence they were taken. As for instance, the governour of *Smolensco*, upon the borders of *Poland* and *Russia*, though not here called by his own name, is mentioned as a person formerly nominated; which might well be done in the papers, whence this particular was extracted, because he had in them, before that, been quoted by the name of Lieutenant-General *Drummond*. Nor is this, (it is feared) the only passage, wherein the almost necessary dislocation of particulars, that before had a manifest connexion, may need the reader's pardon, which is therefore begged by the author; who yet hopes, that these passages will not be found numerous, and that an attentive reader will, by circumstances, easily enough discern what things are his own, and those comparatively few, that might have been

more expressly delivered, as received from others. This inconvenience was not espied, till it was too late to prevent it.

SOME few particulars in the following Appendix may perhaps be found coincident, as to the main, with some passages of the book it is annexed to, and yet differing in some circumstances. But these the author thought it candid not to suppress, because in historical matters truth is the thing, that is to be principally regarded: besides, that in these points, wherein the relations of the history and of the Appendix agree, they will mutually confirm each other, (which in matters, whereof few trials or observations are yet extant, is a thing of no small moment;) and those circumstances, that may suggest limitations or cautions, may be of good use in the *Philosophick History of Cold*, and engage the curious to make a farther search by heedful and repeated trials.

THE author had divers other papers, that might have enriched the present Appendix, if the confusion, that was occasioned among his manuscripts, by a sudden fire, that obliged him very hastily to remove them after midnight, had not suppressed them, (and which he hath elsewhere complained of, as very prejudicial to him in reference to other tracts) at least till another opportunity. But without the prospect of a larger appendix, the printer wanted not encouragement to press for a second edition, by the favourable reception, that was given to the first by divers learned men, not only at home but abroad: where Monsieur *Du Hamel*, famous for many curious and elaborate pieces, in one of his learned treatises, gives this character of the foregoing history: *Cum anno superiore inciderim in librum de frigoris historia, ab illustri & doctissimo viro D. Boyle compositum, quo argumentum, à philosophis penè intactum, tam diligenter & eruditè pertractavit, ut vix quicquam accuratius sperari possit. Du Hamel Corp. Aff. Cap. de Frigore.* And since him an ingenious doctor of physick, (that in a cold climate has written, though not copiously, yet learnedly and *ex professo*, of cold) speaks thus of our author and of his history: *Agmen hoc*

eruditum (having spoken before of the chief authors, that have written about cold) *claudat Dominus Boyle, delictum & ornamentum nostri temporis, cui jam nunc omnem nostram attentionem renovare æquum est. Non enim aliam ob causam hoc loco ultimo eum amplectendum nobis servavi, quàm ut veluti per compendium, liberiori tamen paulò excursione factâ, & seposito nonnihil capitum præcedentium ordine, tum ea, quæ jam partim allata fuere, tum quæ dicenda adhuc restant, sine tædio & concinnâ brevitate, ejus quasi ductu, quem toto hoc lubrico & glaciale itinere duce mibi proposui, examini ulteriori subjicerem.* *Conradi Dissertat. Medico-phys. de Frigoris Natura & Effectibus, pag. 51.*

THESE just eulogies of our honourable author (to omit many others) are here inserted, not to grate on his modesty by the repetition of his own (tho' merited) praise, but as incitements to the studious to peruse his philosophy, with the principles thereof, contained in this and his other tracts, (which in many things differ from those of the *Peripatus*, the *Academia*, and the *Stoa* too) in regard they have already passed the test of the learned both at home, and also beyond the seas. For though, as an ingenious writer speaks in another case, little heed is to be given to the gale of a private man's fancy, yet it is considerable, when the wind blows from all quarters. The universal approbation, which the labours of our author have met with, requires an high veneration for, and medullary search into, his writings. It was the saying of an ancient rhetor, in reference to oratory, *Ille se multum profecisse sciat, cui Cicero valde placuerit*; which may be applied with as much veracity to Mr. Boyle, whose philosophical lucubrations about the subjects he is pleased to ventilate and discuss, are the top of their kind. Therein the *Initiati* may find great encouragement for their progression, and also those, who are more experienced, and sit but one form below the *Adepti*, may count it no disparagement to learn of him, whose disquisitions have been so instructive to the learned world.

AN ADVERTISEMENT.

THAT the reader may not wonder to find the following dialogue cited in the *History of Cold*, whereunto nevertheless it is subjoined; he is to be informed, that a section about *Antiperistasis* was really both written and transcribed before any part of that history was sent to the press. But finding, that the accession of new particulars had so much swelled it, that it was unfit to pass (as I first designed it should) for one of the titles of the *History of Cold*, I judged it convenient to sever it from the rest, upon the score of its bulk, and yet annex it to them upon the account of those many historical passages in it, that belong to the same subject, that is handled in those sections. The reader will quickly find, that the

tract consists of two parts, whereof the first (which to allow the more freedom of inquiry and discourse, written in the way of dialogue,) contains an *Examen* of *Antiperistasis*, without pretending to question it absolutely and indefinitely, but rather, as it is wont to be taught and proved. And this dialogue, for reasons, that it too little concerns the reader to know, and would take up too much time to tell him, both begins as a continuation of some former discourse, and somewhere mentions the author, as a third or absent person. And to make it the more like to other dialogues, the quotations are not made with the author's punctuality in the rest of this book, but yet with his usual faithfulness; nor hath his introducing

men discoursing (as it were by chance) kept him from putting into the margin the very words of some passages, which he thought the most important and likely to be distrusted. But though this first part be entire and finished in its kind, and so might very well (if not best) have been put forth single, to invalidate the common doctrine of *Antiperistasis*, (in the sense wherein it is there opposed;) yet be-

cause in philosophical matters, it is not so much victory or applause, that is to be sought, as truth; I forbore not to subjoin to a discourse, that may perchance satisfy most of my readers, some scruples, about which I wished for further satisfaction and certainty my self; of the chiefest of which, the sceptical consideration will give the reader an account.

The PUBLISHER to the Ingenious READER.

I AM fully persuaded, you will much rejoice to see that exquisite searcher of nature, the illustrious *Robert Boyle*, come abroad again, as knowing he never does so, but when richly furnished with very instructive and useful matter. He presents you here with a treatise of *New Observations and Experiments, in order to an Experimental History of Cold*. This is the body of the book; but it comes accompanied with some Preliminaries, and an Appendix, whereof the former contains *New Thermometrical Experiments and Thoughts*, the latter an *Exercitation about the Doctrine of Antiperistasis*, followed with a short *Examen of Mr. Hobbes's Doctrine, touching Cold*. From all which it will more and more become manifest, with what spirit and care this excellent person advanceth real philosophy; with what exactness he pursueth his engagement therein; and how great caution he useth, that nothing may slide into the philosophical store, that may prove prejudicial to the axioms and theories hereafter perhaps to be deduced from thence.

HAVING thus shortly given you my sense of the substance of this considerable treatise, I am now to advertise you of one or two circumstances, necessary to be taken notice of in its perusal.

ONE is, that the noble author being at *Oxford*, when the book was printed at *London*, he hopes the reader will not impute to him the errors of the press, which yet he is persuaded will not be many, and out of which must be excepted a blank or two, occasioned by this, that the author's papers being near two years since given to be transcribed to one, whose skill in writing was much greater, than (as it afterwards appeared) his knowledge of what was, or was not good sense, or true English; this person suddenly going for *Africk* before the transcript had been examined, and not taking care to leave all the first copy, the author found, (besides several blanks, that he filled up out of his memory, or by repeating the experiments, they belonged to) one or two, where he was not able to repair the copist's omissions: and besides unexpectedly met with very many passages so miserably handled, that by putting him to the trouble of writing almost a new book, when part of this was already in the press, it much retarded the publication of that, which now comes forth.

THE other is, that, whereas in the preface some passages are so penned, as to suppose the book to be published early in the winter, the reader is to be advertised, that the former part of this preface was sent a good while since to the press, though the latter, however then written out, was hindered from accompanying it, by some hopes of the author's to gain by delay an opportunity (he missed of) to perfect an experiment he was desirous to insert; and that, when the frost began, which was late in the season, the coldness did within a while arrive at that degree, that by its operation upon the moistened paper, it long put a stop to the proceedings of the press. But the author, that he might neither be quite defeated of his aim, nor disappoint the curious of their expectation, did in the first or second week of the frost, which was about the end of the year 1664, present the Royal Society with divers copies of the *History of Cold*, though the book were not then quite printed off. And these books being so near finished, that of twenty-one sections, whereof the *History of Cold* consists, the press had then reached to about the 19th, and I had the 20th in my hands to supply it, when the weather should permit; the author hoped, that by seasonably communicating so much of his intended treatise to so many of the Virtuosi, that were the likeliest to make use of it, he had pretty well provided against the prejudice, that might otherwise accrue from the slowness of the press, and therefore allowed himself to subjoin to the history, the discourse of *Antiperistasis*, and the *Examen* of Mr. *Hobbes's* doctrine *, as belonging to the same subject. And finding the frosty weather to continue later than was expected, (which had he foreseen, before his history was printed off, it would have given him opportunity of enlargements) he hopes the publication may not be yet too late for diligent readers, to make some use of the season for examining his experiments, or trying some of the new ones, those may suggest. And therefore for the quicker dispatch of the book, he purposely omits, and reserves for another occasion, besides the papers, that he hath not yet given me, some that I have already in my hands. And it is, I presume, for the same reason, that he forbears to publish, what he long since writ about the origin of forms and qualities, in a small tract, which he had

* It was thought needless to insert Mr. *Hobbes's* scheme touching this subject, because it only shews, that wind is the cause of cold.

The Author's PREFACE.

thoughts of sending forth in the company of the ensuing history, as a discourse fit to be an introduction as well to that, as to his historical writings about colours and some other qualities.

THIS is all the advertisement I had to give you. And seeing it would be altogether impertinent, for me to take any pains, or to use

any art to procure a gift for a book, composed by Mr. Boyle, I have no more to say, but that the author being so generous as to oblige foreign nations as well as his own, has already taken care of having it put into Latin. Farewel.

London, March
10, 1663.

H. O.

The Author's PREFACE *Introductory.*

COLD is so barren a subject, and affords so few experiments, that are either very delightful for their surprising prettiness, or very considerable for their immediate use, that instead of admiring, that any of my friends should wonder at my having been induced to write of such a theme, I freely confess, that I have been sometimes tempted to wonder at it myself; and therefore I think myself obliged to give my readers an account of these three things; Why I thought fit to write of cold at all? For what reasons I have treated of it after the manner to be met with in the ensuing book? and, Why I venture my unfinished collections about it, abroad so soon?

I. To satisfy the first of these queries, I have several of these things to say.

AND first, that the subject I have chosen is very noble, and important; for since heat has so general an interest in the productions of nature's phenomena, that (motion excepted, of which it is a kind) there is scarce any thing in nature; whose efficacy is so great, and so diffused, it seems not likely, that its antagonist, cold, should be a despicable quality. And certainly cold, and heat, especially when employed by turns, are the two grand instruments, by which nature performs so many of her operations here below, that our great *Venerulam* did not speak inconsiderately, when he called heat the right hand of nature, and cold her left: and though in our temperate climate the effects of cold seem not to be very remarkable, yet besides that in more northern regions they are oftentimes stupendous, the nature of that quality must needs be very well worth our considering, if it were but for the power it has to moderate and check the operations of heat; upon which account alone, if there were no other, it may be looked upon as so considerable a quality, that even lesser discoveries about it may both be acceptable and prove useful.

IN the next place I shall represent, that notwithstanding cold's being so important a subject, it has hitherto been almost totally neglected. For I remember not, that any of the *Classick* authors, I am acquainted with, have said any thing of it, that is considerable. They do indeed generally treat of it, as one of the four first qualities. But that, which they are wont

to say, amounts to little more, than that it is a quality, that does congregate both things of like and unlike nature; the unsatisfactoriness of which vulgar definition I had some years ago an occasion to manifest (in another treatise, the *Sceptical Chymist*;) and having given us this inconsiderate description of cold, they commonly take leave of the subject, as if it deserved no further handling, than could be afforded it in a few lines, wherein indeed they say too much about it, but not enough. And even among other writers of bodies of natural philosophy, or of the doctrine of meteors itself, the reader will find, how little of true and pertinent has been contributed to the ensuing *History of Cold*. And though among the vulgar, and the writers, that adopt their traditions without examining them, I find some few particulars delivered touching cold; yet some of them are so untrue, and others so uncertain, that they have furnished me with little else, than the necessity of questioning, or of disproving them: so that when I considered all these things, I could not but take notice, that very little hath hitherto been said of cold, by those schoolmen, and other writers, (that I have yet met with) who have professedly, (though but perfunctorily, and, as it were, incidentally) treated of it. But yet instead of thinking it a discouragement, that so many learned men, to whom that quality could not but be obvious, and to whom it was as familiar as to me, had in so many ages said little or nothing of it to the purpose; I found this very thing an invitation to my attempt, that I might in some measure repair the omissions of mankind's curiosity towards a subject so considerable, and so diffused, by trying what I could do toward founding the history of a quality, which has been hitherto so neglected, as if all men judged it either unworthy of being cultivated, or incapable to be improved.

ANOTHER inducement to me was, that having six or seven years ago written some tracts (though I have not since had opportunity to publish them) in order to the *History of Heat and Flame*; it seemed the more proper for me to treat of the contrary quality, *Cold*; since, according to the known rule, confronted opposites give themselves a mutual illustration. And another inducement of almost the same nature was afforded me by remembering, that whereas cold, in its higher degrees, is wont to be communicated

communicated to us by the air, (whencesoever the air has it) and I have on several occasions been obliged to treat of divers properties of the air, as of its weight and spring (in my *Physico-Mechanical Treatise*) of the several strengths of that spring, in proportion to the degrees of the air's condensation; the experiments of which, reduced into tables, were first published (and for aught I yet know made) by us, (in the defence of that book against *Franciscus Linus*, chapter the fifth of that treatise) and of divers other qualities of the air in several passages of our other writings, which it were now superfluous to take notice of; all this made it appear convenient enough, that among other attributes of the air, which we either have had, or expect to have occasion to treat of, so eminent and diffused a one as its coldness should not be left untouched by the same pen.

BUT though neither any, nor all these inducements had been sufficient to engage me to draw together, and recruit my observations concerning cold, there was another, that could not miss of prevailing, the command of the Royal Society, imposed on me in such a way, that I thought, it would less misbecome me to obey it unskilfully, than not at all. Especially since from so illustrious a company (where I have the happiness not to be hated) I may in my endeavours to obey and serve them, hope to find my failings both pardoned, and made occasions of discovering the truths, I aimed at.

II. After this account of the motives, that induced me to resolve to draw together the notes I had on several occasions set down, about the phænomena of cold, it may be now expected, that I render some reason, why I have thus digested them, and why I have not written the following treatise in a more accurate way.

First, then I readily acknowledge, that the method is not exact. Nay, that it is less so than the scheme of heads of inquiry, that I drew up, to give my self a general prospect of the subject I was to handle. But when I had considered, how comprehensive a theme I had pitched upon, and how much more comprehensive, future discoveries and hints might make it, I thought it altogether unadvisable for me, that had no more time, nor no more opportunity than I had, when I begun to compile the following history, to engage my self to a method, according to which I was not perhaps able to treat of any one of the principal parts of the designed history. And yet, on the other side, being unwilling to huddle my experiments confusedly together, I thought it an expedient, that might in great part decline both those inconveniencies, to draw up a company of comprehensive titles, under which might commodiously be ranged most of the particulars I had observed, reserving those few, that were not so easily referrible to any of those, to be thrown at last into a section by themselves. And this I the rather did, because I would not, by a confinement to a strict method, discourage others from continuing the history, by adding new titles to those twenty-one, I have treated of, as well as by in-

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serting other experiments or observations in any of them.

THAT the sections or titles are very unequal, will not, I presume, be much blamed by them, that consider, that my design being to set down matters of fact, not write a complete and regular treatise, the length of each section was to be determined, not by its proportion to that which went before it, or followed after it, but by the number and condition of the particulars, that were to compose it. And I thought it much more pardonable, that any of the sections should be disproportionately short, than lengthened either by untruths or by impertinencies.

SOME of the accounts will probably to some readers appear too prolix; and I could very easily, as well as willingly, have prevented that objection, if I had not more consulted the scope of the book, than the ease or reputation of the writer. But my design being, not only to gratify some readers, but to assist others to prosecute the work I had begun, as the experiments are most of them new, and many of them tried by methods hitherto unpractised; I conceived my self obliged to set down somewhat circumstantially, not only the events, but the manner of my trials, that I might at once, both the better satisfy the scrupulous, and be assistant to those, that would examine or repeat such experiments, and also gratify those, who are pleased to think, that a somewhat assiduous conversation with nature may have given me some little faculty in devising experiments, and the ways of making them, above those, that have been conversant only with books and notions. And in some of the following trials I was the more induced to set down all the principal circumstances, because that being not to be made, but by the help of glasses skilfully shaped, and hermetically sealed, and other instruments and operations, that require more tools, and more of manual dexterity, than every ingenious man is master of; it is very likely, that most readers will not be able, or perhaps willing, to reiterate such trials, and therefore will be glad to find them so delivered, as that they may without too much danger acquiesce in them, as being made with diligence as well as faithfulness. The latter of which qualities will, I presume, be allowed me, as well upon the account of the plain and simple way, wherein matters of facts are delivered in the following book, as upon the score of the testimonies, that even adversaries, as well as others, have thought fit to give to the historical part of my former treatises. And (to intimate that on this occasion) this strict fidelity to truth I scruple not to own, though perhaps it may be attended with an inconvenience in point of reputation, that writers of less veracity are exposed to. For I have found by experience, that some men, who probably would not mention the experiments of most others, without vouching their authors, for fear of losing their own credit, in case the thing related should not prove true, have, without taking the least notice of me, made use of such experiments of mine, as I have strong motives to think they never made nor saw, only because

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they

they had been related by one, after whom they thought they might without a hazard of their credit deliver any matter of fact. And the liberty, that some have allowed themselves in adopting my communications (such as they are) is notorious enough to have been publickly complained of more than once, by persons, that are meer strangers to me. But though I had not the probability, which the notice, that begins to be taken of it, seems to give me, of having some justice done me; yet veracity is a quality, that does, I think, so well become a Christian and a writer of natural history, that I had much rather undergo any disadvantage, I may be subject to for it, than decline the practice of it. But to return to the following history.

I CONFESS the prolixity of some passages of our history is increased by the transitions, excuses, and suspicions, that are made use of in them; but I confess too, that if this way of writing be a fault, it was not always caused by inadvertency. For as to what is said to connect the parts of our history together, or excuse the not prosecuting of this or that particular trial, the heedful reader may oftentimes perceive, that they contain in them, though not perhaps conspicuously, either cautions, or advertisements, or hints, not impertinent to my main scope, and improveable by an attentive peruser. And as for the suspicions and scruples, to which now and then I may seem to have too long indulged, I had two or three inducements to invite me to what I did. For the mention of conjectures, that every reader was not so likely to light upon, might more conduce, than at first one would think, to the main design of my book, which was to begin, and promote the natural history of cold; since these suspicions about the causes and scruples about other things, relating to our experiments, may probably produce, not only new reasonings and inquiries, but new trials, to clear the difficulties, and determine the doubts. Besides, I thought it not amiss to take such occasions to make some readers sensible, that to make indubitable inferences even from certain experiments is not near so easy a work, as many are pleased to imagine. And whereas I was not without inducements to think, that some critical and sagacious readers will not only excuse my having taken notice of so many scruples, but wish I had moved more on some occasions, and proposed some in certain cases, where I have not mentioned any, I thought it might invite such jealous readers to think, that I foresaw divers little difficulties and scruples, that might be moved in several cases, where I have not expressly taken notice of them, either because I judged them easy enough to be answered without my help, or because the things themselves were not considerable enough to deserve a long or solicitous discourse to clear them, especially from a writer, that being often tired himself in examining such niceties, was afraid he should too much tire the generality of his readers, if he should too frequently insist upon them.

If it be objected, that notwithstanding some things are set down prolixly, yet other experiments, that might properly be referred to some of the titles I handle, are wholly omitted; I answer, that this were indeed a fault in one, that should pretend to write full and accurate discourses of the subjects proposed in his titles, but not in me; who do not at all pretend to say, under each head, all that may be pertinently referred to it, (for that may probably be a great deal more, than is yet come to my knowledge) but only those particulars, that I myself have tried or observed, or at least have received upon credible testimony. And, perhaps, some amends may be made for these omissions, by my having frequently enough mentioned the experiments, that, when I proposed them, I had only designed or attempted without perfecting them. For the experience of many ages has shewn us, that hitherto, not only men do not appear to have made any store of trials concerning cold, but seem not to have so much as designed it. And therefore it seemed not unreasonable to presume, that it would prove an assistance to the generality of readers, if probable and practicable experiments were proposed to them. And since it is the improvement of the subject that I aim at, by whomsoever it may happen to be improved, I thought it but reasonable to use my endeavour, that those experiments, which for want of opportunity I myself could not try, might be tried by others, who may be befriended by more favourable circumstances. Nor is that great ornament and guide of philosophical historians of nature, the Lord *Verulam* himself, ashamed to substitute, on I know not how many occasions, his *fiat experimentum*; that is, a precept or a wish to have an experiment made, instead of an account of the experiment made already. And yet in this mention of things, I could wish to have tried, I have been far more sparing than every reader will take notice of. For I judged it not discreet to mention all the experiments I had thought upon, or even already set down in several catalogues, lest they should appear extravagant to those, that are unacquainted with the several notions, and trials, and contrivances, which made them appear to me not irrational, and which yet it would have been tedious, and not worth while to have particularly mentioned.

BUT that in what we have newly (and a little before) had occasion to say of our ways of making experiments, our meaning may not be misconstrued, we must here advertise the reader, that though, in many of the following experiments, the contrivances will not, perchance, be disliked, yet, in many others, they are far enough from being such, as might have been proposed by one, that had wanted no accommodations fit for such a work as ours. But I was reduced to make many of those experiments in a village; and whilst I was writing them, was obliged to make frequent removes, by which means I seldom had the liberty to make my trials after such a manner, as I could contrive them; if I could have instruments and
other

other assistance to my wish. For sometimes I wanted conveniently-shaped glasses; sometimes the implements necessary to seal them up with; sometimes such ingredients, as I needed to work on; oftentimes frosty weather, for the freezing of bodies to be exposed to the open air, and not seldom ice and snow for artificial congelations; sometimes weather-glasses, especially sealed ones, two of which being unluckily broken after one another, kept me from being able to make divers considerable experiments; sometimes tender scales, and sometimes other mechanical instruments of several sorts, and more than sometimes (for it happened very frequently) I wanted time so to prosecute and finish the experiments, as to satisfy myself about divers circumstances, which, though possibly few readers will take notice to be wanting, I would gladly have observed, if I had not been hindered, not only by the haste I was often fain to make for fear of losing a frost, but the importunities both of other avocations, and even of the distraction given me by the multitude of experiments, which haste made me prosecute at once. And indeed, as in divers others of the treatises, I have occasionally written, so particularly in a great part of this *History of Cold*, my writing in places, where I wanted such mechanical accommodations, as I could have wished for, and devised, has reduced me oftentimes both to leave experiments untried, that would have much illustrated my subject, or cleared the difficulties of it, and contrive several of those I mention, not after the best manner that might be, but after the best manner, that was practicable by the accommodations I was then able to procure: so that it need not be wondered at, or blamed, if in some passages of these papers, experiments to the self-same purpose are more accurately tried, or by more expedient ways at one time than another. For as a physician, if he come to practise in the country, where apothecaries shops are but ill furnished, both as to the number and as to the quality of the drugs, must accommodate his practice to the scant *materia medica*, of which alone he has the command: so when I write of experimental matters, in places where I cannot have workmen, nor instruments fit for my turn, I must be content to vary my experiments accordingly; and suit them to the accommodations I am confined to; which, though it be an unwelcome condition, is made the less so to me, by a hope, that the equitable readers will think it to be all, that a man is bound to do in such cases, to procure the best assistances he can, and manage those, he is able to procure, to the best advantage.

AND this I rather take notice of on this occasion, that ingenious men might not be too much discouraged by imagining, that, because they live in the country, or upon other scores, cannot furnish themselves with the best instruments and accommodations, nor enjoy the assistance of the skilfullest artificers; they are either unqualified for the making of experiments and observations, or superseded from it. For though, in some cases, where the measures

of things must be nicely determined, and principally in observations, whereon either theorems or hypotheses about the proportions of things are to be grounded, very good instruments are exceeding useful, and sometimes necessary; yet there are thousands of particulars, whose knowledge may be instructive to those, that are or would be Naturalists, where no such nicety is requisite, and where the measuring things by ounces and inches will serve the turn, without determining them to lines, and grains. And even in cases, where exact observations are (to some purposes) requisite, those, that are not so, may be oftentimes very useful, by affording hints, by which others may be excited and assisted to make those more accurate trials. And here let me take notice, that a tool or instrument is not therefore to be despised, if it be proper enough to the particular use, to which it is applied, because some more mechanical head or hand may propose or make another, that is more artificially contrived, or more neat and portable, or that will also perform other things, than that we are speaking of. For there is a vast multitude of physical phenomena, wherein mathematical exactness is not necessary, and observations about these may be well enough made by divers other ways, than by the most artificial, that can be devised. As though a fine watch may have these advantages, that it is a neater thing, and more portable than an ordinary clock; that it may be improved by the addition of an alarum, and that it may also, perhaps, shew the day of the month, the age of the moon, the tides, and divers other things, of which the clock shews not any: yet an ordinary clock may serve to measure an hour by, as well as this finer engine; and so may a sun-dial, and many other instruments on divers occasions; though in other cases, and other regards, they be far less commodious, than either a watch or clock. Besides, that in many cases a skilful Naturalist will, by a variety and collation of experiments, make the same discoveries, and perform the same things, for which others be wont to be beholden to instruments, and perhaps do many things without them, that have never been done with them. And since necessity is proverbially allowed to be the mother of inventions, even in tradesmen, and vulgar heads, why should we doubt, but that the rich and inventive intellect of a philosopher may, in cases of necessity, turn itself, and contrive the things it can dispose of, into so many differing forms, that it will often make its own sagacity and industry supply the want of exact tools and instruments? And these considerations, that tend to keep ingenious men from despondency, I therefore think fit to inculcate, because the commonwealth of learning would lose too many useful observations and experiments, and the history of nature would make too slow a progress, if it were presumed, that none but geometers and mechanics should employ themselves about writing any part of that history.

BUT to return to those trials of our own, that occasioned this (as I hope, seasonable) digression,

digression, I was about to add, that as the acknowledgment I was making; that some of the trials were, for want of accommodations, less artificial than I could have designed or wished them, touches not all, nor haply the greatest part of the following experiments; so it need not derogate from the reader's reliance on those, which it does concern. For though some of them might have been more artificially performed to the manner, yet they could not have been more faithfully registered, as to the events. Which though I dare promise myself, that most readers will be induced to believe, upon the considerations not long since intimated; yet I think it requisite to give this intimation on this occasion, because, that though I have (in the two essays of the *Unsuccessfulness of Experiments*) largely manifested to what contingencies divers experiments are liable, yet I have found very few; whose events are so subject to be varied, by slight and not easily heeded circumstances, as several experiments concerning cold; where oftentimes the degree of that quality, or the time during which it continues applied, or the manner of application, or the thickness, shape and bulk, &c. of the vessels, that contained the matter exposed to it, may have a far greater influence on the success, than those, that have not tried, can easily imagine. And it increases the difficulty, that these experiments of ours being (very few excepted) the only, that are yet made publick concerning cold; we cannot so easily, as in other cases, free ourselves from the doubts, that may be suggested by different events, by comparing together several experiments of the same kind; though to obviate this inconvenience, as far I may, I have divers times in cases, where the experiments seemed like to be thought strange, or to be distrusted, set down several trials of the same thing, that they might naturally support and confirm one another.

OF those contingent experiments about cold, I was newly speaking of, the reader may meet with an eminent example in the 21st title, where mention is made of the differing effects of air blown out of a pair of bellows upon a weather-glass: and as for the suspicion I there conclude with, (though I yet doubt, whether it will reach all the cases incident to that experiment) I have since been confirmed in it; by finding, that by purposely varying the temper of the bellows themselves, I could divers times considerably vary the operations, which the winds, blown out of them in their differing states, had upon the liquor in the weather-glass*. Of this I expect to have an opportunity of saying more, and therefore shall at present add but this one particular, which may sufficiently justify me for having said, that weather-glasses and our sensories may give very differing informations about the tempe-

rature of the air turned into wind; by being blown out of the same pair of bellows. For having taken two hermetically-sealed weather-glasses furnished with highly rectified spirit of wine, and purposely made for my experiments by a person eminently dexterous in making such instruments, and having likewise provided a large pair of bellows, I found, that by blowing twenty blasts at a time on the ball of one of them, though the pipe were not only slender, but of an unusual length, amounting to about thirty inches, yet the liquor did not sensibly subside any more than rise. And in the other weather-glass, whose pipe was less long, but whose ball was purposely made far greater to be the fitter for short and nice experiments, we found more than once, and (that as well in the cold air, as in a close room) that the wind, that was blown in divers blasts out of the bellows against the lower part of the instrument, did not only make the spirit of wine subside, but did make it manifestly, though but very little, ascend. And it is not necessary, for the making good of what I taught, that such trials should always succeed just as these did, since it may suffice to prove what I pretended, that a good sealed weather-glass did divers times discover the wind to be rather warm, than cold, when upon trial (then purposely made) it felt not only manifestly, but considerably cold, both to a by-stander's hand, and to my own hand and face, though my hand, that was blown upon, were immediately before more than ordinarily cold.

AND I shall here add, that judging it fit to make further trial with an unsealed weather-glass, I made one, that was in some regards preferable to those mentioned in the second preliminary discourse, by making the bubble large, and the cylindrical pipe so proportioned to it, that instead of a drop of water, a pillar about an inch long of that liquor was kept suspended, and played as well conspicuously as nimbly up and down in the pipe: and having fastened this instrument in an erected posture, with the spherical part uppermost, to the inside of a window, by blowing upon the ball with the bellows above-mentioned, which had lain some hours not very far from the chimney-corner, (but without seeming to be sensibly warmed by the neighbourhood of the fire) a very few blasts made the suspended water hastily subside, (and thereby witness the expansion, and so the warmth of the included air;) and upon my ceasing to blow, the same water would re-ascend in the pipe, and that, though I stood near it to watch it, (which shews, that the former depression was not caused by the approach of my warm body) and this I did more than once both alone and before witness, notwithstanding that the air blown at the same time out of the same bellows upon our hand and face seemed cool

* Another remarkable instance of the variable success of the experiments of cold I have met with in an experiment of the learned Dr. Merret's, about the congealing of oil of vitriol. For though I exposed that liquor in small vessels of differing sizes and shapes, and even in slender glass pipes, sealed but at one end, yet neither the cold of the air in frosty nights, that were extraordinarily sharp, nor, which is more, our frigorifick mixture of ice and salt, would make the experiment succeed; notwithstanding that we tried it with several parcels of oil of vitriol. And yet, that the learned doctor by the help of the air alone (for he uses not our frigorifick mixture) did bring that liquor, either to a true congelation, or a coagulated substance, that looked just like ice, both some eminent Virtuosi, and I my self, who had the curiosity to examine it, can bear him witness.

cool enough. But fearing to insist any longer in this matter in a Preface, I think it now unreasonable to add, that as some contingent experiments in subsequent trials may fail oftener, so others may, perchance, succeed oftener than is expected: as I have sometimes observed in the figures, that appear in the ice made of some liquors, that abound with volatile, urinous, or with certain other salts. But to say a word in general of experiments, whose success is not always uniform; as a magnetick needle, though it do not always precisely respect the poles, but both declines sometimes eastward, and sometimes westward, and varies that declination uncertainly as to us, does nevertheless so far respect the North, as in spite of its variations to be an excellent guide to navigators; so there are contingent experiments, whose events, though they sometimes vary, are seldom very exorbitant, but for the most part are regular enough to afford philosophers very useful informations and directions.

If it be demanded, why in the 15th, 18th, and 19th sections I have inserted so many quotations out of several authors, and how that agrees with what I have said, not far from the beginning of this Preface, of the uncultivatedness of the subject I have adventured on; I answer, that what I have done crosses not what I have said. For my complaint was, that there has been very little, especially of any moment, delivered concerning cold, by classick authors; and that even other learned writers, who have had occasion to say something purposely of cold, have handled it exceedingly jejune: but this hinders not, but that if a man will take the pains to seek out, and inquire of travellers, and has the curiosity to consult voyages and navigations, he may, among a multitude of other things, that have nothing to do with cold, meet with some few, that concern that subject: and yet the authors, that deliver such particulars, can no more properly be said to have written professedly of cold, than of botanicks, or zoology, or meteors, or civil philosophy, because in the same journal they mention a great frost, or a great snow, as chancing to happen on such a day, with as little particular design, as they mention a storm, or a whale, or a bear, or the manners of an Indian people. This consideration being premised, it will not be difficult to return an answer to the former part of the question lately proposed. For the unfrequency of my quotations in most of the sections of the following history will, I presume, sufficiently persuade the reader, that I would not needlessly employ so many of them in the three sections, that are named in the quotation. But the writers of physicks being, for aught I know, silent as to the particulars I have transcribed out of other writers, and the observations being such, as I could not myself make in this temperate climate; I must either make use of other men's testimonies, or leave some of the remarkablest phenomena of cold unmentioned. And they, that shall try, how much pains it will cost them, to range among books, which many of them contain little but melancholy accounts of storms and distresses, and ice, and bears, and foxes,

to cull out here and there a passage fit to make a part of such a collection, as they may here meet with, will possibly rather thank, than blame me, for having, to gratify my readers, given myself so laborious and unpleasant an entertainment. And I was the rather content to enlarge a little on the forementioned occasions, not only because I was unwilling to be engaged more than once in so troublesome an employment, but (and that chiefly) because most of the particulars, I have collected out of navigators, are afforded me by the voyages of our own countrymen, who having written only in English an account of what their relations contain of most material concerning cold, will probably be welcome, as well as new, to the curious of other countries, who cannot understand their books; divers of which having been long out of print, are so hard to be procured, even here in *England*, that I doubt not, but these extracts of them will be acceptable, even to divers of the virtuosi of our own nation; especially since I have been careful to alledge most of the testimonies in the writer's own words, though they are not always the best, wherein the things he delivers might be expressed. And this course I the rather took, that I might do what I think very useful to be done by all writers of natural history, who would do well to distinguish more carefully, than hitherto many have done, betwixt the matters of fact, they deliver as upon their own knowledge, and those, which they have but upon trust from others. I know it would be more acceptable to most readers, if I were less punctual and scrupulous in my quotations; it being by many accounted a more genteel and masterly way of writing, to cite others but seldom, and then to name only the authors, or mention what they say in the words of him, that cites, not theirs, that are cited. And there are some writers of such known diligence and veracity, as to be safely trusted, and some cases, wherein I do not dislike, but comply with this custom, (after having first consulted my author to be master of his true and genuine sense;) but in matters historical, and whereon philosophical and important truths are to be built, I should think myself beholden to a writer, for setting them down in such a way, as that I may satisfy myself, that the testimony is faithfully reported. In order to which, it will be sometimes very useful to be enabled to repair to the original witness, and, if need be, survey there the context of the alledged passage. For I must here advertise the reader, that in matters of any moment, it is not from every writer, that I dare trust the quotations he makes of the passages of other authors, in his own words, not theirs: for upon comparing very many quotations, I have found, that oftentimes there is no such thing, as is pretended to be really met with in the place referred to; and even when neither the book, nor chapter, nor page are misquoted, I have too frequently found, that the alledgers of testimonies do either, through inadvertency, misapprehend, or miscite the sense of the author they quote, or out of design make him speak that, which

may comply with their own purpose, whether it were his own sense or no; and by their indefinite citations made it too troublesome and difficult a work, for the reader to find out, whether they have imposed upon him or not. But it is only by the by; to return therefore to the passages we were speaking of, in the 15th, 18th, and 19th sections, I shall now add, that having in the beginning of the XIXth title of the ensuing history itself rendered an account of my not scrupling to assert some strange relations concerning cold, it will not be requisite to mention here, what the reader will meet with there. And I scarce doubt, but he will excuse such passages, if we consider, that as I could not omit them, without leaving out some of the eminentest phænomena of cold, so being unable to examine them here in *England*, all I could do was, to report them faithfully, and mention only such, as were either affirmed by eye-witnesses (as the most I have inserted, are) or, at least recommended by credible testimony, whereof we shall say more by and by; to which sort of narratives I know not whether I may refer that, which (yet for its strangeness may deserve a transient mention,) came a-while since to my ears, of an Englishman, who related to an eminent virtuoso of our acquaintance, that a Dutch master of a ship, returning from the northern countries, very solemnly affirmed, being therein seconded by one of his countrymen, and offered to produce his journal for proof, that endeavouring to sail northwards as far he could, he came within less than a degree of the pole itself, and found the sea open, and the cold very tolerable. But to return to what we were saying, before this odd relation diverted us, I did not only decline the mention of divers things, with which I fear many writers would have adorned a history of cold; but even of those, that I myself, have inserted, I would have left out divers, were it not, that many of the relations, that may appear so wonderful, seem not to me to be repugnant to the nature of things, but only suppose a far greater degree of cold, than we have in these parts; and yet the familiar effects of the cold we have here, would, perhaps, be looked on as incredible, by one, that was born and bred in the kingdom of *Congo*, where *Odoardus Lopez*, who lived long there, informs us, that ice, that is, water made solid, is so known a rarity, that it would there be valued as so much gold. And a learned physician, that lived in *Jamaica*, being asked, how far he found the temperature of that country to be like that of *Congo*, answered me, that in that island he observed not all the winter long, either frost or snow. And yet here it will not be unseasonable to say a word or two of the three principal authors, from whom most of our strange relations we are considering are transcribed.

THE first is *Gerat de Veer*, who writ the voyage of the Hollanders to *Nova Zembla*, a book so eminent in its kind, that it may seem a wasting of time to set down a character of it; and therefore I shall only advertise the reader of two things; the one, that the

Dutch did, indeed, make three consecutive voyages to *Nova Zembla*; but that the third being that, in which they wintered there, most of the particulars are to be understood of that. The other thing is, that having lost the translation, that was made of those voyages out of Dutch into English, (published in a book by themselves,) without being able to procure another, I was obliged to have the citations transcribed, as I found them extant in that faithful collection of voyages compiled by *Purchas*; who seems, by the style, to have (as to the book we are speaking of) only plaid the part of an interpreter. And here it will be seasonable to add, that whereas that excellent collection consists of several distinct tomes or volumes, the many quotations to be met with, in the margin of our history under the name of *Purchas*, are to be understood, (unless the contrary be intimated) to belong to the third part of his *Pilgrim*, where the Dutch and other voyages into the northern countries are to be found.

THE next book I intend to mention, is *Olaus Magnus's* History of the Northern Nations. And though this author is of very suspected credit, and delivers some things upon hear-say, which they are kinder to him, than I, that are pleased to believe; for which reason I do but very sparingly make use of his history; yet, considering, that he was archbishop of *Upsale* in *Sweden*, and appears to have more learning, than many, that never read his books, imagine; I thought I might, now and then, make use of his testimony, in matters, wherein he either professes himself to speak upon his own knowledge, or delivers but such things, as being consistent with the laws of nature, appear improbable, only, because of the intense cold, that they suppose: which I the rather say, because he himself somewhere speaking of the cold, that by the laws of nature reigns in the North, subjoins this passage, (*Lib. 1. Titulo de frig. asperitate*, page 9.) *Sub quo quia natus, & versatus sum etiam circa elevationem graduum poli arctici 86, arbitror me posse hoc, & multis sequentibus capitulis, nonnihil cæteris vaga opinione scribentibus clarius demonstrare, quam vebemens & horrendum sit illic frigus.*

AND, though perchance few readers will perceive it, I have been so severe in rejecting not only relations, but even authors not otherwise obscure, that, how much soever I foresaw my scrupulousness might impoverish my history, yet there are some whole treatises about cold countries, whence I have shunned to borrow any one authority, because I perceived the authors had not observed the things they recount themselves, and were too easy in believing others.

THE third writer I meant to take notice of, is captain *James*, a person from whose journal I have borrowed more observations, than from those of any other seamen, not only because his book supplied me with them, and because it is somewhat scarce, and not to be met with in *Purchas's* tomes, (having been written some years after they were finished) but because this gentleman was much commended to me,

me, both by some friends of mine, who were well acquainted with him, and by the esteem, that competent judges appear to have made of him. For having been, not only employed by the inquisitive merchants of *Bristol*, to discover a north-west passage into the South-sea, but designed for so difficult a work by so judicious a prince, as the late king, and having, at his return, published his voyages by his Majesty's command; as by these circumstances, though not by these only, this gentleman's relations may well be represented to us, as likely to deserve our consideration and credit; so, by his breeding in the university, and his acquaintance with the mathematicks, he was enabled to make far better use than an ordinary seaman would have done, if the opportunity he had to observe the phænomena of cold, by being forced to winter in a place, where he endured little (if at all) less extremity of cold, than that of *Nova Zembla*.

I PRESUME it will easily be taken notice of, that in the following history I have declined the asserting of any particular hypothesis, concerning the adequate cause of cold. Not but that I may have long had conjectures about that matter, as well as other men, but I was willing to reserve to myself an intire liberty of declaring what opinion I most inclined to, till the historical part being finished, I may have the better opportunity to survey and compare the phænomena; and the leisure, (which I cannot promise myself in haste) of calmly considering what theory may best agree with them: especially since I freely acknowledge, that I found the framing of an universal and unexceptionable hypothesis of cold to be a work of greater difficulty, than every body would imagine; especially to me, to whom some experiments, purposely made, have suggested a puzzling difficulty, which it is like that philosophers have not yet thought of. And whatever applause is wont in this age to attend a forwardness to assert hypotheses, yet, though fame were less to be sought than truth, this will not much move me, whilst I observe, that hypotheses hastily pitched upon do seldom keep their reputation long; and divers of them, that are highly applauded at the first, come, after a while, to be forsaken, even by those, that devised them.

As for the title of the following book, I call the experiments new, because indeed, if I mistake not, nine parts of ten (not to say nineteen of twenty) are so. But though 150, or 200 experiments of that kind, besides collections from travellers, and books, that do not professedly treat of cold, may, I presume, allow me to have begun the natural history of cold; yet, in the very title-page I think fit to intimate, that I look upon what I have done but as a beginning. For though some very noted virtuosi have been pleased to seem surprized, to see what so barren and uncultivated a subject has been brought to afford this treatise; yet I look upon these as things, that do rather promise than present a harvest, and but as some early sheaves of that crop, which men's future industry will reap from a subject, that is in-

deed barren, but not unimprovable. For I see not, why it should not hold in the history of cold, as well as in many other attempts, that the greatest difficulties are wont to be met with at the beginning; and those being once surmounted, the progress becomes far more easy. And as the magnetick needle, though it point directly but at the north and south, does yet discover to the seaman the east and west, and all the other points of the compass; so there are divers experiments, which though they do primarily and directly teach us but a notion or two, may yet assist us to discover, with ease, many other truths, to which they seemed not at first sight to afford us a direction. So that what is here already done, such as it is, partly by hinting various inquiries about cold, and partly by suggesting ways not formerly practised of making farther experiments, may possibly make it more easy for others to add to these a number, far exceeding that, which they will here meet with, than it would have been without such assistances, (which I had not) to contribute to the History of Cold, even such a stock as I have begun it with. And this I the rather incline to think, because I find, that when once a man is in the right way of making inquiries into such subjects, experiments and notions will reciprocally direct to one another, and suggest so many things to him, that if I were now to begin this work again, and had cold, and fitly-shaped glasses, and instruments, with other accommodations at command, there are divers parts, on which my enlargements would not, perchance, be much inferior to what is already extant there, if they did not much exceed it. But besides that I have other work enough, and that of a quite other nature upon my hands; the truth is, that I am plainly tired with writing on this subject, having never handled any part of natural philosophy, that was so troublesome, and full of hardships, as this has proved; especially because that not only the experiments being new, and many of them subject to miscarriages, required to be almost constantly watched, but being unable to produce or intend cold, as we can do heat, nor command the experiments, that concern congelation, with as little difficulty, as we can do those, that belong to divers other subjects; I was fain to wait for, and make use of a fit of frosty weather (which has very long been a rarity) as solicitously as pilots watch for, and improve a wind.

III. IT remains now, that I give some account, why I suffer so unfinished a piece, as I acknowledge this to be, to come forth at this time. And I confess, that if I had not preferred the gratifying the curious, before the advantages of my reputation, I should have kept this book in my hands some winters longer, that it might come forth, both more rich, and less unpolished. But how great a power my friends have with me in such cases, the reader may easily guess by the preamble he will find prefixed to the first title of the ensuing history. For by the date of that, he will see, how early my papers about cold were to have been communicated; nor was I any thing near

so much befriended, as I expected, by those interposing accidents, that have for above a year and half kept those papers lying by me. For the then next, and now last winter proved so strangely mild, as to be altogether unfavourable to such a work as I had designed. Wherefore finding, that delays had done me no more service, and pressed by the solicitations of divers virtuosi from several parts, I resolved, that I would suspend till another opportunity the drawing together of what I had observed or collected, touching the regions of the air, and some of the chief hypotheses, that are controverted about cold, with what other loose papers, touching that quality, I could not so readily dispatch to the press; and would not withhold from the curious what assistance my collections could afford them, to make use of this winter to prosecute experiments of cold. And remembering how favourable an entertainment my former endeavours to gratify ingenious men had found among them, I took a course, wherein I was more likely to obtain thanks than praises, and chose rather to adventure on the equity and favour of the reader, for the pardon of those faults and imperfections, that are imputable to haste, than to deny him the opportunity of this cold season, wherein to examine the truth, and supply the deficiencies of what I had delivered. And this I the rather did, both because I was desi-

rous to quit this subject for another, from which it had diverted me, and for which I have more value and kindness; and because, that as a tender constitution of body kept me, whilst I was writing the following history, from adventuring upon some trials, that might (probably) have enriched it; so the continuance of the same disadvantages, together with other inopportune distempers superadded to them, do not permit me to know, whether, and how far I shall be able to prosecute the work I have begun; and do oftentimes reduce me to be more concerned to shun the effects of cold, than observe the phenomena of it. And indeed, whether those prove true prophets or no, that assure me I shall lose no reputation by this history (as incompleat as it comes forth,) I think, if ingenious men knew, how much trouble and exercise of my patience it has cost me, they would, peradventure, vouchsafe me some of their thanks, if not for what I have done, yet for what I have suffered for their sakes, (and would scarce have undergone upon any inferior account whatsoever;) it being, though a less noble, yet no less troublesome an employment, to dig in mines of copper, than in those of gold; and men being oftentimes obliged to suffer as much wet and cold, and dive as deep, to fetch up sponges, as to fetch up pearls.

New THERMOMETRICAL EXPERIMENTS and THOUGHTS.

DISCOURSE I.

Proposing the first Paradox, *viz.* *That not only our Senses, but common Weather-glasses, may misinform us about Cold.*

IT may to most men appear a work of needless curiosity, or superfluous diligence, to examine solicitously, by what criterion or way of estimate the coldness of bodies, and the degrees of it are to be judged; since coldness being a tactile quality, it seems impertinent to seek for any other judges of it than the organs of that sense, whose proper object it is. And accordingly, those great philosophers, *Democritus, Epicurus, Aristotle*, and (till of late) all others both ancient and modern, seem to have contented themselves in the matter with the reports of their senses.

BUT this notwithstanding, since we can scarce employ too much care and diligence in the examining of those touchstones, which we are to examine many other things by, perhaps it will be neither unseasonable nor useless to premise something touching this subject.

For though it be true, that cold in its primary and most obvious notion be a thing relative to our organs of feeling, yet since it has also notable operations on divers other bodies

besides ours; and since some of them seem more sensible of its changes, and others are less uncertainly affected by them, it would be expedient to take in the effects of cold upon other bodies, in the estimates we make of the degrees of it.

AND to make this appear the more reasonable, I shall not scruple to propose the following paradox; namely, That our senses, either alone, or assisted by common weather-glasses, are not too confidently to be relied on in the judging of the degrees of cold.

To make this paradox plausible (which is almost as much as I here pretend to) I shall represent in the first place, that the account, upon which we are wont to judge a body to be cold, seems to be, that we feel its particles less vehemently agitated than those of our fingers, or other parts of the organ of touching. And consequently, if the temper of that organ be changed, the object will appear more or less cold to us, though it self continue of one and the same temper.

THIS may be exemplified by what has been observed by those, that frequent baths, where the milder degrees of heat, that are used to prepare those, that come in for the higher, seem very great to them, that coming out of the cold air, dispose themselves to go into the hot baths, but are thought cold and chilling to the same persons, when they return thither out of much warmer places; which need not to be wondered at, since those, that come out of the cold air, find that of the moderately warm room more agitated, than the cold ambient would suffer the external parts of their bodies to be; whereas the same warm air, having yet a less agitation than that, in which the hotter parts of the bath had put the sensitive parts of the bathers bodies, must seem cold and chilling to them.

BUT it is not only in such cases as this, wherein men can scarce avoid taking notice of a manifest change in themselves, that these mistaken reports of our senses may have place. For oft-times we are imposed upon by more secret changes in the disposition of our sensories, when there needs something of attention and of reasoning, if not of philosophy, to make us aware of them. For being apt to take it for granted, that our temper is the same, when there is no very manifest cause, why it should be changed, we often impute that to objects, whereof the cause is in our selves; and if this change in our selves be wrought by unsuspected agents, or by insensible degrees, we do not easily take notice of it. Thus though in summer divers cellars, that are not deep, are perhaps no colder than the external air was, (when it was judged but temperate,) in winter or the spring; yet it will seem very cold to us, that bring into it bodies heated by the summer sun, and accustomed to a warmer air; nay, cold does so much depend upon the degree of agitation in the parts of the object, in reference to the sensorium, that even when we may think the sensory unaltered, it may judge an object to have a degree of coldness which indeed it hath not; as I remember, that to satisfy some friends, that it is not every wind, which feels cold to us, that is really more cold than the still air, I have sometimes shewn, that in not nice weather-glasses, air blown out of a pair of bellows does not appear to have acquired any coldness by being turned into wind, though if it were blown against the hands or face, it would produce a new and manifest sense of cold: of which the reason seems to be, that though the organ in general seems not to be altered, yet the wind, by reason of its motion, is able not only to drive away the parts of the air contiguous to the hand or face, and the warm steams of the body, which tempered its coldness; but to pierce deeper than the calm air is wont to do into the pores of the skin, where, by comparison to the more inward and hotter parts of the sensory, it must needs appear less agitated and consequently colder.

BESIDES that sometimes we may meet with certain steams in the air, that have in reference to the blood and spirits of human bodies (though not perhaps to divers other liquors) a

certain hidden power of chilling, as opium, even in outward applications, (for in such ways I have known a great surgeon much use it and highly extol it) strikes a coldness into the body by the subtle effluvioms, that insinuate themselves at the pores of the skin; and perhaps too that coldness is ascribed to external bodies, which is produced in us by some frigorifick vapour, or other distemper: which being too slight to be taken notice of as a disease, may yet be of kin to those agents, that produce what physicians call horrors and rigours at the beginning of fevers, and some other distempers; or produce that strange and universal coldness of the external parts, which is frequently enough observed among other symptoms in hysterical women. Moreover, bodies may often appear colder to us than to a weather-glass, because our sensories are more affected by the density and penetrancy of the parts. This may seem somewhat strange, but being suitable enough to some of my conjectures about cold, I have often made trials with very nice weather-glasses, that have assured me, that (at least oft-times) when water seems to be cold enough to our touch, it appears not to be colder to the weather-glass than the ambient air.

THESE trials I have sometimes made with sealed weather-glasses, but the most with another sort of weather-glasses (whose structure and use are by and by to be mentioned) which though they seldom prove durable, nor of any great use in any other than such nice and short experiments, yet they discover slighter changes of the temper of the air, than would be notable (not to say sensible) in ordinary thermometers. But of multitudes of trials, that I sometimes made with these glasses, I can at present find among my loose papers but a very few; and though I remember, that in one or two (made about the same time with some of those that follow) I observed things, that make me now wish I had had opportunity to make those further trials of them, which some of their phenomena seem to direct the making of; yet I shall annex these that follow, as I find them entered, because they are not perhaps destitute of hints improveable by further prosecution. *June 26.* between two and four in the afternoon (the weather moderate for the season) I took a thin white glass-egg blown at a lamp about the bigness of a walnut, with a stem coming out of it about the bigness of a large pigeon's quill four or five inches long, and open at the top; this slender pipe being dipped in water, admitted into its cavity a little cylinder of water, of half an inch long or somewhat more, which (the glass being erected) subsided by its own weight, or the temper of the air in the egg (in reference to the outward air) till it fell to the lower part of the pipe, where it comes out of the egg, and thereabout it would rest. Now if taking this glass by the top betwixt my thumb and forefinger, I depressed the egg under the surface of a basin of fair water (cold enough to the touch) the little aqueous cylinder, that parted betwixt the air in the egg, and the external, would, instead of being made to subside by the egg's immersion

sion into cold water, presently rise up from the lower part of the pipe, till it reached about the middle of it, though the glass were, in this and the following trials, held erected; and as soon as it was taken out of the water into the air, the water would again subside, whether I held the glass, or let it rest upon the boards, or a linnen carpet, that covered the tables, on which the trials were made. And this I did several times as well with as without witness. I tried also that if, instead of water, I made use of quicksilver, though not big enough to cover the egg much above half way, and in the rest proceeded as above; the cold quicksilver would presently make the aqueous cylinder hastily ascend near three inches, sometimes almost, and sometimes quite to the top of the slender pipe, whence the water would again quickly subside, when the glass was taken out into the free air, or set to rest upright as before.

BESIDES, having set the vessel of quicksilver and the basin of water very near one another, I did at least upon three or four several trials find, as I expected, that when by immersing the egg in water, the pendulous cylinder was raised so high, that it did no longer sensibly ascend, by nimbly taking the egg out of the water and depressing it in the quicksilver, it would rise far higher: and I also tried, that nimbly removing the egg out of the quicksilver into the water, the pendulous cylinder would subside, after plunging the egg under water, though not so fast, nor near so low, as it would do, in case the glass were removed from the quicksilver into the air. Upon another trial made much about this time, though not the self-same day; the pendulous water in the same glass, (the day being for the most part windy and rainy) did subside upon the immersion of the glass into water, not only a while before noon, but an hour or two after dinner, and at distant hours afterwards, though the descent of the pendulous water was neither quick, nor so considerable, as it had been formerly in the mornings.

June 27. In the morning a small cylinder of water pendulous in the above mentioned glass, upon the immersion of the egg in a basin of water, would immediately and very considerably subside; whereas the same glass, being immersed in the vessel of quicksilver formerly mentioned would presently ascend. Both parts of this experiment we several times tried, and the reason was suspected to be, that the quicksilver had staid all night in my chamber, which was somewhat warm, whereas the water was brought up that morning, and to the touch seemed colder than the quicksilver; and a while after dinner, the same water having been still kept in the room, we divers times found, that as well that, as the quicksilver, did immediately, upon immersion, impell up the pendulous water in the slender pipe. Another time in the frosty weather (and about the beginning of *January*) we did with such a glass (as has been already several times mentioned) take some drops of water out of a vessel, wherein that liquor had for a good while been kept; that it might be reduced as near as we could to the temperature of the ambient

air; then suffering the suspended water to continue a convenient while in the long and slender stem of the weather-glass, that the internal air might be reduced to the temper of the external, we took up the glass by the open end; and immersing the obtuse part of it into a shallow vessel, containing some of the above mentioned water, we found the suspended drop suddenly impelled upwards about half an inch or more, and the ball of the thermometer being taken out of the water into the air, the pendulous drop did again (though far more slowly than it ascended) subside. This was repeated three or four times with some intervals between (and that in a room where there was no chimney) and still with the like success, save that in the two last trials we took the weather-glass out of the shallow water, and plunging it into a deep vessel of the same water (that stood very near the other) we found (for further confirmation of the experiment) that the pendulous water was, upon these new immersions, impelled up, near (if not full) as high again, as when we had immersed it only in the shallow vessel: and taking it out of this deep glass, we found the cold of the external air to reduce it to its former humble station. Thus far the notes, I have yet been able to recover: and though, as I said, I dare not build very much upon them, yet by small sealed weather-glasses I find enough to invite me to suspect, that of the degrees of heat and cold in the air we may receive differing informations, when we employ only our organs of touching, and when we make use of fit instruments.

I SHALL add on this occasion, that not only water it self, but moist vapours abounding in the air, may make us think it colder than the weather-glass discovers it to be. For though it be generally taken for granted, that the thermometer does only more exactly measure or determine the effects, which cold hath both upon it and upon our sensories; yet I have long suspected there is somewhat else in the case, and I have observed, that sometimes the weather seemed more or less cold to me, than that which preceded, when the contrary appeared in the weather-glass; and that, when upon consideration of the whole matter, that difference did not appear to depend upon those circumstances of exercise or rest, or the temperature of the air I came out of, or any of those other things, to which a considerate man, that goes upon no better than the common opinions about weather-glasses, would be apt to impute to that phenomenon. And I was the less disposed to think my self mistaken, because having purposely enquired of others in the same house, who were not told, what information the weather-glass gave, they agreed with me in the sense I had of the temperature of the weather. And having since, as occasion served, communicated my observations and suspicions to divers ingenious men, I have been by their reciter observations confirmed, that what I have taken notice of, was not the effect of any *Idiosyncrasia*. From which and other particulars, that we may have elsewhere opportunity to mention, we may plausibly enough infer, that

it were not amiss, not only to take notice, when we have opportunity, of the sense, that is expressed of the degrees of cold by birds and other animals, whose diet is more simple and regular than ours, and whose perceptions are commonly more delicate and less diverted; but especially, to examine the coldness of the air and other bodies as well by experiments and instruments, as by the touch. And on this occasion I must not pretermitt that memorable account, that is given us by *Martinus*, in that noble piece of geography, which he calls *Atlas Chinensis*, where speaking of the air of that populous country, he has this singular passage: *Ad cæli* (says he) *solique temperiem quad attinet, majus in hac provinciâ frigus est, quàm illius poscat poli altitudo; vix enim illa excedit gradum secundum supra quadragesimum; & tamen per integros quatuor sæpe menses flumina omnia adeò durè concresecunt gelu, ut currus equosque ac gravissima etiam onera glacies ferat, innoxie ac securissimè transeant: ex iis ingentia etiam glaciei frustra excinduntur, quæ in futuram æstatem ad delicias servant. His mensibus omnes naves ita in ipsâ glacie defixæ sunt, ut progredi nequeant ubicunque illas frigus occupat (quod certo certius circa medium Novembris ingruere solet) per quatuor illos menses inmota. ibi perstare coguntur, neque enim resolvitur glacies ante Martii initium; hæc plerumque glaciei concretio uno fit die, cum non nisi pluribus fiat liquefactio.* To which he adds, what makes most to our present purpose, *omnino illud mirum, tantum non videri aut sentiri illud frigus, ut Europæos ad hypocausta subeunda videatur posse cogere, aut in Europâ ad glaciem producendam sufficere, unde ad subterraneas illic exhalationes pro harum rerum causis indagandis omnino recurrendum est, &c.*

BUT all that I have been implying of the necessity and usefulness of the weather-glass, is no ways inconsistent with the truth of the latter part of our formerly proposed paradox; namely, that we are not rashly to rely upon the informations even of common weather-glasses themselves. For though they be an excellent invention, and their informations, in many cases, preferable to those of our senses, because those dead engines are not, in such cases, obnoxious to the same causes of uncertainty with our living bodies; yet I fear they have too much ascribed to them, when they are looked upon as such exact instruments to measure heat and cold by, that we neither can have, nor need desire any better. For, not yet to mention some inconveniencies in the contrivance of them, which makes them unapplicable to some purposes, and less proper in others, than thermoscopes might be made, even in divers cases, wherein they are presumed to be unexceptionable, their reports are not to me, I confess, quite exempt from suspicion. For, in ordinary weather-glasses, some part of the liquor being contiguous to the external air, it is subject to be impelled more or less upwards, not only according as heat or cold affects the included air, but according as the incumbent air happens to be heavier or lighter. And though this be a thing not taken

notice of by those, that have treated of weather-glasses, yet after what we have elsewhere manifested concerning the weight and spring of the air, and what we have probably conjectured concerning the varying height of the mercurial cylinder in the Torricellian experiment; I see not why it should not much call in question the informations we receive from common weather-glasses in those cases, where the height or weight of the atmospheric pillar, that presses upon the water in the weather-glass, is considerably longer or shorter, lighter or heavier than is usual.

See the 1st Sch of our New Physico-Mechanical Experiments.

FOR besides the reason of the thing, we have experience on our side. I might mention, on this occasion, an experiment I thought on, and also attempted, last winter, to show, even upon a ballance, the varying gravity of the atmosphere in one and the same place, by hanging a small metalline weight at one end of a pair of scales so strangely exact, that they would turn with far less than the five hundredth part of a grain; and counterpoising it at the other end with a hermetically sealed glass bubble, which being blown as large and as thin as could possibly be procured of so small a weight, might, by its great disproportion in bulk to the metalline body, lose more of its weight than that would upon the ambient air's growing more heavy. But the particular account of this attempt belonging to another place, the trial ought not to be more than hinted here; especially since it may suffice for our present purpose to alledge, that having found (as we have already in other papers noted) that in a weather-glass, where the water is not fenced from the external air, the weight of the atmosphere may make it alter considerably between the top and the bottom even of a church or steeple, though it appeared by more certain thermoscopes, that it was not the differing temperature of the air, as to cold and heat, but the differing gravity of the atmosphere, which being shorter and lighter at the top, pressed less forcibly upon the subjacent water and the included air, as is more fully made out in the treatise above related to. And having, by the the intervention of a learned acquaintance, desired to have some experiments made of the effect of the air upon weather-glasses in deep pits or mines, where the atmospheric cylinder is longer and heavier, I received information, that an ingenious physician, (Dr. H. P.) who had the opportunity of trying what I desired, had found, that in the bottom of one of those very deep pits, the water, in a common weather-glass, rose near three inches higher than at the top, in a shank or pipe of about thirty inches long. And this notwithstanding the warmth, that is usual in such deep places, which seems not any thing near so plausibly referrible to any other cause, as to the increased gravity of the atmospheric pillar incumbent on the water, that pillar being heavier at the bottom than at the mouth of the pit, by the weight of an aerial pillar equal in length to the pit's perpendicular height or depth.

In the Defence against Linus, chap. 4.

BUT these are not the only cases, wherein the differing gravities of the atmosphere may, as well

well as heat and cold, have an interest in the rising and falling of the liquor in common weather-glasses. For though you should not remove them out of one place; and though consequently it may seem, that the atmospherical pillar, that presses upon the water, must be still of the same length, yet (not to urge, that that may alter unknown to us) if retaining its length it retain not its gravity, we may be easily imposed upon, and take that ascension or subsidence of the liquor for the effect of a higher or remiss degree of cold, which may either totally or at least in part (and in what part, we are left to guess) be the effect of the increased or lessened weight of the atmospherical pillar, happening either by the copious dispersion of vapours and other heavy steams through the air, or upon other occasions not necessary to be here discoursed of, or by the precipitation of such vapours by rain, or into dew, or else by the removal of the occasions of the augmented gravity or pressure of the air. For we have often observed great variations to happen in the height of the mercurial cylinder, in the Torricellian experiment, upon great rains and fogs, and other sudden and considerable mutations of the incumbent air. But since I myself thought fit, notwithstanding the plausible ratiocination, that led me to this conjecture, to examine it by experience; I can scarce doubt, but that others may have the like curiosity that I had. And therefore, because it may seem a paradox, it will not be amiss, of many to annex three or four trials I made to examine the proposed doctrine, especially ours having been the first observations of this kind, that, for aught we know, have been made by any. And indeed others could scarce have well made much, though they lighted on the same thoughts, for want of such sealed weather-glasses to make them with. To omit then those, that I made with a sealed weather-glass, and an ordinary one (in which the water remains suspended beneath the included air) I shall briefly relate, that in a room unfurnished with a chimney, I kept two weather-glasses, which, for more exactness sake, I caused to be made of a length far greater than ordinary; so that the divisions of the one were half inches, and those of the other not much less, and yet were numerous. The one of these, which was furnished with good spirits of wine, was sealed, the other not; but this last I caused to be so made of the shape represented by the scheme, that the air being shut up in the lower part of the instrument (not as in common weather-glasses at the top) the liquor might as well in this, as in the sealed weather-glass, rise with heat and fall with cold. In these thermoscopes (where the ascension and relapse of the liquors were, by reason of the length of the pipes, far more conspicuous than in vulgar weather-glasses) I observed, with pleasure, that the hermetical thermoscope (if I may for distinction-sake so call it, by reason of its being hermetically sealed) did regularly enough descend in cold weather, and ascend in warm: but the other, which was not sealed, but had a little hole left open at the top of the pipe, though, when

the atmosphere continued of the same weight, it would, like the other, rise with heat and fall with cold, yet when the atmosphere's gravity was altered, they would not uniformly move together, but when (as we gathered from other observations) the atmosphere grew heavier, the liquor in the pipe did not ascend, as high as it would have done, if the atmosphere had continued in its former degree of gravitation. And, on the contrary, when the incumbent air came to be lighter, the liquor would rise in the open weather-glass in a proportion greater than the single increase of heat would have exacted; so that by comparing the two weather-glasses together, I did usually foretell, whether the mercury in the Torricellian tube (which I keep purposely by me in a frame) were risen or fallen, and consequently whether the external air were heavier or lighter than before: As, on the other side, by looking on the height of the mercurial cylinder, I could easily tell before-hand, whether the liquor in the open weather-glass were higher or lower than that in the hermetical; the rising or falling of the mercurial cylinder one quarter of an inch (the temperature of the air continuing as to heat and cold) usually signifying a great disparity betwixt the ascension or the falling of the liquors in the two instruments.

AMONG the several notes, I find among my loose papers, and in a diary I kept for a while of these observations, I shall content my self to transcribe the following two, because, though divers others were made by my Amanuensis, whose care is not to be distrusted, yet by reason of my absence I could not take notice of them myself. The first of these *Memorandums* runs thus.

LAST night I took notice, that there was but one or two divisions difference betwixt the two thermometers, but upon such a change of weather, that happened this day, as made me imagine, that the atmosphere would be lighter than before, consulting the barometer (if to avoid circumlocutions, I may so call the whole instrument wherein a mercurial cylinder of 29 or 30 inches is kept suspended after the manner of the Torricellian experiment;) I found the quicksilver lower than it had been a great while, and thereupon concluding, there would be a notable disparity, between the sealed and open weather-glass, I halted to them, and found that the latter being much alleviated from the weight of the incumbent air, was no less than 17 divisions higher than the others; and comparing the height the two instruments were this day at, with an observation I myself made about a week ago, when the quicksilver was much higher than now it is; I found, that although this afternoon the sealed glass being at 41, the other was 58; yet then, when the sealed weather-glass was five divisions higher, namely, at 46, the unsealed weather-glass was but at 27. So that betwixt that time and this, the liquor in the sealed weather-glass, has descended five divisions, but that in the open weather-glass has ascended 31.

THUS far the first of the above mentioned notes; the second is as follows.

THE mercurial cylinder being higher, than it has been a good while, and yet the weather warm and sun-shiny, when the liquor in the sealed glass stood very near the 50th division, that in the unsealed was fallen down as low as the 32d.

So that it is very possible, that the unheeded change in the weight of the external air may have a greater power to compress the included air in an unsealed weather-glass, than a not inconsiderable degree of warmth may have to dilate it; and consequently in an ordinary weather-glass, where the air is included at the top, it may often fall out, that contrary to what men suppose must needs happen, the pendulous water may rise in warmer weather and fall in colder.

AND even since the writing of the immediately foregoing part of this page, within a few days that intervened, I have myself made observations, that do yet more clearly manifest this truth, as may appear by the following notes. The first of which speaks thus.

Memorandum, THAT yesterday night the quicksilver being at 29 inches, the liquors in the sealed and unsealed weather-glasses were near about the same division, the former being at 40, and the other being but half a division short of that number. But this night the quicksilver being risen about $\frac{1}{2}$ of an inch; the liquor in the sealed is ascended to 45, and the other descended beneath 35 about half a division, so that there are now 10 divisions between them.

THIS the first note, to which the following night enabled me to add this other.

THE quicksilver being risen almost $\frac{3}{4}$ of an inch above the station it rested at, the night before last night, the hermetical weather-glass being as it was then above the 40th division; the liquor in the other, which was open, in two days and nights is fallen to the 17th, and consequently is subsided about 23 divisions, whilst the other is about the same height, at which it was at the beginning of that time.

Two or three days after, being returned to the place, wherein I had made this last observation, and from which some urgent occasions had for that time exacted my absence; I found the disparity betwixt the two thermometers, that is expressed in the following memorial.

THIS day the quicksilver being risen to 30 inches, when the liquor in the sealed weather-glass was at about 41 divisions, that in the other was depressed a pretty deal below the 9th division; so that the difference between the two thermometers was increased since the last observation from 23 near to 33 divisions, all which the liquor in the open weather-glass had sunk down, whilst that in the sealed continued almost at a stand. And the day after this memorial, I had occasion to register another, which being the last, I shall here think requisite to take notice of in this discourse, I shall subjoin it with that, which immediately preceded in order of time.

THIS day the quicksilver continuing at the same height, at which I observed it yesterday, but the weather being grown much colder, the liquor appears in both the glasses to have uni-

formly enough subsided; that in the sealed weather-glass being about the 33d, and the other being sunk quite below the lowest mark of all, which was more than I apprehended it would have done, when there was no frost: especially since by my diary it appears, that one of the last times I observed the hermetical weather-glass to stand at near about the same height, namely, the 34th; the liquor in the other glass was no lower than 41: nor probably would there be now so great a difference, if the atmosphere had not been this day very heavy; whereas, when this freshly-recited observation was made, I find by the diary, the quicksilver to have ascended but to 29 inches, and a pretty deal less than a half.

SINCE that time, being forced by several avocations to be often absent from the place where my thermoscopes were kept, I was not careful to prosecute such observations, those already set down (not to mention those, that are not here transcribed) being judged abundantly sufficient to evince the paradox proposed to be proved by them: only to manifest, that after I desisted from registering my observations, the phenomena may probably have been as remarkable as before; I shall add, that one of the last times I chanced to take notice of the difference to be gathered by comparing the two weather-glasses, I found (the weather happening to be warmer than ordinary) the difference between them to exceed any, that I remembered myself to have then observed, amounting to 44, if not to 45 divisions.

AND even since the writing of the last line, we have had opportunity to observe a phenomenon, which if it had occurred to us in the place, where we might have compared the baroscope with the exact weather-glasses hitherto mentioned, (and whereby we had been invited to rely upon it) would perhaps appear more considerable, than any of the observations yet recorded. For not very many hours ago, finding in the morning the quicksilver to be risen in a good baroscope of mine (though another from that, all this while referred to, and elsewhere kept) above $\frac{3}{4}$ of an inch higher than the place it rested at the night foregoing, and a somewhat nice weather-glass (where the included air is kept in the lower part of the instrument, which is shaped like that already described in this discourse) being consulted to show, what effect so great and sudden a change of the atmosphere's gravity would have upon it; I saw the tinted liquor in the shank depressed a full inch or more beneath the surface of the ambient liquor in the phial, which strange depression of the liquor in a pipe above 20 inches long, and where the alterations of the air as to heat and cold are not wont to produce any thing near so great an effect, I could not but take much notice of. Since the season of the year makes it no way likely, that the night, though cold, could have had so powerful an operation on it, especially since an amanuensis, that watched it much longer than I, affirms, that he saw the liquor driven down quite to the very bottom of the pipe, and a bubble of the outward air to make its passage through the water, and to join with the air contained in the cavity of the phial.

DISCOURSE II.

Containing some new Observations about the Deficiencies of WEATHER-GLASSES, together with some Considerations touching the New or Hermetical Thermometers.

AND since I had occasion to speak of the deficiencies of weather-glasses, and the mistakes, whereto men are liable in the judgment they make of cold and heat upon their informations, it will not perhaps appear impertinent to add three or four considerations more, to excite men to the greater wariness and industry, both in the making and using weather-glasses, and in their judging by them.

I. AND first, I consider, that we are very much to seek for a standard, or certain measure of cold, as we have settled standards for weight, and magnitude, and time; so that when a man mentions an acre, or an ounce, or an hour, they, that hear him, know what he means, and can easily exhibit the same measure: but as for the degrees of cold (as we have elsewhere noted concerning those of heat) we have as yet no certain and practicable way of determining them; for, though, if I use a weather-glass long, it is easy for me to find, when the weather is colder, or when warmer, than it was at the time, when the weather-glass was first finished; yet that is a way of estimating, whereby I may in some degrees satisfy myself, but cannot so well instruct others, since I have no certain way to know determinately, so as to be able to communicate my knowledge to a remote correspondent, what degree of coldness or heat there was in the air, when I first finished my thermoscope: for besides that we want distinct names for the several gradual differences of coldness, we have already declared, that our sense of feeling cannot safely be relied upon to measure them. And as for the weather-glass, that is a thing, which, in this case, is supposed to be no fit standard to tell us what was precisely the temper of the air, when itself was first finished, since that does but inform us of the recessions from it, or else that the air continues in the temper it was in at the making of the instrument, but does not determine for us that temper, and enable us to express it; as indeed it is so mutable a thing, even in the same place, and oft-times in the same day, if not the same hour, that it seems little else than a moral impossibility, to settle such an universal and procurable standard of cold, as we have of several other things. And indeed there is scarce any quality, for whose differences we have fewer distinct names, having scarce any for the many degrees of coldness, that may be conceived to be intermediate, betwixt lukewarmness and the freezing degree of cold, and even these are undefin'd enough; for that, which to some men's senses will feel lukewarm,

by others will be judged hot, and by others, perhaps, cold; nor is even the glaciating degree of coldness well determined, since not only differing liquors, as oil, wine, and water, will manifestly freeze much more easily one than another, but even liquors of the same denomination; and of waters themselves, some are more easily turned into ice than others: and I see no great cause to doubt, but that there may be sufficiently differing degrees of cold, whereof the mildest may suffice for the congelation of some waters. I must not forget to add, that the same person, that has made many observations with a weather-glass, is so confined by that numerical instrument, that, if by the spilling of the liquor, or the cracking of the glass, or the casual intrusion of some bubbles of air, or by any of divers other accidents, that may happen, the instrument should be spoiled, he would, though he should employ again the same instrument, be reduced to seek out a new standard, wherewith to measure the varying temperature of the air. And though it be not difficult to include in the cavity of a weather-glass some other fluid body instead of air, yet it will be very difficult, if not impossible, to include a body, fit to resent and show the alterations of the ambient air, without being also liable to receive impressions from it at the time of its being first shut up.

YET I will not here omit, that I have sometimes considered, whether the essential oil of aniseeds (which is that, that is distill'd by the intervention of water in a limbeck) might not, during a good part of the year, be of some use to us, in making and judging of weather-glasses. For this liquor, as we elsewhere also note, having the peculiarity of losing its fluidity during almost all the winter, and a good part of the spring, and autumn too, when the weather, or the time of the day, is colder; this liquor, I say, being such, in case you very gently thaw it, and then putting into it the ball of a weather-glass, furnished with spirit of wine, that will burn all away, you suffer the oil to re-congeal leisurely of itself, you may, by observing the station of the spirit of wine in the thermoscope, when the oil begins manifestly to curdle about it, be in some measure assisted to make another weather-glass like it*. For if you put such rectified spirit of wine into a glass, the cavity of whose spherical, and that of its cylindrical part, are as near, as may be, equal to the correspondent cavities in the former glass, you may, by some heedful trials made with thawed and recongealed oil of aniseeds,

* An ingenious man has proposed another way of settling a standard for weather-glasses, namely, by observing the coldness, which is requisite to make distill'd water begin to freeze: but though the accurateness of this way may be as well as the other justly questioned, and cannot often be put in practice, even in winter itself, nor without trouble; yet it may also be advantageously made use of, when the cold happens to be great enough to freeze water.

feeds, bring the second weather-glass to be somewhat like the first; and if you know the quantity of your spirit of wine, you may easily enough make an estimate, by the place it reaches to in the neck of the instrument, whose capacity you also know, whether it expands or contracts itself to the 40th, the 30th, or the 20th part, &c. of the bulk it was of, when the weather-glass was made. By the help of the same oil you may make some kind of estimate, though a more uncertain one of the difference of two weather-glasses of unequal bigness: and though I know not how much may be alledged to shew the uncertainty of this way of making a standard for weather-glasses; yet as what I have formerly represented may manifest me to be far enough from looking on it as an exact standard of cold; so perhaps the way proposed may not be altogether usefess in the making and comparing weather-glasses, since, in such cases, where we are not to expect to hit the mark itself, it is of some advantage to be able to shoot less wide of it, than otherwise we should.

II. BUT not to insist any further on a difficulty, which is so hardly evitable as that, which occurs about settling a perfect standard of cold, there are unaccuratenesses in the measuring of cold by weather-glasses, which may be avoided, but are not; for men are not wont to take care, that the stems be even and cylindrical enough, but are wont to make use of such, as are much wider at the upper part near the bubble, than elsewhere; nor do they observe, as they might, a proportion betwixt the diameter of the bore of the cylinder, and that of the cavity of the spherical bubble, and divers other circumstances are commonly neglected, which, if well ordered, would make much towards the certainty and instructiveness of the informations, afforded us by weather-glasses. To which may be added, that even in those, where some part of the liquor is exposed to the external air, there may be made contrivances much more convenient, in order, at least, to some particular purposes, than that of the vulgar weather-glass; some of which we have employed, and others have been either skilfully devised, or also happily attempted by some eminently ingenious members of the Royal Society. And though that, which we have already described in another treatise, be very simple, yet it is much more commodious for several of the following experiments of cold, than that, which is commonly in use. For in this, where the included air is as it were pendulous at the top of the glass, it is very troublesome and difficult so to apply cold bodies, and especially liquid ones to it, as therewith to measure their temper; whereas the thermometers, I speak of, being made by the insertion of a cylindrical pipe of glass (open at both ends) into a phial or bottle, and by exactly stopping with sealing-wax, or very close cement, the mouth of the phial, that the included air may have no communication with the external, but by the newly-mentioned pipe: in this kind of instrument, I say, by chusing a phial as large as you please, and fitting it with

a cylinder, slender enough, the proportion between the part of the phial possess'd by the included air, and the cavity of the cylinder, in which the liquor is to play up and down, may be easily made so great, as to make the liquor in this instrument, with the same degree of heat and cold, rise or fall four or five, or more times, as much as the pendulous liquor is wont to do in an ordinary weather-glass, where the cavity that lodges the air, is wont to be much too small, considering the bigness of the pipe, whereinto the air must, when it is rarified, expand itself. But it is not the greater sensibility (if I may so speak) of this very kind of weather-glasses, nor their not needing frames, that makes me take notice of them in this place, (where I purposely pass by contrivances that I know to be more curious) but this other quality, which makes them fit for divers of the following experiments, wherein we shall have occasion to mention them; namely, that with little or no trouble and inconvenience we may employ liquors or other bodies to refrigerate the included air, by immersing the phial, if need be (by a weight) into the liquor to be examined, and letting it stand there as long as we please. And so we may also measure the coldness of earth, snow, powdered ice, and other consistent bodies, which may be heaped about the phial, or in which it may be buried.

III. I CONSIDER too, that though men are wont confidently enough to conclude, that in case (for instance) the coldness of the weather make the liquor in a thermoscope yesterday an inch higher than it was the day before, and this day an inch higher than it was yesterday, the air must be this day as cold again as it was yesterday, or at least that the increase of cold must be double to what it was yesterday, and so in other proportions; yet the validity of this collection may very justly be questioned; for, though we should grant, that cold is that, which of itself, or by its own power, contracts the air, yet how does it appear, that a double degree of cold must produce a double degree of condensation in the air, and not either more or less? Since besides that it is taken for granted, but not proved, that the differing qualities of included air in several instruments, and the differing bignesses of the pipes, and the differing degrees of expansion, wherein the included air may happen to be, when the ascension of the water begins to be reckoned, may render this hypothesis very suspicious; besides all this, (I say) I am not inclined to grant, (what philosophers have hitherto supposed) that the condensation of the air, and the ascension of the water, is only, or so much as principally, collected by the proper virtue of the cold, but by the pressure of the ambient air, as we shall ere long more fully declare. And if this be made out, then the computation, we are considering, will be found to be very fallacious; for we have elsewhere shewn, *that the strengths Defence a- required to compress air are in reciprocal pro- gainst Li- portion, or thereabouts, to the spaces compre- nus, chap- 5.* bending the same portion of air. So that if a cylinder (for instance) of four inches of air, be

Dr. Wren.
Dr. Goddard.
Mr. Hook.

be just able to resist a strength or pressure equivalent to ten pound weight, when it comes to be compressed into two inches; in this case, I say, an equal force superadded to the former, (which makes that a double force, or equivalent to twenty pound weight,) will drive up that already-compressed air into half the space; that is, into one inch or thereabouts. Whence it follows, that in estimating the condensation of the air in a weather-glass, we must not only consider, how much space it is made to desert, but also, what proportion that deserted space bears to the whole space it formerly possessed, and to what degree of density it was reduced, before the application of the then force; and we must remember, that the resistance of the included air is not to be looked upon, as that of a weight, which may remain always the same, but that of a spring forcibly bent, and which is increased more and more, as it is crowded into less and less room. But these nicer speculations it would here be somewhat improper to pursue.

IV. WHEREFORE I shall proceed to what may seem a paradox, that even the particular nature of the liquors, employed in weather-glasses, is not altogether to be neglected, till we have a better and more determinate theory of the causes of cold, than I fear we have: for, though usually it matters not much, what liquor you employ, yet it is not impossible, that in some cases men may slip into mistakes about them; for it will not follow, that if of two liquors, the one be much the more obnoxious to the higher degree of cold, that of glaciation, the other must be less easily susceptible of the lower degrees of cold; since those, that make sealed weather-glasses, some with water, and some with spirit of wine, have confessed to me, that they find these (last named) much more apt to receive notable impressions from faint degrees of cold, than those, that are furnished but with water, which yet is easily turned into ice by the cold of our climate, which will by no means produce the like effect upon pure spirit of wine.

BESIDES, we cannot always safely conclude (as philosophers and chymists generally do) that the more subtile and spirituous liquors must be the least capable of being congealed (that is, made to lose its fluidity, as oil and some other substances are wont to be reduced to do, by the action of cold) for the chymical oil of aniseeds distilled by a limbeck is so hot and strong a liquor, that a few drops of it conveniently dissolved will make a whole cup of beer taste as strong, and, perhaps, heat the body as much as so much wine; and yet this hot and subtile liquor I have found upon trial, purposely made, to be more easily congealable (in the sense freshly explained) by cold than even common water, and to continue so several days, after a thaw had resolved the common ice into fluid water again. And I know some distilled liquors, whose component particles are so piercing and so vehemently agitated, that the tongue cannot suffer them, and that they are not perhaps inferior to most chymical oils, nor to aqua fortis it self; and yet these

may be congealed by far less degrees of cold, than such, as would yet prove ineffectual to freeze either the generality of chymical oils, or the generality of saline spirits.

AND indeed, till we attain to some more determinate theory of cold, and come to know more touching its causes, than we yet do, I see not, why it should be absurd to suspect, that though there be some kind of bodies, which seem fitted to produce cold indiscriminately in the bodies they invade or touch; yet if the refrigeration of a body be but the lessening of the wonted or former agitation of its parts (from what cause soever that remissness proceeds) it seems not impossible, but that besides those bodies or corpuscles, that may be looked upon as the catholick efficient of cold, there may be particular agents, which in reference to this or that particular body may be called frigorifick; though they would not so much refrigerate another body, which perhaps would be more easily affected, than the former, by other efficient of cold. For we may observe, that quicksilver may be congealed by the steams of lead, which have not been taken notice of to have any such effect, upon any other fluid body; and yet quicksilver is not to be deprived of its fluidity by such a degree of cold, as would freeze not only water but wine. And by what we have formerly related upon the credit of that great traveller, the Jesuit *Martinius*, it seems, that water it self may in some regions be so disposed by the constitution of the soil, that it is susceptible of strange impressions of cold in proportion to the effect, which that degree of cold produces there in human bodies. Besides, opium also, of which three or four grains have too oft destroyed the heat of the whole mass of blood in a man's body, though that be a very hot, subtile, and spirituous liquor, does not sensibly refrigerate water, as far as I could observe with a good sealed weather-glass, which I put sometimes in a glass of ordinary water, and sometimes into a glass of water of the same temper, and (as we guessed) of the same quantity, wherein opium, enough to kill very many men, was put in thin slices, and suffered to dissolve; which seems to argue, that as differing liquors have each their peculiar texture, so there may be certain bodies, whose minute particles by their peculiar size, shape, and motion, may be qualified to hinder, or at least lessen, the agitation of the particles of the appropriated liquor, into whose pores they insinuate themselves; and thereby, according to the lately mentioned supposition, they may refrigerate that particular liquor, without having the like effect on other liquors, whose textures are differing. And I might countenance this by adding, that as fiery and agitated a spirit as that of wine, when well dephlegmed, is justly thought to be; yet I know more liquors than one, that being mingled with it, will in a trice deprive it of its fluidity; and the like change I have sometimes made in some other liquors also. But I must not insist on such matters, having mentioned them but only to awaken men's curiosity and circumspection, and not to build much upon them; which will be easily credited,

credited, if it be remembered, that a little above I my self sufficiently intimated, that this conjecture supposes something about the theory of cold, which is not yet sufficiently cleared. Only, because the former experiments shew, that the various agitation of the minute parts of a liquor, whereon its fluidity depends, may be hindered or suppressed by the intervention of adventitious corpuscles, but do not clearly shew, that the liquor by being deprived of that kind of agitation does actually acquire a coldness; I might subjoin thus much, that by the addition of a certain substance (which for just reasons I must forbear to describe) that would scarce sensibly refrigerate common water; I can make a certain (and for aught I know, one only) liquor, that is wont to the touch to be much of the temper of water, to receive a considerable degree of coldness. This, I say, (as strange as it may seem) I might here subjoin to countenance the conjectures, I have been delivering, and afford some new corollaries; but for the reason newly intimated I forbear, and the rather, because I think it high time to return thither, whence the considerations, I have offered about weather-glasses, have made me digress.

I WAS going then to take notice, upon the occasion offered by what I related of the influence of the atmosphere's gravity upon common weather-glasses, of the difference between them and those that are hermetically sealed. And indeed these are in some things so much more convenient than the others, that (if I be not mistaken) it has already proved somewhat serviceable to the inquisitive, that I have directed the making of the first of them, that have been blown in *England*. At the beginning indeed I had difficulty to bring men to believe, there would be a rarefaction and condensation of a liquor hermetically sealed up, because of the school-doctrine touching the impossibility of a vacuum, and especially, because I had never seen any experiment of this kind, nor met with any that had: but after some trials, which my conjectures led me to make successfully enough, that in hermetically sealed glasses, both air and water might be alternately rarified and condensed; I found my work much facilitated by the sight of a small sealed weather-glass, newly brought by an ingenious traveller from *Florence*, where it seems some of the eminent virtuosi, that ennobled that fair city, had got the start of us in reducing sealed glasses into a convenient shape for thermoscopes. But since that, the invention has in *England* by a dexterous hand, that uses to make them for me, been improved, and the glasses we now use are more conveniently shaped, and more exact than the pattern, I caused the first to be made by. But the filling of these long ones, that we now use, is a work of more niceness and difficulty, than they, that have not tried, will be apt to imagine, and therefore may elsewhere deserve either from our pen, or his, that is most versed in making them, a more particular account of the way of performing it; the advantages of these weather-glasses being at no hand inconsiderable. For,

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the weight or pressure of the atmosphere (which, as we have noted, may work very much upon others,) their being sealed defends them from: and by this advantage they may be used in the highest and in the deepest places, with as much certainty as any where else. Next, whereas in other thermometers the liquor is very subject to be spilt, in case they be removed from place to place, and, which is worse, though they be not removed, is subject to be preyed upon and wasted by the air, whereby informations of such weather-glasses are rendered in tract of time somewhat uncertain; in sealed weather-glasses, there is no danger, that liquor should either spill or evaporate. And upon the same account, these have this advantage, that you may safely let them down into the sea, and immerse them in any liquor, you please, without excepting the most corrosive to examine their coldness: not to mention, that instead of the coarser liquors used in common weather-glasses, which are some of them not unapt to freeze, and others unapt enough to comply with the slighter alterations of the air, and instead of the colourless liquor, whether water or no (I know not) used in the Florentine weather-glass I saw, we employ highly rectified spirit of wine, whose being brought to a lovely red with cochineal, opened by the most subtle volatile spirit of urine, by which means the included liquor is not only very conspicuous and secured from freezing, but so susceptible of even the slighter impressions of external bodies (which would work but faintly on water) that 'tis pleasant to see, how many inches a mild degree of heat will make the tincture ascend in the very slender cylindrical stem of one of these useful instruments; of which we have spoken the more particularly in this place, because we shall have frequent occasions to mention them in the following papers; and no body as yet, that we know, has written any account of them.

BUT though these weather-glasses be much more to be relied on, than those, that are commonly in use, yet we would have a philosopher look upon both these and our sensories, but as instruments to be employed by his reason, when he makes his estimates of the coldness of bodies: and though perhaps it will signify nothing in the event, yet I see not, why it should misbecome a naturalist's diligence and circumspection, to try, whether even such weather-glasses ought to be so far allowed of, as to hinder men from looking after any other kind of ways of estimating cold.

FOR, though the sealing of these weather-glasses protect the included liquor from the pressure of the air, and keep it from evaporating, yet it will not follow from hence, that they must be exempt from all the other imperfections, which we formerly mentioned to be imputable to weather-glasses.

I KNOW not, whether you will allow me to add on this occasion, that tinted spirit of wine (and the like may, for aught we know, be said of any such liquor) being a particular mixture, in case it be allowed possible, that the subtle steams of such bodies (as we formerly noted

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to be frigorifick in respect to some liquors) may insinuate themselves through the pores of glass; as it is granted, that the effluvia of the loadstone do readily permeate it: in this case, I say, though I willingly allow it not to be likely, yet it is not absolutely impossible, that some steams, that wander through the air, may be more or less cold, or may more promote or hinder an agitation among the minute parts in reference to it, than in reference to other liquors: as we formerly noted, that a grain or two of opium will exceedingly allay the warmth and motion of the whole mass of blood in a man's body, though ten times that quantity will not sensibly refrigerate the tenth part of so much water. And that this may appear the less extravagant, I shall here add some mention of an odd phenomenon, that, as it were, by some fate has occurred to me, since I began the discourse I am now upon: for whilst I was yesterday writing it, I had occasion to examine by such a sealed weather-glass (as I have been speaking of) the temper of a certain strange kind of mixture, that towards the close of this treatise, I shall have occasion to take special notice of: and though to the touch it appeared but lukewarm, yet having put into it the ball, and part of the stem of the sealed weather-glass, I found the included liquor slowly enough impelled up so high, that at length, to my wonder, it rose eight or nine inches in a stem, which was not much above a foot long. But that which I relate, as the surprizing circumstance, is, that when I had taken out the thermoscope, and removed it again into a deep glass full of cold water, whence I had just before taken it out, to put it into the anomalous mixture, I had a mind to examine; the tincture in the weather-glass did not (as it was wont, and as any one would have expected) begin to subside again towards its former station, but continued within about half an inch or less of the very top of the instrument, though neither my own busy eyes, nor those of a person very well versed in making and using thermoscopes, could perceive, that the expanded tincture was any where discontinued by any air or bubbles, which at first we suspected might possibly (though it were very unlikely) have been generated by the tepor of the mixture. But that, which continued our wonder, if not increased it, was, that during four or five hours, that the instrument continued in the cold water, and during some hours also, that it was exposed to the air, the tincture did not subside above half an inch; and, which is yet more strange, having left the glass all night in the window of a room, where there was no chimney, I found in the morning, that its descent was scarce sensibly greater, for it continued about eight inches higher than the mark it stood at, when I first put it into the lukewarm mixture; and how long it will retain this

strange expansion, is more than I can tell. But by this, and what I may have occasion hereafter to relate, concerning this mixture, it may appear somewhat the more reasonable to suspect, than even sealed weather-glasses furnished with high rectified spirit of wine, may in some (though very rare) conjectures of circumstances, and from some peculiar agents, either by their insinuating themselves through the pores of the glass, or on some other account, receive impressions, that, as far as can easily be discerned, are not purely the genuine and wonted operations of heat and cold.

THE chymist *Ortbelius* tells us, that the liquor distilled from the ore of magnesia or bismuth (which seems to be the same mineral that we, in English, call tin-glass) will swell in the glass it is kept in, not only manifestly, but very considerably at the full moon, and shrink at the new moon; and if all my endeavours to procure that ore had not proved fruitless, I should be able, by my own experience, to disprove or confirm so admirable a phenomenon: but being as yet unfurnished to make the trial myself, lest it might appear a vanity, so much as to mention (without rejecting it) a thing so very unlikely; I shall add, that since I find the thing, for the main, which was delivered by the chymist, employed as an argument by a famous mathematician (the Jesuit *Casatus* *) whose expressions are such, as if he himself had observed, that even in stopp'd glasses, the fore-mentioned mineral spirit increased very sensibly in bulk about the time of the full moon; which wonder being admitted, may not only countenance what we were saying, but hint some other very strange things in nature. This brings into my mind, (what I have elsewhere mentioned) that a tincture of amber I had made with high rectified spirit of wine, did, for many months, in a well-stopp'd glass, discover itself to be affected with certain changes, which were thought to proceed from some secret mutations of the air, that did sensibly so work, as I had not observed it to do upon other liquors, wherein the spirit of wine abounded. And, perhaps, upon long and diligent observation, one might find a disparity betwixt weather-glasses kept in the same place, but furnished with differing liquors; a disparity, I say, that could not be so well ascribed to any thing, as to the peculiar nature of the respective liquors, which, though of divers kinds, may (to add towards the facilitation of trials) be made of a very conspicuous colour, by the self-same metal, copper, which not only gives the known colour in aqua fortis, but affords us a fair solution in aqua regis, and it makes a liquor of a deep and lovely blue in spirit of urine, or of sal armoniac, and the like: nay, I have found, that in good chymical oil of turpentine (for expressed oils are too easily congealed) the bare filings of it will yield a sufficient tincture. But because it is yet but a bare suspicion,

* *Vitrum optimè clausum ne quid exspirare possit, in loco ubi quiesceret, statui, nec sine animi voluptate licet in plenitudine manifesta inclusi liquoris incrementa observare, in novilunio vero decremenda, &c.* They are the words of *Paulus Casatus*, in his *Terra Machinis mota*, Pag. 143. But since the writing of these preliminary discourses, the author of them having consulted, by the means of some ingenious friends, the learned *Casatus*, finds, that he never made or saw the experiment himself, but relates it upon the authority of a certain Dutchman, whose name he adds not, and who therefore may probably be the same *Ortbelius*, that is mentioned by the author of these preliminary discourses; who thinks it requisite to give the reader this advertisement, because *Casatus* himself did not, as he should have done, intimate, that he delivered this but upon another's credit.

suspicion, that sealed weather-glasses, made of differing liquors, but in other points alike, may be otherwise uniformly affected by the temperature of the external air; I shall now add an observation already made, to shew, that even the sealed weather-glasses, furnished with spirit of wine, are not so perfectly secluded from all commerce with external bodies, and liable to their operations, but that they may be wrought upon otherwise than we think. For I have more than once observed, that even in sealed thermoscopes (made purposely at home for me, and with great care, by the expertest maker of them) after a good while, and when no such matter was expected, there have emerged bubbles, which, whether they proceeded from some undiscernible particles of air, harboured in the pores of the water, which, in process of time, by their union, came to make conspicuous bubbles, or from some disposed particles of the spirit of wine itself, by successive alterations, brought to a state of elasticity, I now examine not; but only affirm, that sometimes I have had, of these bubbles, great enough to possess the space of many inches, in the shank of a long sealed weather-glass, and I have been troubled with them in more weather-glasses than one or two: which I therefore take notice of, not only because it serves to prove what I was saying, but because it is very fit an advertisement should be given of it to prevent mistakes. For when these bubbles are small, and are generated, or happen to stay at or about the place where the spherical and cylindrical parts of the glass meet, they may easily (as I have observed) lurk unheeded, and reaching from side to side, so divide the spirit of wine in the ball from that in the stem, that the latter shall not be able to rise and fall according to the changes of the weather; the bubble, notwithstanding its aerial nature, being more indisposed to be moved up and down in the slender stem of a small weather-glass, than the spirit of wine itself, as we have elsewhere shewn, that when air is not forced, a bubble of it will not, in several cases, so readily pass through a very narrow passage, as would that grosser fluid, water.

BUT all these difficulties (not to call them extravagancies) which I have been mentioning about sealed weather-glasses, I represent not to shew; that it is (at least as yet) worth while to suspect us so far, as to employ all the diligence and inventions, that were requisite to prevent or silence the suspicions of a sceptick, or that might be thought upon, in case the matter did require or deserve such extraordinary nicety, but only to give men a rise to consider, whether it would be amiss to take in (when occasion presents itself) as many collateral experiments and observations, as conveniently we can, to be made use of, as well as our sensories and weather-glasses, in the adjudications of cold. And, perhaps, an attentive enquiry, purposely made, would discover to us several other bodies, natural or factitious, which we might make some use of in estimating the degrees of cold. For though (to give an instance) water be thought to be the liquor, that is most susceptible of such an intensity of cold, as will destroy or

suspend its fluidity; yet, not here to repeat what we formerly delivered of the easy congelableness of oil of aniseeds, we have (as we elsewhere note to another purpose) distilled a substance from benzoin, which becomes of a fluid, a consistent body, and may be reduced to the state of fluidity again by very much lesser alterations of the ambient air, as to heat and cold, than would have produced ice or thawed it. I could also here take notice of what I have sometimes observed in amber-grease, dissolved in high rectified spirit of wine, or in other sulphureous or resinous concretions dissolved in the same liquor: for now and then, though it seemed a meer liquor in warm weather, it would in cold weather let go part of what it swallowed up, and afterwards re-dissolve it upon the return of warm weather; some of these concretions, as I have seen in excellent amber-grease, shooting into fine figured masses, others being more rudely congealed. And I might also add, what I have observed in chymical liquors, (not unskillfully prepared out of urine, hartshorn, &c.) which would sometimes seem to be totally clear spirits, and at other times would suffer a greater or lesser proportion of salt to crystallize at the bottom, according to the mutations of the weather, in point of cold and heat. Such kind of instances (I say) I could mention, but I shall rather chuse to prosecute my examples in that obviouslest of liquors, water; and add, that even that may afford us other testimonies of the increased or lessened cold of the air, than that which it gives us in common weather-glasses. For in some parts of *France* the watermen observe, that the rivers will bear boats heavier loaded in winter, than in summer; and I have upon inquiry been credibly informed, that seamen have observed their ships to draw less water upon the coasts of frozen regions (where yet the sea is wont to be less brackish) than they do on our *British* seas: which argues, that water is thicker and heavier in winter than in summer. Nay, I shall add, that not only in differing seasons of the year, but even at several times of the same day, I have often observed the coldness of the air to be (regularly enough) so much greater at one time of the day than at another, that a glass bubble hermetically sealed and poised so as to be exactly of the same weight with its equal bulk of water, as that liquor was constituted at one time of the day, would about noon, when the warmth, that the summer's sun produced in the air, had somewhat rarified the water, and thereby made it, bulk for bulk, somewhat lighter than before, the bubble would sink to the bottom of the water, which (for the better marking the experiment) I kept in a glass-tube; but when at night the coolness of the air had reconcondensed the water, and thereby made it heavier, it began, by little and little, to buoy up the bubble, which usually by morning regained the top of the water; and at other times of the day it not unfrequently happened, that the bubble continued swimming up and down betwixt the top and the bottom, without reaching either of them, sometimes staying so long in the same

L'Hydro-graphie de P. Fournier, Liv. 18. cap. 12.

part of the tube, that it much surprized divers of the virtuosi themselves, who thought the poising of a weight so nicely, not only a very great difficulty (as indeed it is) but an insuperable one. But of this experiment I elsewhere say more; and because about other weather-glasses, I have said so much already, I think it may not be improper to sum up my thoughts concerning the criteria of cold, by representing the following particulars:

1. THAT by reason of the various and unheeded pre-dispositions of our bodies, the single and immediate informations of our senses are not always to be trusted.

2. THAT though common weather-glasses are useful instruments, and the informations they give us are in most cases preferable to those of our sense of touching, in regard of their not being so subject to unheeded mutations; yet even these instruments being subject to be wrought upon by the different weights of the atmosphere, as well as by heat and cold, may (upon that and perhaps some other accounts) easily misinform us in several cases, unless in such cases we observed by other instruments the present weight of the atmosphere.

3. THAT the sealed weather-glasses, we have been mentioning, are so far preferable to the common ones, as (especially they not being

obnoxious to the various pressure of the external air) that there seems no need in most cases to decline their reports, or postpone them to those of any other instruments: but yet in some nice cases it may be prudent (where it may conveniently be done) to make use also of other ways of examining the coldness of bodies, that the concurrence or variance to be met with in such ways of examination, may either confirm the testimony of the weather-glass, or excite or assist us to a further and severer inquiry.

4. THAT I would not have men too easily deterred from devising and trying various experiments (if otherwise not unlikely or irrational) about the estimating of cold, by their appearing disagreeable to the vulgar notions about that quality. For I doubt, our theory of cold is not only very imperfect, but in great part ill grounded. And I should never have ventured at trying to make sealed weather-glasses, if I could have been withheld either by the grand Peripatetick opinion, that (to shun a void) water must remain suspended in glasses, where, if it fall, the air cannot succeed it; or the general opinion even of philosophers as well new as old, that air must be far easier, than any visible liquor condensed by cold.

DISCOURSE III.

Containing the second Paradox, viz. Touching the Cause of the Condensation of Air, and Ascent of Water by Cold in common Weather-glasses.

THOUGH I thought here to end the preliminary discourse, as doubting it may be thought prolix enough already, yet for confirmation of what I was lately noting, about the incompleteness of the theory of cold, (and because the evincement thereof may give rise to many trials, that may enrich the history of cold) I will here subjoin a discourse formerly written on another occasion. For though upon that account I am fain to leave out the beginning of it, as not suited to the present occasion, yet the main body of the discourse may be (I think not improperly) annexed to what has been already said about weather-glasses; since it examines the causes of the principal phenomenon of them, and will perhaps help to discover the incompleteness of men's notions about cold, by shewing, that the true cause, even of the most obvious phenomenon of common weather-glasses (though almost every man thinks he understands it) has not yet been sufficiently inquired into.

THE discourse then, that first part of it (as foreign to our present purpose) being omitted, is as follows.

— To prosecute our disquisition satisfactorily, it will concern us to consider, upon what account the water rises in cold weather, and falls

in hot, in common weather-glasses, whose construction being so well known, that we need not to spend time to set it down, we may forthwith proceed to take notice, that concerning the reason, why in these weather-glasses the water, or other liquor in the shank or pipe, ascends with cold, and descends with heat; there are three opinions, that will deserve our consideration.

THE first is the common opinion of the schools and Peripateticks, and indeed of the generality of learned men of differing sects, who teach, that the cold of the external air, contracting the air included in the weather-glass, and thereby reducing it into a narrower room than formerly it possesseth, the water must necessarily ascend to fill the place deserted by the retired air, lest that space should become a vacuum, which nature abhors.

BUT against this explication, we have several things to object.

FOR first, I am not satisfied, that any of the schoolmen or Peripateticks (at least of those I have met with) have solidly evinced, that nature cannot be brought to admit of a vacuum. Nor do I much expect to see that assertion well proved, by these, or by any other, that forbear to make use of the argument of the Cartesian drawn from the nature of a body, whose very

very essence they place in its having extension: which I say, because about this argument I neither have yet published, nor do now intend to deliver my thoughts.

NEXT, it seems a way of explicating, that little becomes a naturalist, to attribute to the senseless and inanimate body of water an aim at the good of the universe, strong enough to make it act, as if it were a free agent, contrary to the tendency of its own private nature, to prevent a vacuum, that, as is presumed, would be hurtful to the universe.

BUT these arguments we have elsewhere urged, and therefore need not insist longer on them here.

THIRDLY, If you take a bolt-head, with a large ball and long stem, and do, with that and quicksilver, make the Torricellian experiment, there will be an instrument prepared like a common weather-glass, save that the stem is longer, and that the liquor is mercury instead of water; and yet in this case we see not, that the mercury, which remains pendulous in the pipe at the height of about thirty inches, offers to ascend into the cavity of the bolt-head, to fill up the space, whence the air was expelled by the mercury, and which the quicksilver also by its subsiding deserted. And the outward application of cold bodies to the forsaken part of the head will not, perhaps, occasion the rising of the quicksilver $\frac{1}{4}$ of an inch, if half so much, though the like degree of cold would make the water ascend in a vulgar thermometer, though shorter, to the height of several inches. But this argument I also, on another occasion, further display and vindicate.

WHEREFORE I shall add one more, taken from the consideration of these sealed weather-glasses, that are described in this present History of Cold. For, in these the air does not shrink, but rather seems to be expanded, when the weather grows colder. If it be said, that water being contracted by the cold, the air follows it, to prevent a vacuum; I answer, that those, that say this, should explain why, whereas in common weather-glasses the water ascends to follow the air, in these the air must descend to follow the water; and why, since to avoid a vacuum, the one in common weather-glasses, and the other in sealed ones, resists contraction, nature does not rather make the air in common thermometers retain the extension, they conceive due to its nature, than put herself to the double labour of suffering the air to be preternaturally condensed, and compelling the water to ascend contrary to its nature. But these arguments I will not urge so much as this other, that in our present case the above proposed answer will by no means solve the difficulty. For if the water be really condensed into less, and the air expanded into more space, than they respectively possess before; I see not, how a vacuum or a worse inconvenience will be avoided. For I demand, since glass is granted to be impervious to air and water, (as indeed else nature would not need to make water ascend contrary to its own tendency in a common weather-glass) what be-

comes of the body, that was harboured in the space deserted by the water upon its condensation? which question those, that do not say any thing escaped away through the glass, or that any thing was annihilated, will not easily answer. But this is not all; for I further demand, when the air expands itself to follow the water, how by that expansion of the air, a vacuum both *coacervatum* (as the old Epicureans spoke) and *interspersum*, is avoided. For the aerial corpuscles cannot advance into this space deserted by the water, without leaving either in whole or in part the spaces they filled before; so that by this remove an aerial corpuscle only changes place, but does not adequately fill any more place than it did before. But if it be said, that the same air, without any substantial accession, may adequately fill more space at one time than at another; if this, I say, be pretended, I shall not urge, that it appears not, why it were not more easy for nature in common weather-glasses, as well as in sealed ones, to rarify the air, which they teach to be so very easily rarified and condensed, than to make the heavy body of water to ascend. For I may very well reply, that I scarce know any opinion in natural philosophy, that to me seems more unintelligible, and more worthy to be confidently rejected, than this harsh hypothesis of rarefaction. Of which I should think it injurious to so judicious a philosopher, as my Lord *Brouncker*, to endeavour here to manifest the absurdity, though I had not in another place Defence A-
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nus, chap.
3. shewn it already.

THE next opinion, we are to consider touching the cause of the ascension of water by cold in weather-glasses, is that of Mr. *Hobbes*, who, in the last chapter of his book *de Corpore*; sect. 12. having premised a delineation of a common weather-glass, subjoins this explication:

In the sixth and seventh articles of the 27th chapter (where I consider the cause of cold) I have shewn, that fluid bodies are made colder by the pressure of the air, that is to say, by a constant wind, that presseth them. For the same cause it is, that the superficies of the water is pressed at F, and having no place, to which it may retire from this pressure, besides the cavity of the cylinder between H and E, it is therefore necessarily forced thither by the cold, and consequently it ascendeth more or less, according as the cold is more or less increased. And again, as the heat is more intense, or the cold more remiss, the same water will be depressed more or less by its own gravity, that is to say, by the cause of gravity above explicated.

BUT however the author of this explication, to prepare us to receive it, tell us, that however the above-mentioned phenomena be certainly known to be true by experience, the cause nevertheless has not been discovered; yet I confess, I think this newly recited assertion might as well have been placed after his explication, as just before it.

FOR first, whereas, he remits us to the sixth and seventh articles of the 27th chapter (for the reference is misprinted) as containing the

grounds of this explication, I must profess myself far from being satisfied with the general theory of cold delivered in that chapter, as being partly precarious, partly insufficient, and partly scarce intelligible, as I shall elsewhere have occasion to shew. And as for what he particularly alledges in the sixth and seventh articles of a constant wind, that presses fluid bodies, and makes them cold, besides that that is prooflessly affirmed, we shall anon have occasion to mention an experiment, where water was not only much refrigerated, but turned into ice, though it were sealed up in glass vessels, and those suspended too in other glasses; wherein some of them had air about them, and some others were totally immersed in unfreezing liquors; so that the water, that was sealed up, was sufficiently protected from being *raked* by the wind, as Mr. *Hobbes's* conceit of the cause of freezing requires.

SECONDLY, I see no necessity, that the cold should press up the superficies of the water into the shank of the weather-glass, especially since it is manifest, that the water will rise with cold in a weather-glass kept in a still place, and free from any sensible wind. Besides that it should be proved, and not barely affirmed, that an insensible motion deserves the name of wind, and that such a one is the cause of the refrigeration of water; and it should be also shewn, how this wind comes to be able to raise the water, and that to the height of many inches more in one part of the superficies than in another. Besides all this, I say, we find by experience, that water poured into a bolt-head, till it have filled the ball, and reached a good way into the stem, will, upon a powerful refrigeration, short of freezing, (which is the case of water in weather-glasses, when the air grows colder) manifestly shrink into a narrower room, instead of being impelled up higher in the pipe. And if in an ordinary weather-glass, with a long shank, you apply a mixture of ice or snow, and salt to the bolt-head, the water will readily ascend in the shank to the height of divers inches, which, how it will be explained by Mr. *Hobbes's* hypothesis, I do not well see.

THIRDLY, I wonder he should tell us, that the reason, why the pressed water ascends into the shank of the weather-glass, is, because it hath no other place, into which it may retire from the pressure of the wind; since he, rejecting a vacuum, and affirming the world to be every where perfectly full, should not, methinks, have so soon forgotten, that in the very paragraph or section immediately preceding this, himself had told us, that he *cannot imagine, how the same place can be always full, and nevertheless contain sometimes a greater, sometimes a less quantity of matter; that is to say, that it can be fuller than full.* So that I see not, why the water should find more room to entertain it, in the cylindrical cavity of the weather-glass already adequately filled with air, than other where. And in the sealed weather-glasses we have above been mentioning, and wherein the water descends with cold, it will be very hard for Mr. *Hobbes* to make out the phenomenon according to his doctrine. Be-

sides that his explication gives us no account of the condensation of the air by cold in such weather-glasses, as those, wherein the water descends with cold and rises with heat.

FOURTHLY and lastly, whereas Mr. *Hobbes* takes notice of no other cause of the depression of water in weather-glasses by heat, but its own gravity, he seems to have but slightly considered the matter. For though, in some cases, the gravity of the water may suffice to depress it, yet, in other cases, that gravity alone will by no means serve the turn, but we must have recourse to the expansive motion or spring of the air included in the cavity of the glass. For if you place a thermometer with a large ball, wherein the water ascends but a little way into the shank, in a window exposed to the warm sun, you will often perceive the surface of the water in the pipe to be a good deal lower than that of the water on the outside of the pipe; which shews, that this depression proceeds not from the bare sinking of the water, but from its being thrust down by the pressure of the incumbent air; since the water's own weight would make the internal water fall but to a level with the surface of the external water, and not so much beneath it. And for further proof, you may, by keeping such a weather-glass long enough in the hot sun, bring the air so far to expand itself, as to drive the water out of the shank, and break through the external water in divers conspicuous bubbles, after whose eruption the remaining air being again refrigerated by the removal of the weather-glass into a cooler place, the loss of that part of the air, that escaped away in bubbles, will make the water ascend higher in the shank, than in the like degree of cold it would formerly have been impelled. And thus much may suffice to shew the unsatisfactoriness of Mr. *Hobbes's* conceit.

THE third and last opinion we shall mention, is that of some ingenious modern naturalists, who acknowledging, that the air has a weight, (which Mr. *Hobbes* also does in effect admit, though he make not so good use of it as they) do by that explicate the ascension of water in weather-glasses; teaching, that the cold of the ambient air making the included air shrink into far less room than it possesseth before, the water in the subjacent vessel is, by the weight of the incumbent air, which presses on it more forcibly in all the other parts of its surface, than it is pressed upon in that included in the shank, impelled up into that part of the shank, which was newly deserted by the self-contracting air.

BUT though this account be preferable by far to those, which we mentioned beforeit, and though it be not only ingenious, but, as far as it reaches, true; yet to me I confess it seems not sufficient, and therefore I would supply what is defective, by taking in the pressure, (and in some cases the spring) of the external air, not only against the surface of water, (for that the newly mentioned explication likewise does) but also against the internal or included air. For the recited hypothesis gives indeed a rational account, why the water is impelled in-

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to the place deserted by the air; but then supposes, that the air is made to contract it self by cold alone, when it makes room for the water, that succeeds in its place; whereas I am apt to think, that both the effects may proceed, at least in great part, from the same cause, and that the pressure of the contiguous and neighbouring air does, according to my conjecture, eminently concur to reduce the cooled air, shut up in the weather-glass, into a narrower space. This it does in common weather-glasses, because the ambient air retains the whole pressure it has, upon the account of its weight; whereas the internal air, by its refrigeration, even when but equal to that of the external air, loses part of the pressure it had upon the account of its weakened spring.

BUT this, as I newly intimated, is not the sole account, upon which the air may in some sorts of weather-glasses impel up the water, and contribute to the condensation of the air incumbent on the water. For in some circumstances (one or two of which we shall produce by and by) it may so happen, that the rest of the air, that bears up the water to be raised, will not be so much refrigerated, as the included air, that is to be condensed; and consequently the other air will have a stronger spring, than this last mentioned air will retain, and therefore the former will have a greater pressure, than the latter will be able to resist.

WE shall not now examine, whether the spring of the air depend upon the springy structure of each aerial corpuscle, as the spring of wooll does upon the texture of the particular hairs it consists of, or upon the agitation of some interfluent subtiler matter, that, in its passage through the aerial particles, whirries each of them about, or upon both these causes together, or upon some other differing from either of them: but this seems probable enough; that as, when air, being sealed up in a glass, is afterwards well heated, though it acquire not any greater dimensions, as to sense, than it had before, yet it has its spring much increased by the heat; as may appear, if the sealed tip be broken under water, by the eruption of bubbles, by the endeavour of the imprisoned air to expand itself; so upon the refrigeration of the air, so sealed up, though the additional spring (if I may so speak) which the heat gave it, will be lost upon the recess of that heat, or as soon as the effect of that heat is destroyed, yet there will remain, in the included air, a considerable spring, and sufficient to make it as well fill (at least as to sense) the cavity of the sealed glass, as it did when its spring was stronger. And proportionably we may conceive, that though cold, at least such as we meet with in this climate of ours, does make the spring of an included parcel of air weaker than it was before the refrigeration of that air, yet it may not make it so much weaker, but that the aerial corpuscles may be kept so far extended, as not at all (or scarce sensibly) to quit the room they possessed before, in case there be not, contiguous to them, any other body, which, by its pressure, endeavours to thrust them inwards,

and so make them desert part of that space. Which clause I therefore add, because, that if the case proposed do happen, it is obvious to conceive, that the weakened spring of the air cannot retain so much force to resist an external pressure, as it would have, if the cold had not debilitated it; and consequently this cooled air must yield and suffer itself to be condensed, if it come to be exposed to a pressure, to which it was but equal before its being weakened. And such in common weather-glasses is the pressure, that is constantly upon the surface of the water without the pipe, upon the account of the gravity of as much of the air or atmosphere as comes to bear upon it.

HAVING thus explained our conjecture, we will now proceed to the experiments we made to countenance it, as we find them entered in our loose notes.

IN one of which, I find what follows:

WE took a phial capable of containing five or six ounces of water, and having filled it almost half full with that liquor, we inverted into it a glass-pipe of about ten inches long, and much bigger than a large swan's quill, sealed at one end, and at the other filled top-full with water; so that the open orifice being immersed under the vessel'd water (of the phial) there remained no air at the top of the pipe. Then, as much of the orifice of the phial's neck, as was not filled by the pipe, being carefully closed with cement, that no air could get in or out, the phial was placed in snow and salt, till the vessel'd water began to freeze at the top and bottom; and, according to our expectation, we found, that, notwithstanding this great degree of infriegeration of the air in the phial, the water in the pipe did not at all descend: so that either the air did not shrink by so great a cold, or the water, whether to avoid a vacuum, or otherwise, did not remove out of the pipe to possess the place deserted by the refrigerated air.

AFTERWARDS we endeavoured to repeat the experiment with the same glasses; but having had occasion to be absent a little too long (though not very long) we found, at our return, the upper and sealed part of the pipe beaten out, which we supposed to have been done by the intumescence of the water in the phial upon its glaciation.

WHEREFORE we fastned into the same phial another pipe, some inches longer than the former, and drawn very slender at the sealed end, that it might easily be broken there; and having set the phial to freeze, as before, without finding the water to descend in the pipe, we did, with a forceps, break off the sealed end, that the outward air might come to press upon the suspended water, and, by it, upon the cooled air in the phial; whereupon, as we expected, the water was swiftly depressed, by our estimate, eight or ten inches, but not so low by a pretty deal, as the surface of the water in the phial.

AFTER this, by rarifying the air in the vial, and by blowing into it through the pipe, the water was raised within about half an inch of the

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the top of the pipe, whose slender end being sealed, the phial was again placed in snow and salt; but the spring of the air at the top, which was rarified before, was, by refrigeration, so weakened, that it was unable sensibly to depress the water; wherefore, breaking off the apex, as before, the upper air immediately drove it down divers inches.

OUR last trial therefore was, to leave in the same pipe about $3\frac{1}{2}$ inches of air rarified as little as we could, and placing the phial in salt and snow, as before, we observed, that the air in the pipe did, upon the refrigeration of the air in the phial, expand itself very little, though the water in the phial were in part turned into ice; but upon breaking off the slender sealed end, the outward air presently depressed the water above two inches beneath the last level, and by removing the glass into a warmer room, we found, that the water ascended a pretty deal above an inch higher than the same uppermost level, whereby we probably concluded our weather-glass to be stanch.

THUS much I find together in one place, among my promiscuous collections: but after this, coming to have the conveniency of glasses so shaped as to be easily sealed, I judged it fit to make use of some of them, to keep even the most suspicious from objecting, that I should also have made some trials with glasses, which being hermetically seal'd, would be sure most accurately to hinder all immediate intercourse betwixt the internal and external air. And I remember, that once we took a glass, like the bolt-head of a common weather-glass, save that the small end was drawn very slender, for the more easy breaking of the apex: and into this glass a convenient quantity of water was poured, and then the glass being sealed up at the sharp end and inverted, the water fell down to that end, and possess'd its due space in the pipe. Then the round end of the glass having a mixture of snow and salt applied about it, though the internal must needs have been thereby much refrigerated, (as will be readily granted, and may be gathered from divers of the experiments mentioned in these papers) yet we observed not the water manifestly to rise. And though an attentive eye should in such a trial discern some sensible intumescence in the water; yet that may well enough proceed from some little expansion of the aerial particles, which we have elsewhere shewn to be usually latent in common water, upon the diminution of the pressure of the air above the water, caused by weakening that air's spring by the cold. But when we had, to compleat the experiment, broken the slender end of the glass under water, the included air, becoming then contiguous to that had obtained immediate intercourse with that water, whose surface was every where prest by a pillar of the external air that leaned upon it, the water was by the gravity of that outward air hastily impell'd into the cavity of the pipe (the spring of whose air was, as we said, weakened by the cold) to the height, if I misremember not, of several inches.

ANOTHER sort of trial I remember we made after the following manner: We took

glass-bubbles (blown with a lamp) some of about the bigness of a nutmeg, and some much greater; each of these bubbles we furnished with a very slender stem (often no bigger than a raven's quill) which was usually divers, and sometimes many inches long. Into this stem a drop or two of water being conveyed, might easily enough, by reason of the lightness of so little liquor, together with the slenderness of the cavity (which permitted not the included air to penetrate the water at the sides, but rather impel up the intire body of it) be kept suspended, and so betray very small changes, See more concerning these weather-glasses in the first of these three discourses. (and much smaller than to be taken notice of by common weather-glasses) as to rarification and condensation in the air it leaned upon. Now when in one of these instruments, if watching when the pendulous water was somewhat near the top of the stem, we nimbly applied to the orifice of that stem the flame of a candle, we could by that heat almost in a moment seal it up, by reason of the thinness of the glass, and the slenderness of the stem. And if then we placed the thus sealed glass in a mixture of snow and salt, how much soever the air within the cavity of the ball must be, in all probability, refrigerated by this operation, yet it would scarce sensibly, and not at all considerably shrink; as we gathered from the pendulous waters remaining in the same place, or its falling at most but inconsiderably lower. But if then, with a pair of scissors or otherwise, we dexterously broke off the sealed end of the stem, and thereby exposed the internal refrigerated, to the pressure of the external air, the water immediately would be hastily thrust down, sometimes divers inches below its former station, and sometimes quite into the cavity of the round end of the glass. To which we shall add, that not only, when these thermometers were sealed, neither the usual degrees of cold, nor those of the heat in the ambient air would at all considerably depress or raise the pendulous water, which, if the glass were not sealed, would, as we formerly noted, shew it self wonderfully sensible of the mutations of the air, as to those two qualities: But we sometime purposely tried, that though upon the refrigeration of the formerly rarified air in the glass, the pendulous water were descending fast enough, yet if even then we nimbly sealed up the open orifice of the stem (which may easily be done in a trice) the descent of the water would be presently stopt, and it would stay either just in, or very near the same part of the shank, wherein it chanced to be, when by sealing of the glass it came to be fenced from the pressure of the atmosphere; and in that place it would continue till the sealed end were broken off. For then in case the ambient air were as cool, as it was when the glass was sealed, the water would for the reason already given be further depressed, according as the weakened spring of the inward rarified air was more or less remote from an equality to the pressure of the ambient air.

BESIDES, for further trial, we took a large glass-egg with a long stem, which stem was purposely so bent, that it represented a glass-siphon,

siphon, in whose shorter leg the glass was drawn very small, that it might be the more easily first sealed, and then broken.

THIS done, we got in a convenient quantity of water, which ascended to a pretty height in both the legs of the bent glass, after which the shorter leg being nimbly sealed after the manner hereafter to be mentioned, there remained a pretty quantity of air above the water in that shorter leg, which was purposely left there, that it might, by its spring, impel up the water in the longer leg upon the refrigeration of the air included in that longer leg. All this being done, the whole glass was so placed in a convenient frame, that the oval part of it was supported by the frame, beneath which the bended shank of the weather-glass did hang so, that a mixture of ice and salt might be conveniently laid upon this frame to surround and refrigerate the air included in the egg, without much cooling the air in the cylindrical part of the glass. The account, that I find of this trial in one of my notes, is this.

See the figure among the rest of the schemes.

In the greater bent egg, that was sealed up with water, in both legs, upon the application of ice and salt to the ellipsis at a convenient time, the water in the longer leg ascended a little, but not by our guess above a barley-corn's length, if near so much, and about four inches of air (as I remember) that were left in the shorter leg, expanded itself (to sense) as much; but as soon as I broke off the slender wire, wherein the shorter leg ended, the external air rushing in made the water rise about

two inches and a quarter in the longer leg, and then, there not being water enough, broke through it in many bubbles.

THUS far the note, to which I shall only add, that in this case the ascension of the water in the longer leg cannot be attributed to the weight of the air in the shorter leg, that being, I know not how much, too small to lift up so much water, but to the spring of that air: and also that we need not marvel, the expansion of that air should be so small, since some of the experiments, hereafter to be related, will shew us, that the refrigeration of the air in such trials (as that newly recited) does not weaken the spring of it any thing near so considerably as one would expect. So that the air in the longer leg could yield but a very little to that in the shorter leg, especially since the smallness of this last named proportion of air made its spring to be more easily and considerably weakened by a small expansion.

THUS far our paradoxical discourse, which contains divers particulars, that, being added to the considerations, whereunto we have (by way of appendix) subjoined it, might afford us several reflections: but having dwelt too long on one subject already, we shall now conclude with this, upon the whole matter;

THAT there is somewhat or other in the business of weather-glasses, which (I fear) we do not yet sufficiently understand, and which yet, I hope, that by other trials and more heedful observations we shall discover.

The Paper, that was prefixed (by way of a short prefatory Address) to the ensuing History of Cold, when being to be brought in, and presented to the Royal Society, it was put into the hands of its most worthy President, the Lord Viscount Brounker, was as followeth.

Little Chelsea, Feb. 14. 1662. S. A.

My Lord,

THE time your lordship and the society appointed me for the bringing in of my papers, concerning cold, is so very short, that to give you the fruits of my obedience as early as you are pleased to require them, I must present them you very immature, and I should say very unfit for your perusal, if you were not as well qualified to supply deficiencies and imperfections as to discern them. For of all the old observations, I made divers years ago, in order to the history of cold, I have not yet found enough to fill up one sheet of paper: and as for those, I made the last frosty season, besides that I was several times diverted by avocations distracting enough, the sharpness of the weather, which gave me the opportunity of making some experiments, brought me an indisposition, which by forbidding me to be often, and stay long in the cold air, hindered me from making divers others; and (which is worst of all) whilst I was confined to a place, where I wanted

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divers glasses, and other instruments I would have employed, the ways both by land and water were so obstructed by the snow and ice, that I could not seasonably procure them from London, and was thereby reduced to leave several trials, I should have made, either unattempted, or unperfected. But lest you should think, that what I intend only to excuse my unaccuracy, is meant to excuse my pains, I shall without further apology apply myself to do what the shortness of the time will allow me, which is little more, than to transcribe into this historical collection most of the particulars, which your lordship's commands exact, though haste will make me do it in the very words, for the most part, that I find them, in a kind of note-book, wherein I had thrown them for my own private use; which I the less scruple now to do, not only because the haste, that exacts from me this way of writing, may serve to excuse it in me, but that it may the better appear, how little I had designed to wrest or byass them to any pre-conceived hypothesis.

U u u

The

The EXPERIMENTAL HISTORY of COLD begun.

TITLE I.

Experiments touching bodies capable of freezing others.

TO go methodically to work, we should, perhaps, begin with considering, what subjects are capable, or not capable of harbouring the quality we are to treat of; and to invite us to this, it seems probable enough, that among the bodies, we are conversant with here below, there is scarce any except fire, that is not, at some time or other, susceptible of actual cold, (at least as to sense) And even concerning fire it self, till that difficulty be clearly determined, which we have elsewhere started; namely, whether fire be not, as wind, (at least like such as is made by air blown out of a pair of bellows) rather a state of matter, or matter considered whilst it is in such a kind of motion, than a distinct and particular species of natural bodies, there may remain some doubt; since we see, that bodies, which may be either in a moment, as gunpowder, or (as far as sense can judge,) totally, as high rectified spirit of wine, turned into fire, may yet immediately before their accension, be actually cold: and as to gunpowder, presently after accension, its scattered parts caught in closed vessels will also appear cold to the touch. But such things nevertheless we must not now insist on, partly because it requires the resolving of a somewhat difficult question, which more properly belongs to the considerations about heat, where we have already handled it; partly because our design in the following collections was not so much to gather and set down observations, that were obvious to any, that was furnished with a mediocrity of attention, as experiments purposely made in order to the history of cold; and partly too, because in this collection, though we do, as occasion serves, take notice of experiments and phenomena, that relate to cold in general, or indefinitely; yet our chief work has been to find out, and deliver, the phenomena of congelation, or of that intense degree of cold, which either does freeze the bodies it works upon, or at least were capable of turning common water, fitly exposed to it, into ice. And this may serve for a general advertisement about the ensuing papers; and consequently having premised it, we shall without any further preamble proceed to the setting down such things, as we have tried and observed concerning those matters; beginning with those, that belong to the title prefixed to the first part, or section, of our history.

1. THE bodies, that are cold enough to freeze others, are in this climate of ours but very few, and among the most remarkable is a mixture of snow and salt, which, though little known, and less used here in *England*, is in *Italy* and some other regions much employed, especially to cool drinks and fruits, which men may easily

do, by burying, in this mixture, glasses, or other convenient vessels, filled either solely with wine, or other drinks, or else with water, that hath immersed in it the fruits to be refrigerated.

2. THE circumstances we are wont to observe in making and employing this mixture, we shall hereafter in due place deliver; and therefore here we shall only take notice, that we could not find upon some trials, that such glasses filled with water, as would be frozen easily enough by this mixture of snow and salt, would be in like manner frozen, in case we employed snow alone, without mingling any salt with it. I deny not, that it is very possible, that in very cold countries, as well snow as beaten ice may freeze water poured into the intervals of its parts. But there is great odds betwixt water so intermingled with ice or snow, and only surrounded with it in a vessel, where the water is, as it were, in one entire body, and of a comparatively considerable thickness: and there is also a great difference betwixt the degrees of coldness in the air of frigid regions, and of *England*. And perhaps too there may be some disparity betwixt the degrees of coldness of ice and snow in those climates, and in ours. And we must have a care, that in case a phial full of water buried all night should freeze, we ascribe not the effect to the bare operation of the snow, which may be (entirely, or in great part) due to the coldness of the air, which would, perhaps, have performed the effect without the snow.

3. BUT though snow and salt mixt together will freeze water better than snow alone, yet we must not think, that there is any such peculiar virtue in sea-salt, to enable snow to freeze, but that there are divers other salts, each of which concurring with snow is capable of producing the like effect. For we found upon trial, that we could freeze water without the help of sea-salt, by substituting in its place, either nitre, or alum, or vitriol, or sal armoniac, or even sugar; for either of those being mingled with a due proportion of snow, would serve the turn, though they did not seem equally to advance the congealing power of the snow; nor scarce any of them did do it so well as sea-salt. But of this elsewhere more.

4. WHEN we had made the newly-mentioned trials, some particular conjectures, we have long had about the nature of salts, invited us to try, whether, notwithstanding the comminution and consequent change produced in salts by distillation, the saline corpuscles, that abound in the distilled liquors of those concretes, as well as in their solutions, would not likewise, by being mixt with it, enable snow to freeze water, at least in small and slender glasses? This we first went about to try with good spirit of salt: but we found, as we feared, that though it made a sufficiently quick dissolution of the snow it wrought upon, yet its fluidity hindered it

it from being retained long enough by the snow, to the bottom of which it would fall, before they had stayed so long together, as was requisite to freeze so much as a little essence-bottle full of common water.

5. WHEREFORE we bethought our selves of an expedient, whereby to try the operation, not only of those spirits, but of divers other bodies, which were unapt for a due commixture of snow after the way newly mentioned, or of which we had too little, or valued them too much, to be willing to spend quantities of them upon these trials. And this way (that remains to be mentioned) we somewhat better liked, because the experiments made according to it would also prove experiments of the transmission of cold through the extremely close body of glass.

AND even in this way of trying, we did at first meet with a discouragement, which, lest it should happen to others, we shall here take notice of; namely, that having put a convenient quantity of snow into a somewhat thick green glass phial, though we copiously enough mixt with it a somewhat weak spirit of salt, (being loth to employ the best we had) and having well stoppt the vessel, did carefully shake together, and thereby agitate the mixture in it, yet the glass appeared only bedewed upon the outside, without having there any thing frozen. But suspecting, that the thickness of the glass might be that, which hindered the operation of the included mixture, we put snow and a convenient proportion of the self-same spirit of salt into a couple of thin phials, one of which we closed exactly, and the other negligently, and having long shaken them, we found, that what adhered to them on the outside, was (though but somewhat faintly and thinly) frozen.

6. AND, as to this sort of experiments, we shall here observe once for all, that the snow or ice included, together with the saline ingredient (whatever that were) was always thawed within the glass; and that consequently, it was the condensed vapour of the air, or other liquor that adhered to the outside of the glass, which was turned into ice, which is the reason, why in mentioning these experiments we often use the word freeze in a transitive sense, to signify the operation of the frigorifick mixture upon other bodies.

7. THIS premised, let us proceed to relate, that we afterwards took oil of vitriol, and mixing it with snow in such another phial as that last mentioned, we found its freezing power far greater than that of spirit of salt. And lest it should be pretended, that in these experiments the cold was not transmitted through the sides of the glass, but that the air within the phial, highly refrigerated by the mixture, did upon the account of their free intercourse enable the air contiguous to the outside of the phial to freeze the dew it met with sticking on it; we prosecuted the experiments with the addition of this circumstance, that on several occasions we sealed up the phial, that contained the snow and the other frigorifick body it was mixed with, and afterwards by the

help of this mixture froze the externally adhering moisture.

8. HAVING then, according to this way, substituted spirit of nitre for oil of vitriol, or spirit of salt, we found, that it froze yet more powerfully than either of those two liquors, and continued to do so in those parts of the outsides of the glass, that were adjacent to the included snow, till that snow was almost totally resolved into a liquor. This we tried both in a thin sealed glass, and in a pretty thick glass stopped only with a cork.

9. AFTERWARDS we successfully enough tried the experiment with spirits less acid, as not only with spirit of vinegar, but with spirit of sugar; I mean the red empyreumatical spirit forced over in a retort, which mixed with snow, according to the manner of the experiment, did at length freeze the externally adhering moisture. But the films of ice were very thin, and very apt quickly to disappear.

10. HAVING thus made a number of trials with acid spirits, we thought fit to make some with urinous spirits, that abound in volatile salt; and accordingly having mixt spirit of urine and snow in an open phial, and agitated them, we found, that the external moisture did discernably, though not very strongly, freeze.

BUT with spirit of sal armoniac drawn from quick-lime (according to the way I have delivered in another treatise) the operation was quick and powerful enough.

11. HAVING tried to freeze water with acid, and with volatile spirits apart, we thought it not amiss to try what they would do both together; and accordingly pouring upon snow both some spirit of urine, and a little oil of vitriol, and shaking them into the snow in an open phial, we found, that the mixture did freeze, though the glaciation, in this case produced, were very languid.

12. HAVING thus tried salts disengaged from their grosser parts, or shattered into corpuscles by distillation, we made some trial likewise with grosser salts, as with sal-gem, with a sublimate made with common sublimate and sal armoniac, nay, and with both loaf and kitchen sugar, with all which, among the like bodies, that I can now remember, the experiment succeeded well enough: also a very strong solution of pot-ashes, mixed with snow in an open single phial, did freeze, but that very faintly. And both a very strong solution of very pure salt of tartar, and (at another time) a strong solution of pot-ashes, being the one as well as the other, mixed and agitated with snow in a single phial, produced films of ice (though thin ones) on the outside of the glass.

13. AFTER this, we thought fit to make a trial of another kind, of which I find this account among my notes. We filled a single phial with snow, and then poured into it a convenient proportion of a strongly sweet solution of minium in spirit of vinegar, and having shaken the mixture together, we found, that this sweet sugar of lead did, as well as acid and alkali-zate salts, excite the cold of the snow so much, as to produce films of ice on the outside of the glass: but a parcel of the same solution, being for

for divers hours kept in snow and salt, was not thereby frozen.

IN order to the discovery of some hints of the account, upon which the above-mentioned mixtures were more intensely frigeactive than snow alone, we sealed up a single phial full of snow unmingled with any other ingredient, and found it to thaw much more slowly, than any of those parcels of snow, which we had mixt with salts or spirits.

IN prosecution of this conjecture, we shall add, that, for aught we could find, by divers trials, no salt, that helps not the snow to dissolve faster than else it would, did enable it to produce ice, though usually it did produce dew on the outside of the phial, that contained the mixture; and accordingly, neither crystals of tartar, nor borax, both beaten to powder, nor, which is more, (considering what we lately noted of the effects of another sort of sublimate) would sublimate enable the snow to freeze; as well the powder of sublimate as that of borax, and that of tartar, lying for a great while in the snow undissolved.

14. BELONGING to this matter, I find among my papers also this note.

[WATER of quick-lime (made by quenching store of unslacked lime in common water) twice tried, would not make snow freeze, perhaps because though the water were kept stopt, yet the liquor having been kept in the glass a twelve-month, and more; probably the spirits may have flown away, which I find, by inquiring of one that drinks much lime-water, that it abounds with, when fresh, and grows destitute of a while after: and possibly also the badness of the lime was the cause, why being mingled with snow it would not freeze, though all the phials, that did not freeze, did yet gather store of dew on the outsides (perhaps because of the snow, whose melting alone may suffice) to produce that effect.]

15. IT may seem somewhat more strange, that distilled oil of turpentine, which is so hot and fiery a liquor, should not enable snow to freeze; but this agrees not ill with the conjecture lately mentioned, for it will hereafter appear, that in oil of turpentine ice dissolves slower than in divers other liquors, without excepting common water itself.

16. AND yet notwithstanding the bad success of this trial, we were not discouraged from making another with spirit of wine; for though, according to the common opinion of chymists and physicians, it be a meer vegetable sulphur, yet we, that have elsewhere ventured to ascribe some such operations to it as chymists would have belong to saline liquors, did not scruple to seal up, in a single phial almost filled with snow, a convenient quantity of the pure spirit of wine, (drawn off from quick-lime, the better to dephlegm it) and of this mixture we found the operation more powerful than any of those we have formerly mentioned: for the freezing virtue of this did not only last long, both in the sealed single phial, and in another that was open, but the inclosed mixture presently crusted the outside of the glass (or of the neck, if it were made to fill that) with ice,

which might be taken off in flakes of good breadth, or in pieces of good thickness. Nay, it presently froze urine into figured ice, which might be taken off in scales.

17. THIS last circumstance puts me in mind of another experiment, whereby we tried by a vigorous mixture of snow, and some choice spirit of nitre, we had met with, to freeze liquors of more difficult congelation than fair water.

WE took then some snow, and mingled with it some of the newly mentioned spirit of nitre in so lucky a proportion, that it froze very vigorously and very suddenly; insomuch, that once almost as soon as it was set to the ground, it froze the phial to the floor it was set on, and the outside of the glass, that contained this mixture, we wetted with spirit of vinegar, which was frozen into pretty thick ice, but yet (not quite to forget that circumstance) retaining the salt taste of spirit of vinegar. And though this mixture would not discernibly freeze spirit of nitre on the outside, yet it transmitted cold enough to freeze weak spirit of salt, and to give us the pleasure of seeing some saline liquors presently turned into figured ice; as not only the last mentioned spirit exhibited some little (as it were) saline icicles crossing each other, and quickly vanishing, but (which was far prettier) having often observed, that sal armoniac being dissolved in water, and the solution being put very slowly to evaporate part, but not too much, away, the remaining liquor would, in the cold, shoot into parcels of salt very prettily figured; some of them resembling combs with teeth on both sides, and others resembling feathers: having observed this, I say, and being desirous to try, whether the spirit of sal armoniac, distilled by the help of quick-lime, being put to congeal on the outside of a glass, would not afford a resemblingly figured ice; we found upon trial, both that the mixture was able to freeze that subtle spirit, and also, that it shot into branches almost like those, exhibited by such salts undistilled. And it was not unpleasant to behold, how upon inclining the glass so, that the freezing mixture rested a little, near any part of the spirit, this liquor would shoot into such branches as we have been speaking of, so nimbly, that the eye could plainly discern them, as it were, to grow, and hastily overspread the surface of the glass, but those branches were wont quickly to vanish.

I HAD almost forgot to mention, that I tried the freezing with snow, and divers fermented liquors undistilled, instead of spirit of wine; and though the experiments succeeded not with small beer, much less with water, yet there was a glaciation, though but slight, produced not only by the addition of wine, but even by that of moderately strong ale.

18. HAVING observed, that the liquors and other bodies, that assisted the snow to freeze, were generally such as hastened its dissolution, we thought it not altogether unworthy the trial, to examine, what would be the event of procuring a speedy dissolution of the snow, by substituting bodies actually warm, instead of potential

potential hot ones : of this sort of trials, I find among my notes these two registred.

[1. INTO a single phial almost filled with snow, there was poured a pretty quantity of well-heated sand, that it might dissolve the snow in many places at once, without heating the ambient air, or the outside of the glass : but though the solution of the snow seemed to succeed well enough upon the shaking of the vessel, yet the outside of the glass was only bedewed, not frozen.

2. INTO another single phial almost filled with snow, we poured some water, which we judged of a convenient warmth, and we poured it in by a funnel, that had but a slender orifice beneath, that the warm water might fall into the middle of the snow, without running to the sides ; and taking a convenient time to shake the glass, we did by this way produce a very considerable degree of cold, and much dew on the outside, but were not satisfied, that any of that dew was frozen, though the success would have invited us to have made further trials in greater glasses, if we had had any more snow at hand.]

Wherefore this experiment is to be further and more artificially tried.

19. IT is a common tradition, not only among the vulgar, but (I presume, upon their account) among learned men, that the oftentimes variously, and sometimes prettily enough figured hoar frost, which is wont to appear upon glass windows in mornings, preceded by frosty nights, are exudations, as it were, that penetrating the glass-windows, are, upon their coming forth to the cold external air, frozen thereby into variously-figured ice. How groundless this conceit is, may be easily discovered, if men had not so lazy a curiosity, as not to try (which they may do in a moment, and without trouble) whether the ice be, according to the tradition, on the outside of the window, and not contrary to it on the inside, where indeed it is generated of the aqueous corpuscles, that swimming up and down in the air within the room, are by the various motion, that belongs to the fluid bodies as such, brought to pass along the window, and thereby the vehement cold of the neighbouring external air, communicated through the glass, condensed into dew, and frozen into ice.

20. AND because divers modern naturalists have taught (I think erroneously) that glass is easily enough pervious, not only to air, but to divers subtle liquors, lest the favourers of this doctrine should object, that we have ill assigned the natural cause of the ice, appearing on the outside of the glass in the former experiments, which, according to them, may rather proceed from the subtler (but yet visible) parts of the excessively cold mixture of the snow and saline bodies penetrating the pores of the glass, and settling on the outside of it : to obviate this objection, I say, and to confirm what we have taught in another treatise about the wandring of store of aqueous vapours through the air, we will add the following experiments, purposely made to evince these truths.

21. AT one time four ounces and a quarter

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of a mixture of ice and salt, being inclosed in a phial, and thereby enabled to condense the vapours of the ambient air, was by their accession increased 12 grains.

ANOTHER time a phial, wherein snow (weighing two ounces six drachms and an half) was suffered to condense the vapid air, the dew, that partly adhered to it, and partly fell from it, made the whole weigh four grains more than the phial did, when it was first put into the scale ; in which scale we found some water flowing from the dew, which gave that increase of weight. And here let me add by the way, that the tip of this sealed phial being broken under water, sucked in a considerable quantity of it : whether, because of some little rarefaction of the air included in the sealing, or because of the in frigidation of that air by the snow, or for both these reasons, or any other, I shall not now dispute.

22. BUT other experiments to the same purpose we made, wherein the increase of weight was more considerable ; and that the way, we used, may be the better understood, and the conclusion built upon it the more undiscussed, we will add a couple of trials, that we find among our notes concerning this matter.

[In a single phial we sealed up as much snow and salt, as afterwards, when melted, we found to weigh between five and six ounces ; after a while, the salt beginning to melt the snow, the dew on the outside began to congeal, and being rubbed off, the hoar frost would quickly begin to come again. This phial for further trial being put into a pair of scales with a counterpoise, after a while, as the vapours, that wandered through the air in the warm room, happened to be detained more and more upon the outside of the glass, and to be there frozen, the scale, wherein the glass was, began to be depressed, and to shrink lower and lower ; after which, by adding a little to the counterpoise, we reduced them again to an æquilibrium ; and yet after a while, the scale, that held the phial, subsided again more and more, till the included snow was melted : so that to reduce the scales to their first æquilibrium, we were fain to add in all to the counterpoise a weight, which we estimated to be about eight or ten grains, (for we had then no great weights by us.) The phial being taken out, there appeared near half a spoonful of liquor in the scale it stood in, which proceeded from the thaw of the ice, that was generated about it. But in that part of the scale, which was covered with the convex part of the bottom of the glass, there appeared no wet.

A like or smaller quantity of snow and spirit of wine being sealed up in a single phial, the outside quickly appeared cased with ice as high as the mixture reached within, and this phial also being counterpoised in a pair of scales, did by degrees depress the scale, that held it, till it had sunk it very low, and about seven grains did but reduce the scales to an æquilibrium ; but the scales being somewhat rusty, we could not make the trials with that exactness we desired.]

23. BUT at other times, when the experiment was more luckily, though not more carefully tried

X x x

tried

tried, with better scales, the increase of weight from the condensed vapours of the air was somewhat more considerable; for I find in a short note,

[THAT at one time a mixture of spirit of wine and snow, weighing three ounces and three quarters, afforded of condensed vapours about 18 grains.

AND at another time a mixture of snow and sal gemmæ, weighing three ounces and seventy grains, procured us an accession of water weighing about 20 grains.]

TITLE II.

Experiments and observations touching bodies disposed to be frozen.

1. **I**T were almost endless to try particularly, which bodies are or are not capable of congelation, and the degree of cold would also in such experiments be (as near as men can) determined; because many bodies will freeze in one degree of cold, that will not in another: wherefore we are willing to leave these trials to those, that have more leisure and opportunity to prosecute them, and shall only set down some, and those somewhat various, that we may not leave this part of the History of Cold quite unfurnished. And we must mention the fewer, because, being in the country, we were not provided of divers of the bodies, which we should have exposed.

2. IN very cold snowy weather, we tried, that (besides common water) urine, beer, ale, milk, vinegar, and French and Rhenish wine (though these two last but slowly) were turned into ice, either totally, or in part. But such instances will possibly be thought too obvious to be insisted on; therefore I shall add, that not only we froze a strong solution of gum arabick, and another of white sugar in common water, but that we took alum, vitriol, salt-petre, and sea-salt, and made of each of them in a single phial as strong a solution as we could; we also made a strong solution of verdegrease in fair water (which was thereby deeply coloured) all these we exposed to the cold air. The solution of alum, nitre and verdegrease froze without affording any notable phænomena, either in the figuration of the ice, or otherwise: of the solution of vitriol there remained, at the bottom of the glass, a pretty quantity unfrozen, and of a clear substance, whose colour was very high of the vitriol; whereas the upper part of the same solution differed very little in colour from common ice.

3. BUT because it seems not so strange, that these gross sorts of saline bodies should be turned into ice, we thought fit to try, whether or no also divers salts, freed from the grosser parts of their concretes by the fire, were not likewise capable of congelation. We exposed therefore spirit of vinegar in one small glass, and spirit of urine in another, to an intense cold, and found, that not only the former, but the latter also froze.

4. WE took likewise some of the fiery lixiviate salt of pot-ashes, and a single phial, in which we put, to two ounces of water, a drachm of

the alcali, and exposing it to a very sharp air, we did, when we came to see the success of the trial, find ice lying on the top in little sticks (something crossing one another) almost like the crystals of rocked petre; and besides these, that lay levelled, there were others, that shot downwards in very great numbers.

5. WE also found, that oil of tartar per deliquium, or at least a strong solution of the fixt salt of tartar, though it seemed much to resist the cold, yet it was once by snow and salt brought to congelation.

Appendix to the II^d. Title.

SINCE I wrote the present book concerning cold (expecting some of the appendices) having once had the opportunity of an hour's discourse with an ingenious man, that not only lived some years in *Muscovy*, but was, and is still physician to the great monarch of that empire; and having likewise at other times conversed with navigators, and some other credible persons, that had travelled either to *Greenland*, *Terra Nova*, or other gelid climates, I proposed them divers questions; by their answers to which, I learned some particulars, which, together with others, that I have met with in voyages and other books, I think it not amiss to annex by way of appendices to the foregoing, and some of the following sections, or titles.

ABOUT the freezing of common expressed oils, I know not well what to determine, for that they may, by a very intense cold, be deprived of their fluidity, and be made capable of being cut into portions, that will retain the figure given them, my own trials invite me to believe: but whether such oils will be turned into true (by which I mean) hard and brittle ice, is a question scarce to be determined by any experiments we can make here in *England*, where we could not reduce oil-olive into ice. And for the relations of those, that have lived in colder countries, I find them to disagree: for when I asked the lately mentioned doctor the question, how far he had known oil congealed in *Muscovy*? he answered me, that it did there freeze much harder than in our climate, but would not, that he had observed, be turned into true and perfect ice. On the other hand, I find the testimony of that ingenious navigator captain *T. James*, who relating the effects of cold he met with in the island, where he and his men were forced to winter, does in one place reckon oil among the liquors, such as vinegar, and sack, that even in their house was firmly frozen, and more expressly elsewhere. "All our sack Page 53.
" (says he) vinegar, oil and every thing else,
" that was liquid, was now frozen as hard as a
" piece of wood, and we must cut it with a
" hatchet." And *Olaus Magnus* speaking of the
fights, wont to be made upon the ice in the
northern regions, *Glacialis congressus* (says he) Olaus Magnus
ni Gent.
Sept. Hist.
1. 11. c. 24.
*fit in laneis calcibus, non pellibus, aut coriis
unelis: vis enim frigoris, quodcumque sit unctuo-
sum, convertit in lubricitatem glaciale.*

THERE being a great similitude in point of inflammability, and disposition to mix with many subtle oleous bodies, betwixt spirit of wine

wine and oil, and as great an affinity in divers other regards, betwixt that spirit and both aqueous and saline liquors, with which it will readily mix; I had a great curiosity to know, what kind of change would be produced in vinous spirits, in case they were exposed to a cold great enough to work a visible change in their texture. I therefore solicitously inquired of the *Russian* emperor's lately mentioned physician, whether or no he had observed in *Muscovy* any manifest change produced by cold in hot waters, and spirit of wine? To which he returned me this answer; that common aniseed-water, and the like weak spirits, would be turned into an imperfect kind of ice; and that even the very strong spirits, though they would not be turned into ice, would be turned into a kind of substance like oil.

T I T L E III.

Experiments touching bodies indisposed to be frozen.

1. **W**E found many liquors, whose subtle parts being by distillation brought over, and united into very spirituous liquors, and so either totally, or in great measure freed from those phlegmatick or aqueous parts, that dispose bodies to congelation, could not be brought to freeze, either by the cold of the external air, to which in frosty nights we exposed them, or by such an application of snow and salt, as served to freeze other bodies.

2. OF this sort were, among acid menstruums, aqua fortis, spirit of nitre, of salt; also oil of turpentine, and almost all, (I add the word almost, because the essential oil of aniseeds and the empyreumatical oil of common oil will lose their fluidity in a less degree of cold, than that of our mildest frosts,) I say almost all the chymical oils we had by us, as likewise spirit of wine, and other strong spirits of fermented liquors, and even sack itself, if it were good, would very hardly be brought to afford us any ice at all: but among the many liquors, that would not freeze, there were a few, whose trials afforded us some circumstances not altogether unworthy their being mentioned.

As 1. I being desirous to satisfy some friends, that it was the brisk spirit of the grapes, whether resulting from, or extricated and exalted by fermentation, that kept (all) the rest of the sack from freezing; I took a parcel of that liquor, that would afford us no ice at all, and by the help of a lighted candle, or some other actually flaming body, kindled it; and letting the inflammable part burn away, the remaining part of the liquor (which was by vast odds the greatest part) was easily brought to freeze.

NEXT, when the formerly mentioned trial was made with water and pot-ashes, we likewise, in another glass, exposed a solution, wherein the proportion of salt of pot-ashes, in reference to the water, was four times greater; there being in this ziii . of the salt to 3j . only of water: and this solution, though the glass were covered with hoar frost and ice on the outside, froze not at all within. And likewise,

when another time we made a very strong solution of salt of tartar, that was very pure and fiery, it did not freeze, though a considerably strong solution of salt of pot-ashes, that was exposed with it, did. So that these experiments about the glaciation of lixiviate liquors must be repeated, to be reduced to a certainty.

3. THAT the common expressed oils of vegetables will, after their manner, freeze, that is, lose their fluidity, and become, as it were, curdled in very cold weather, is a matter of common observation; but I had a mind to try, whether or no train oil, that is made of the fat of animals, (commonly that of whales) though not by distillation, properly so called, yet by the help of fire, would not be more capable of resisting the violence of the cold; and accordingly I found, that train-oil, exposed to the air in a convenient phial, continued fluid, notwithstanding a more than ordinary sharpness of weather: and this I tried two or three several times, but at length one night proved so very cold, that the next morning I found the oil unfluid. Which differing events seem a little to countenance, but more to disavour the report of *Olaus Magnus*, who writes, that whereas in northern regions it is usual for strong places to lose in winter the protection afforded them in summer, by their ditches, though never so wide and deep, because the frost makes them easily passable to the enemy; this inconvenience is wont to be prevented by pouring into the ditches, the ice, if there be need, being first broken, great store of this train oil, which swimming upon the surface of the water, and being incongealable by the cold, protects the subjacent water from the freezing violence of the cold, and keeps the moats unpassable. But because our author mentions this as a known and vulgar practice in those icy regions, it may perhaps deserve a little enquiry, whether the whale oil, used by the Swedes, Laplanders, Muscovites, and other inhabitants of those parts, be not differing, either as to the fishes it is made of, or as to the way of making it, or as to the way of keeping it, from such train oil as we employed; unless perhaps it do already appear by the relation of writers belonging to those countries, or of travellers, that have been in them, that *Olaus Magnus* has in that particular, as I fear he has in some others, misinformed his readers.

4. WE took notice, that a strong solution of common sugar was easily enough turned into ice; but on a strong solution of sugar of lead we could not with salt and snow work the like change, and this, though the trial were not negligently made: which I therefore think not unworthy to be mentioned, because that the two only ingredients of this sugar were lead, which is esteemed a very cold body, and spirit of vinegar, from which, as I noted above, we did, by the like degree of cold to that we here employed, obtain ice. And though in this metalline sugar, we may well suppose the saline parts of the spirit of vinegar to be much more concentrated or united, than they were in the spirit; yet the solution must abound with aqueous parts: and this sugar seeming but

Olaus Magnus in Historia Gentium Septentrionalium, lib. 11. cap. 20, § 21.

a kind of vitriol of lead, it is worth our notice, that its solution would not freeze, as well as that of common vitriol, though in this latter concrete, metal be corroded by a spirit, which, as far as can be judged by the liquors afforded in distillation, is very much sharper and stronger than spirit of vinegar.

5. We likewise tried to freeze quicksilver, and for that purpose provided a bubble, that being blown with a lamp, was but thin, and so flat, that the sides almost touched, and it held but a little mercury; and that by the figure of the glass, being reduced to a large surface, with but very little depth or thickness, it was far more exposed, than if it had been in an ordinary round bubble, to the action of the cold. But we could not at all freeze this extravagant liquor, though we tried it more than once, and though the last time we exposed it in the same vessel to the same degree of cold, wherewith we made one of the following experiments, that required a very intense degree of that quality. And in another thin glass-bubble we long exposed quicksilver to an extraordinary sharp air; but though the cold had some operation upon it, not here necessary to be mentioned, yet we could not find, that it did at all bring it to freeze. Wherefore I could wish that trial were made in *Muscovy*, *Greenland*, *Charles-Island*, or some other of the most icy regions, where the effects of cold (which are here upon quicksilver but languid) are the most considerable, and sometimes stupendous.

6. It is very remarkable, that though not only the solutions of other gross salt, but, as we have seen, divers more saline and spirituous liquors, were brought by snow and salt to congelation; yet a brine made very strong of common salt, could not be brought to freeze at all, though we kept it exposed with the other saline solutions, that did freeze, during a whole night, that was exceeding sharp. Which experiment I also tried many years since, to draw thence an argument in favour of the Cartesian hypothesis about cold, which I shall not now consider; but rather add, that being desirous to try, with what proportions of sea-salt and water the congelation of them might be effected, I found, I could freeze some sea-water, that had been brought up in a barrel to that monarch of the virtuosi, the King; for the making of trials with it; and that having in a single phial exposed to the air, in a very bitter night, a solution consisting of twenty parts of water, and one of salt, which is double the proportion of salt to be commonly found in our sea-water, the next day we found a good part of the liquor frozen, the ice swimming at the top in figures almost like broom, spreading from the surface of the water downwards. And to add that upon the by, we suffered the ice of salt water to thaw, to try, whether it would yield fresh water, but it seemed not devoid of some brackishness; which, whether or no it proceeded from some parts of the contiguous brine, that adhered to the ice, I leave to further and exacter observations, since I am credibly informed, that in *Amsterdam* there are

divers, that use the thawed ice of the sea-water to brew their beer with, instead of common fresh water.

3. AND since I made that experiment, I find in the industrious *Bartholinus's* newly published book, *De Nivis Usu*, a confirmation of the probability of the report I just now mentioned, his words being these; *De glacie ex marinâ aquâ certum est, si resolvatur, salsum saporis deposuisse; quod etiam non ita pridem expertus est Cl. Jacobus Finckius Academiae nostrae senior, & physices professor, bene meritus, in glaciei frustis à portu nostro allatis.* Cap. vi. pag. 42.

T I T L E IV.

Experiments and observations touching the degrees of cold in several bodies.

1. AFTER having treated of the bodies, that are the most capable of producing cold, and of those, that are most disposed or indisposed to receive it, it would be methodical to take notice of the *Degrees of Cold*, to be met with in differing bodies. But though a work of this nature might somewhat conduce to the discovery of cold in general, yet it is so laborious a task; and, to be well performed, requires so much more of leisure, and convenience, than I am master of, that I must resign it to those, that are better furnished with them. Which I the freelier do, because the experiments, which at this time make the principal part of our history, being chiefly of the highest *Degrees of Cold*, we may seem to have done something of what more properly concerns our present design, by having made the experiments, anon to be subjoined within this present section or title. And yet thus much we elsewhere do toward the framing of a table of the *Degrees of Cold*, that we do on other occasions set down those hitherto unpractised ways, that we have employed, to estimate the greater or lesser coldness of bodies, by several kinds of weather-glasses, differing from the common ones, and far more fit than they, for such a purpose. For by hermetically sealed thermoscopes furnished with high rectified spirit of wine, we can estimate the differing degrees of coldness in liquors, of which we shall presently mention an example. And by using such weather-glasses, as have their air included not at the top, but at the bottom of the instrument, we can, within some reasonable latitude, measure the coldness both of intire solid bodies, or minuter bodies, as salts, &c. by beating them alike, and very small, and placing the instruments at equal depths in the powder of each of them: and besides, that the shape of these thermoscopes does, as we have elsewhere shewn, make them proper for these uses, for which the vulgar ones, where the included air is at the top of the instrument, are not fit; besides this, I say, it is easy in these we make use of, to make the pipe so slender in proportion to the cavity of the phial, whereinto it is inserted, that very much minuter differences of cold will be manifest in these, than are wont to be sensible in common weather-glasses. And besides these two sorts, we have elsewhere proposed, and described

See preliminary discourse.

scribed a third and new kind of thermometer, wherein a drop of liquor being suspended in a very slender pipe of glass, betwixt the outward and the inward air, makes it far more fit for those experiments, wherein we either despair, or care not to measure the difference of cold betwixt two bodies, but are only desirous to try, whether or no they differ in coldness; and in case they do, which of them has most: for these weather-glasses are so exceeding sensible even of the minute difference of heat and cold, as manifestly to discover disparities, which other thermoscopes are not nice enough to give us any notice of. Only this advertisement we must add about them, that when we use them to examine the coldness, not of liquid, but of consistent bodies, we alter a little the figure of the wide end of the glass; and instead of making it a round bubble, as we have elsewhere described, we make it with a flat or flattish bottom, that the whole instrument might thereon, as on a basis, stand of it self upright, and so, being still taken up by the open and slender end, for fear of rarifying the included air, (which caution is here given once for all) may be transferred with a pendulous drop in the pipe, and placed sometimes on one, and sometimes on another of the solid bodies to be examined by it. For if the body, it is moved to, be more or less cold than that it rested on before, that coldness communicated through the glass to the air, by which the pendulous drop is supported, that air's expansion or contraction will manifestly appear by the rising or the falling of the drop. And thus we have taken pleasure to remove it from one kind of wood to another, from woods to metals, and from metals to stones, &c. But the expedients, that may be proposed to improve these little instruments to the purposes we have been treating of, and the cautions, that may be added to prevent men's drawing mistaken inferences from the informations they seem to give them, will take up more time, than we are willing to spend upon an occasion, that will not perhaps be thought to deserve it, nor much to require any others, than those we shall by and by subjoin. And therefore I shall proceed to the experiment promised at the beginning of this title or section.

2. To make so much as a tolerable estimate of the difference betwixt such great degrees, as are not any of them too weak to congeal water, is a thing, which as we have not yet known to be attempted, so it seemed not easy to be performed. For freezing having been commonly reputed the ultimate effect or production of cold, men have not been solicitous to look beyond it. And though the disparity we find betwixt several fits of weather, all of them frosty, seem to be too manifest and frequent to be probably ascribed to nothing, but the differing dispositions of our bodies; yet how to estimate that difference, it is not so obvious. For though we should have recourse to common weather-glasses, yet they might easily deceive us, since not only by estimating by them, the coldest day of one winter with the coldest day of another, but in judging of the coldness of any two days in the same fit of frosty weather, there

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intervenes time enough to make it doubtful, whether the varied gravitation of the atmosphere produce not the change observed in the weather-glass. Besides that, admitting vulgar thermometers could not, as they easily may, mis-inform us, they are employed only to give us an account of those degrees of cold, which nature, of her own accord, produces in the air; but not to discover, whether or no nature, assisted by art, may not produce greater: and, it will easily be granted, that they are yet less made use of to help us to an estimate of this disparity. And though some guess may be made by the operations of cold upon liquors exposed to it, yet some, as water, and very aqueous liquors, will freeze too soon, and others, as vinous spirits, will not at all, (that we have found) here in *England*. And though French wine will sometimes be brought to begin to freeze, yet that happens but very seldom, and in many winters not at all, and leaves too great an interval betwixt the degrees necessary to congeal wine, and sufficient to congeal water; not to mention the uncertainty proceeding from the differing strengths of the wines.

3. UPON these and other considerations, we thought it requisite to make use of an expedient, whose nature and use will be easily gathered out of the following experiments: and though by a mischance, that broke my weather-glass, I have been hindered from measuring exactly in what proportion to the whole bulk the spirit of wine was contracted, by the surplusage of cold, that was more than necessary to make water freeze, yet I doubt not but something of use to our present theme, may be thence collected, and especially the main thing designed will manifestly appear, which is the intensity of cold produced by art, beyond that, which nature needs to employ upon the glaciating of water.

[4. A SMALL sealed weather-glass furnished with spirit of wine, the ball being about the bigness of a small nutmeg, and the cylindrical stem being very slender, and about ten inches long, the ball and part of the stem being immersed in a vessel of water, half buried in snow and salt, when the water began to freeze at top, the bottom and the sides, (but before the ice had reached the ball, for fear it should break it) the tinted liquor was found subsided to $5\frac{2}{3}$ divisions, being half inches; and being taken out thence, and ice and salt being immediately applied to the ball, the liquor fell lower to about $1\frac{1}{2}$ division.]

AND that it may not be doubted, but that the water, though in part congealed, remained warm in comparison of the spirit of wine, though uncongealed, that had been refrigerated by the snow and salt, we will add this other experiment, which we find in another of our notes thus set down.

[5. THE sealed weather-glass being kept in 4. Jan. 15. the water till it began to freeze, descended to $5\frac{1}{2}$: being immediately removed into the same snow and salt, that made the water begin to freeze, it descended at the beginning very fast, and afterwards more slowly, till it came to the

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very bottom of the stem, where it expands it self into the ball; then being removed into the same glass of water, whence it was taken, and which was well stored with loose pieces of ice, it did nevertheless hastily ascend at the beginning, and was soon after impelled to the former height of five divisions and an half, or thereabouts.]

6. BUT perhaps some amends may be made for the disaster of the weather-glass, by adding, that I found by another trial, that the condensation of liquors by such colds, as we are wont to have, or can easily produce here, is nothing near so great as one would imagine. And though for want of a glass-ball, furnished with a neck slender enough, I could not make the experiment so much to my satisfaction, as perhaps else I might have done; yet the goodness of the scales I made use of, and some greater care, than possibly every experimenter would have employed, may make the following observation luciferous.

7. WE took then (on a cold, but not frosty day) oil of turpentine, as a liquor, whose being free from phlegm or water we could easily be more certain of, than if we had employed spirit of wine; and this oil itself we rectified in a gentle heat, to make it the more pure and subtil. Then we took a small round vessel of clear glass furnished with a conveniently long stem or pipe, and having first weighed the glass alone in a pair of very good scales, we found it to weigh $\text{zj. } \text{ss. } 56\frac{1}{2}\text{ gr.}$ Then putting in oil of turpentine, till it filled the round part of the glass, and ascended a little way into the stem, we carefully marked with a diamond on the outside of the glass, how high it reached, and then weighed the glass and the oil together, which weighed $\text{zj. } \text{zviij. } \text{and } 34\frac{1}{2}\text{ gr.}$ Then we put in, by degrees, a quarter of a drachm, and with a diamond carefully marked, how high it reached in the pipe, and so we continued putting in several quantities of oil, still carefully weighing each parcel in the scale, and marking its height on the outside of the glass (which we did in order to a certain design, and found it a work tedious and troublesome enough) till the liquor and the glass together weighed $\text{zij. } \text{ss. } 4\frac{1}{2}\text{ grains.}$ Then we put fair water into an open-mouthed glass, in which we also placed the little bolt-head with oil of turpentine, and by such a circumposition of salt and snow, as is * hereafter to be often mentioned, we made the water, which was contained in the wide-mouthed glasses, and by which the spherical part of the bolt-head, containing the oil, was surrounded, we made this water, I say, begin to freeze; and when we perceived a little ice to be produced in it, we carefully marked with a diamond, to what part of the stem the oil of turpentine was subsided, and then transferring the bolt-head into a mixture of snow and salt, where we kept it for an hour or two, till we could perceive it to fall no lower, and marking with a diamond, this station also of the liquor, we afterwards removed the glass into a warmer air, till the oil, by expanding it self, had regained the highest mark, whence it had begun to sink. Then into a very little

* See the latter part of the next title.

glass, carefully counterpoised in a pair of exacter scales than the former, we gently poured out of the oil, till what remained rested against that mark on the outside of the stem, to which it fell, when the water began to freeze: and this we found to amount to somewhat above $9\frac{1}{2}$ grains; so that, for conveniency of reckoning, we may safely enough take the intire number of 10 grains. After this, we poured out of the remaining oil into the same little glass, till what rested in the pipe was even with that mark, to which the snow and salt had made it fall; and this parcel of oil happened to be almost precisely of the same weight with the other: so that in this trial (for perhaps in others, which it were therefore worth while to make, the degree of cold may much vary the events) the artificial way of freezing we employed, made the oil subside as much after it had been refrigerated and condensed by a cold capable of freezing water, as that degree of cold had been able to condense it at first. And lastly, having deducted the weight of the glass from the weight of the whole oil and glass, to obtain the weight of the oil alone; and having divided the weight of the whole oil, first, by that of the former parcel, we have mentioned to be ten grains, and then by the superadded weight of the second parcel, we took out, (both which parcels together we estimated at twenty grains,) we found that rectified oil of turpentine of a moderate temper, being exposed to such a degree of cold, as would freeze common water, did, by shrinking, lose but about a ninety-fourth part of its bulk; and being reduced to as great a degree of cold as we could bring it to by snow and salt, even then it lost but about a forty-seventh part of its bulk: I say about, because I thought it needless, as well as tedious, to mind fractions and little odd numbers; especially since, as we formerly intimated, it was scarce possible to arrive at a great exactness in such a neck as that of our bolt-head, though it were proportionable enough to the ball, and chosen among several, that were purposely procured for the trying of experiments.

8. THERE are some other trials about the degrees of cold, which for want of ice and other accommodations we could not make, as we would have done often; nor shall scarce be able to do it, till more friendly circumstances afford us an opportunity: and yet because our trials, though not prosecuted as far as we thought, may possibly prove not unwelcome, yet we will subjoin something about two of the chiefest of them.

9. THE one was designed to measure in what proportion water, of a moderate degree of coldness, would be made to shrink by the circumposition of snow and salt, before it begin by congelation to expand itself: of this, what we shall here take notice, is only, that by a trial purposely made with common water, in a round glass furnished with a long stem, we found the water in that stem to subside so very little, that, whether or no it were insensible, it was inconsiderable. But probably a greater quantity of water, and a slenderer stem, would have

have made the shrinking of the liquor more notable, and upon that account it is, that I here mention it.

10. THE other thing was, to measure by the differing weight and density of the same portion of water, what change was produced in it, betwixt the hottest time of summer; and first a glaciating degree of cold, and then the highest we could produce by art. And in order to this, we weighed with a pair of exact scales, a glass bubble heavier than water, in that liquor, when it seemed to be at a moderate temper, as to coldness, and by the diminution, which we found of the glass's weight in the water, we easily collected, according to the rules of the hydrostaticks, the weight of as much water, as is equal in bulk to the glass bubble, and thereby the proportion betwixt the glass and an equal bulk of such water, as we first weighed it in: then by the application of snow and salt, we made that water begin to freeze, and weighing in it again the same bubble, it was easy to collect, by the decrement of its weight in this refrigerated water, what proportion an equal bulk of the liquor did then bear to the glass: and by comparing these two differing proportions together, we were assisted to make an estimate, how much the water was made more heavy and dense by the action of a freezing degree of cold. Afterwards taking our time in summer, we thought fit in the same parcel of water (that had been purposely reserved in a glass) to weigh the same bubble, that by the difference of its weight in the water, when made much lighter by the heat of the ambient air, we might obtain the information we desired. To which we shall add, that we also recommended to some Virtuosi, that were likely to have the opportunity of gratifying us, that such an experiment might be procured to be made in the midst of summer in some part of *Italy*, by the help of the there not unfrequent conveniency of a conservatory of snow, wherein the water might be reduced to freeze before the end of the same hour, at whose beginning the there warmer air had given it its greatest expansion, and so the difference betwixt the density of the same parcel of water might be the more conspicuous. But as I have not received any account of my desires from abroad, so coming now at home to review the memorial, I caused to be written of the newly mentioned observation, I find, that through the negligence or mistake of an *Amanuensis*, there must needs be a manifest oversight committed in the setting down the numbers which my memory does not now enable me to repair. And the season being now improper to repeat the experiment, as well as the numerical parcel of water I had kept, and I employed both times, being thrown away, I think it may be sufficient, if not too much, to have thus particularly intimated the way we took, without adding the cautions, wherewith we proceeded, nor what trials we made to the same purpose with high rectified spirit of wine, since unlucky accidents frustrated our attempts.

11. WHETHER the making of these kind

of trials, with the waters of the particular rivers or seas, men are to sail on, may afford any useful estimate, if, and how much, ships and other vessels, may on those waters be safely loaden more in winter than in summer, may be an enquiry, of which I shall not in this place take any further notice, than to intimate thus much, that the difference betwixt water highly refrigerated, and that which is but of an usual degree of coldness, is not so great, as some learned moderns seem to have thought. For on a day, which (though made cold by snow intermingled with the rain that then fell) was not a frost, we took common water, and weighed it in a glass bubble, whose weight in the air was 150 grains, and this bubble, weighed in that water, lost so much of its former weight, as to weigh about $28\frac{1}{2}$ grains: and then by snow and salt, reducing that water to such a degree of coldness, that it began to be turned into ice about the inside of a small open glass that contained it, we found the same bubble not to weigh at all above one eighth part of a grain less than it did before. So that if we may judge of the shrinking and condensation of the water by the increment of weight, it shrunk but about a 230th part of its former bulk, and this according to a pair of scales, that would turn with about the 32d part of a grain: which may keep us from wondering at what we lately delivered concerning the very inconsiderable subsidence of the water, we exposed to snow and salt in a small bolt-head. And it may also make that the more probable, which we not long since related about the oil of turpentine's not losing much above a 100th part of its bulk, by being exposed to such a degree of cold, as made water begin to freeze. Whether we may from this, and from the formerly recited experiment, of the great subsidence of spirit of wine in a sealed weather-glass, safely conclude, these subtiler distilled liquors to be much more sensible than waters of cold, as well as of heat, further trials will best resolve: and these I have not now so much opportunity, as I could wish, to pursue.

12. BUT they that have a mind to prosecute experiments of this kind, and others, that relate to the degrees of cold, may perchance be somewhat assisted even by these relations, and especially by those passages, that mention the use of the sealed weather-glass, furnished with spirit of wine, and of those wherein a drop of liquor is kept pendulous. For the former of these being not subject to the alterations of the atmosphere's gravitation, (nor, as may be probably supposed, by reason of the strength of the high rectified spirit of wine) to be frozen, by sending the same weather-glass (which may be portable enough, as I have tried by transporting one of them in a case, that might be easily carried even in a pocket) from one country to another, one may make far better discoveries of the differing degrees of coldness in differing regions, and know (somewhat near) how much the air even of *Muscovy*, or *Norway*, or *Greenland* itself, is colder than that of *England*, or any other country, whence the weather-glass shall be sent: the instrument being accompanied

with

with a memorial of the degree, it stood at, when exposed to such a cold, as made water begin to freeze.

13. THE other thermometer, where a drop of liquor is kept pendulous, may not only be employed in such cases, where the pipe and bubble can be erected upon the horizon, but by reason, that the outward air will indifferently impel the bubble laterally or upwards, upon the refrigeration of the inward, and that the bubble will not barely by its weight drop out of the inverted instrument, because of the resistance of the subjacent outward air; for these causes, I say, such a thermoscope may, as we have tried, be also used, where the pipe shall be held horizontal, or inclined, or even perpendicularly downwards, so that the flat part of the bubble may be applied to discover the coldness either of the wall, or of the ceiling of a room, or other bodies however situated. And if the pipe be made long and even, (as sometimes we employ one above a foot long) not only sensible, but great effects of very little disparities in the coldness of bodies, to which the instrument is applied, may with pleasure be observed. And the same drop of liquor may be long enough preserved useful in the pipe. But this advertisement I shall give, that as sensible as this instrument appears to be of the nicer differences of coldness, as of heat, yet they, that shall have the curiosity to examine with it, as I have done, the temperature, I say not, of more resembling bodies, but of liquors, that may be thought to have their parts so differing agitated, as common water, high rectified spirit of wine, and even rectified oil of turpentine, (I add not dephlegmed oil of vitriol, because of some odd phenomena not here to be insisted on) will perhaps find the event so little, in many cases, answer the expectation he would have had of uniformly finding great disparities in their actual coldness, if he had not met with this advertisement, that he will not much wonder, that a person, who wants not other employments for his time, was willing to decline so tedious and nice a task.

TITLE V.

Experiments touching the tendency of cold upwards or downwards.

1. **T**HOUGH, after the consideration of the sphere of activity of cold, it would be the most proper place to take some notice of the direction of its activity, yet, because one of the experiments, that belong to this head, is of great use to facilitate the trial of many of those, that follow, throughout this whole collection; we will no longer delay to say something of this matter, namely, in what line, or, if you please, towards what part the frigidative virtue of cold bodies does operate the furthest and the most strongly.

2. IT is a known doctrine among philosophers, that the diffusion of heat tends chiefly upwards, as the flame of a candle will burn many things held over it at a greater distance, than it would considerably warm them at, in case they were held beneath its level, or even

by its sides: and it is true, that in all cases vulgarly taken notice of, the observation, for reasons elsewhere discoursed of, holds well enough; and therefore it may be worth enquiry, whether in cold, which is generally looked upon as the contrary quality to heat, the diffusion (from cold bodies) be made more strongly downwards, than either upwards or towards the sides.

ABOUT this matter, I can as yet find among my notes but the two following experiments, and those not both together.

[A VERY thin bubble was blown at a lamp, and purposely made flat at the bottom, that it might be the more exposed to the cold, and it was suspended by a string within a pretty deal less than an inch of a mixture of beaten ice and salt, wherewith we had half filled a conveniently large wide-mouth'd glass; but we could not find, that a cold, capable of freezing, did strike so high upwards, for the water in the bubble remained altogether unfrozen; which agrees very well with what we have observed, that a mixture of ice and salt did not congeal the vapours, that wandered through the air, above half a barley-corn's breadth higher, than the mixture in the glass reached.]

3. [A MIXTURE of snow and salt being put into a phial with a long neck, the round part of it was by a weight kept under water, out of which being taken after a while, the outside of the glass beneath the surface of the water was cased with solid ice, *N. B.* especially about the bottom of the phial, of greater hardness and thickness than any one could easily imagine.]

4. **T**HUS far the notes, from which nevertheless I will not positively conclude, though they seem to persuade it, that the tendency of the cold produced by bodies qualified to freeze others is greater downwards than upwards: for the satisfactory determination of that matter may, for aught I know, require trials more artificial and nice, than those we have been reciting. And I could wish, that I could find the last of them to have been carefully repeated and registered, because it seems somewhat strange, that the ice should be much thicker at the bottom of the phial, than elsewhere; in regard that when we have, as we very frequently have, put mixtures of snow and salt into phials, and left them in the open air, we generally observed, that the outside of the glass was cased with ice, or covered with hoar frost, directly over against that part of the inside of the glass, wherein the frigorifick mixture was. So that part of the snow and salt resolving one another, and falling down in the form of a liquor to the bottom, the unmelted part of the mixture would float upon this liquor, and the external ice would appear over-against the floating mixture, by which it was generated: so that as the mixture grew thinner and thinner, so would the zone or girdle, if I may so call it, of external ice, grow narrower and narrower, till at length, when the snow was quite melted away, the external ice would quickly also vanish. But from this observation (which we frequently made) that as in such phials the ice did not appear (as I just now related) above half

half a corn's breadth higher than the mixture in the glass; so I remember not to have observed it much lower beneath the mixture: from those things, I say, it may be probably conjectured, that even the coldest bodies (at least unless their bulk alter the case) do not diffuse their freezing virtue, either upwards or downwards to any considerable distance.

5. THESE trials, as I was intimating, may suggest some difficulties about the last of the two experiments, transcribed out of my notes. But as it is evident these observations were made in the open air, by the freezing of its roving vapours, and the mentioned experiment was made under water; so how much this difference of mediums may alter the case, as to the way of the diffusion of cold, I dare not, till further trial, boldly determine: especially since one circumstance, to be under the next title mentioned, about the freezing of eggs, may pass for an additional experiment as to our present inquiry. For the cases obtained by frozen eggs suspended under water seem to argue, that the diffusion of their cold was made every way, since they were quite inclosed in the ice, they had produced.

6. THOUGH the experiment of freezing water, by the intervention of salt and snow, be not a new one for substance, yet I hold it not amiss, to make a further mention of it on this occasion. Because that what I am to deliver about it, is a particular not taken notice of (that I know of) by others; the premising of which will, according to what we lately intimated, much facilitate the trial of many of the experiments to be set down in the following part of these papers, and will indeed appear to be of no small moment in our whole attempt of framing an *History of Cold*. For it has long seemed to me one of the chief things, that has hindered men from making any considerable progress in this matter, that whereas glass-vessels are generally much the most proper to freeze liquors in, because their transparency allows us to see, what changes the cold makes in the liquors exposed to it; the way of freezing with salt and snow, as it has been hitherto used, does almost as little, as the common way of barely exposing vessels to the cold air in frosty weather, prevent the unseasonable breaking of the glasses. For in both these ways, the water or other liquor usually beginning to freeze at the top, and it being the nature of glaciation, as we shall see anon, to distend the water and aqueous liquors it hardens, it is usually and naturally consequent, that when the upper-crust of ice is grown thick, and by reason of the expansion of the frozen liquor bears hard with its edges against the sides of the glass contiguous to it, the included liquor, (that is by degrees successively turned into ice) requiring more room than before, and forcibly endeavouring to expand it self every way, finds it less difficult to burst the glass, than lift up the ice; and consequently does the former, and thereby spoils the experiment, before it be come to perfection, or have let us see what nature would have done, if she had not been thus hindered in her work.

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7. THE consideration of this invited me to alter the common way of freezing, and order the matter so, that whensoever I pleased, the exposed liquor should not begin to freeze at the top or sides, but at the bottom; which I concluded it very easy to do, by mingling the salt with that part only of the snow, which was to lie beneath and about the bottom of the glass I placed in it. For by this means the snow, that was contiguous to the sides, was able but to cool the water, and dispose it to glaciation; whereas the mingled snow and salt, on which the bottom of the glass rested, did actually turn the neighbouring liquor into ice, and lift up the incumbent liquor towards the higher and empty parts of the glass. And this liquor also I could afterwards freeze at pleasure, without danger of breaking the vessel, only by so applying salt and snow to the sides of the glass, that they never reached, except perhaps at the very conclusion of the experiment, so high by a reasonable distance, as the upper surface of the liquor in the glass; so that the superiour parts of that liquor were always kept fluid, and capable of being easily impelled higher and higher, by the expansion of the freezing parts of the subjacent liquor.

8. THE speculative inference, that may be drawn from this experiment, of making water begin to freeze at the bottom, not the top, will be more properly taken notice of in another place: in the mean time, I shall only intimate by the way, that there is no great necessity of any nice proportion of salt to snow, nor of any exquisite mixture of them: a third or fourth part, or thereabouts, of sea-salt, in reference to the snow, will not do amiss; nor do I usually put salt to all the snow at once, unless in some case, wherein I have a mind to freeze a liquor quickly, and make a speedy resolution of the snow and salt in order thereunto. To which I shall only add, that by the way abovementioned, I do upon particular occasions make the exposed liquor freeze, not at the bottom or the top, but next to what side of the glass I please, according to the exigency of the experiment. But though it may suffice to have hinted the speculative inference, that may be drawn from this way of freezing liquors, it will be expedient to give explicitly this practical advertisement concerning it; that whereas it seems to have been taken for granted, that snow is necessary in this artifice, and we our selves were for some time led away with the rest by that supposition; yet that is but a presumption, and ought to be removed, as one very prejudicial to those, that with us design the prosecuting experiments, in order to the *History of Cold*. For snow is but seldom to be found on the ground in comparison of ice, and being but a congeries of many small icicles, with much air intercepted among them, it is not (*cæteris paribus*) near so durable, as the more intire body of solid ice. And yet we have found by frequent experience, that ice, well beaten in a mortar, will serve our turn for artificial glaciations, as well (if not in some respects better) as snow; and therefore in this *History of Cold* we indifferently prescribe snow

In the discourse touching the *primum frigidum*.

and salt, or salt and ice, as the ingredients of our glaciating mixtures.

TITLE VI.

Experiments and observations touching the preservation and destruction of (eggs, apples, and other) bodies by cold.

1. **I**T is a tradition common enough, though not here in *England*, yet among those, that have given us accounts of very cold countries, that if eggs or apples, being frozen, be thawed near the fire, they will be thereby spoiled; but if they be immersed in cold water, the internal cold will be drawn out, as they suppose, by the external, and the frozen bodies will be harmlessly, though not so quickly thawed. This tradition I thought fit to examine, not only because it may be doubted, whether it will succeed in our more temperate climate, and because I love not to rely upon traditions, when I have the opportunity to examine them (especially if no one credible author affirms them upon his particular knowledge,) but also because I thought the experiment, if true, might be so varied and made use of, as to become luciferous enough, and afford us divers phenomena of cold, not so easy to be produced by the more known ways of experimenting. And accordingly having exposed some of these bodies to a cold, that was judged sharp enough, we afterwards put them in water, but found not the event answer our expectations, no ice appearing to be generated: nevertheless we were not hereby so discouraged, as not to repeat the experiment (which we judged to be not unlikely) with more sollicitousness and advantage than before; and having thereby brought it to succeed, we afterwards made several trials of it with several distinct aims, but cannot now find any entry of divers of them. But those I have hitherto met with among my notes; I shall subjoin, as having in them some particulars, that may afford useful hints to an inquirer into the history and nature of cold. And I shall set down together, and that in this place (though it would not otherwise be the most proper) those I have met with, because some circumstances of one or other of them may be of use to us on several occasions in the present treatise.

2. [AN egg weighing twelve drachms and one grain wrapt in a waxed paper (to keep it from the liquor of the thawing snow) and frozen with snow and salt, wanted four grains of that weight: put into a dish of fair water, there crusted as much ice about the outside, as made the egg and ice fifteen drachms and nine grains. The ice being taken off from the shell, and the shell very well dried, the egg was found to weigh twelve drachms and twelve grains; the egg being broken, was found almost quite thawed; the egg frozen swam in water; being thawed, it sunk.]

3. [WE took two eggs strongly frozen, and in a room, where there was a good fire, we put one of them into a deep wooden dish full of very cold water, and set the other by it, upon a table about two yards from the fire, that they

might be in air, of the same temper as to heat and cold; then perceiving the egg, that lay under water, to have obtained a thick crust of ice, we took it out; and having first freed it from the ice, broke it, and found, that some part of the white was not yet freed from a pretty store of little parcels of ice, but the rest of the white (which was much the greater part) and the yolk seemed to be much-what of the same consistence, as if the egg had not formerly been frozen; whereas the other egg, that lay by upon the dry table, had not only its whole white frozen into a consistent body, but the yolk it self, though we saw no distinct particles of ice in it, was grown so hard, that it cut just like the yolk of an egg over-boiled; and being cut quite through, shewed us certain concentrical circles of somewhat differing colours, with a speck much whiter than any of them in the middle of the yolk; which last circumstances, whether they were accidental or no, further observation must determine.]

NOTE, that though we have not found above once, that frozen eggs would swim, yet when we had broken such eggs, the frozen white would swim, but not the yolk.

4. WE afterwards repeated the experiment of laying two frozen eggs near together in the place above mentioned, the one under water, and the other out of it, till that put in water had got a thick icy crust, and by breaking of them both, presently after one another, were confirmed in the persuasion, that frozen eggs will thaw by great odds (*cæteris paribus*) faster when immersed in water, than when surrounded only with air.

5. [WE likewise took a frozen egg, and from a fixed place suspended it so by a slender packthread, that it hung quite under water, without yet touching the vessel, that the water was in. This we did partly upon another design, and partly to observe, whether or no the ice would in this case be considerably thicker or thinner against the lower parts of the egg, as we formerly mentioned our selves to have observed it to be very manifestly at the lower parts of a glass, which having ice and salt in it, was immersed under water; but when we took out the egg, after we saw, that its icy case had covered the packthread it was hung by, we found the case, upon breaking it, of a thickness uniform enough to keep us from concluding any thing from this trial; since, though there were a pretty deal of ice generated at so small a distance from the case of the egg, that it seemed to owe its production to the same cause, yet, which was somewhat odd, we did not find, that this ice stuck to that, which did immediately embrace the egg, though we had some faint suspicion, that the rudiments of it might have been very early parted from the egg, by some little shaking of the table, occasioned by people's passing to and fro in the room.]

6. [WE took some pippins, and exposing them to freeze all night, and putting them the next morning into a basin of very cold water (though in a warm room) they were not long there without being inclosed with cases of ice

ice of a considerable thickness. Where note,
 1. That that part of a floating apple, that was immersed under water, had a very much thicker coat than the other part, which remained above it. 2. That the extant part seemed likewise to be harder than the immersed. 3. That one of these pippins being purposely left out of the basin, but laid by it, seemed, upon cutting, to be harder and more frozen than those apples, which had been put into the water; which scarce seemed to be at all harder than ordinary pippins, that had never been set to freeze, at least as to those parts of the apples, that were near the rind, and consequently near the ice. 4. That neither frozen pippins nor frozen eggs, notwithstanding their great power of turning part of the contiguous water into ice, did appear to us to detain or congeal any of the roving vapours of the air, as ice or snow included with salt in glasses is (as we have formerly observed) accustomed very remarkably to do.]

[7. WE took eggs, and froze them with ice and salt, till the shells of them were made to crack: then we took them out, and put one of them in milk, two of them in a wide drinking-glass full of beer, and two more in a large glass, wherein we covered them with sack, that was poured in till it reached much higher in the glass than the eggs. But none of these trials produced, as we could perceive, one grain of ice.] And being desirous to see, whether the acid salt of vinegar, or the cold in a well-frozen egg, would have the chief operation, if those two bodies were put together; I found upon trial, that the saline parts of the vinegar began to dissolve the egg-shell, as appeared by the much altered colour of it, but the cold of the ice in the eggs was not able to freeze any part of the water or phlegm of the vinegar.

8. WE had also thoughts of trying, whether or no pieces of iron of several shapes and bignesses, being for divers days and nights exposed to the freezing air, and afterwards immersed in water, would produce any ice, as frozen eggs and apples do. For the brittleness of the laths of stone-bows in sharp frosts, together with other observations elsewhere mentioned, seem to argue, that (to use a popular phrase) the frost does also get into these bodies. And I have been assured by one, whom the trials I had made with eggs and apples, invited me to consult, that a great cheese he immersed in water in a cold country, was presently covered over with ice. But though, as I said, I had thoughts of making the above-mentioned trials, yet for want of a frost sufficiently durable, I was not able to effect what I designed. But thus much I tried, that though I kept good lumps of iron, and, as I remember, of other metals, besides pieces of glass, and a stone or two of a convenient size, in snow or salt, I know not how much longer, than would have sufficed to make eggs or apples, or such kind of things, fit to produce store of ice in water, upon their being thawed therein; yet we could not find, that upon the immersing the several newly named mineral bo-

dies, there was the least ice produced in the cold water, where we kept them covered. I must not, nevertheless, omit to make some mention of that, which lately seemed to happen at the door of our own laboratory, (respecting the north east) where some glasses, newly brought from the shop, and not employed, lying in a basket, as they poured water into one of them to rinse it, part of it was presently turned into ice, whilst one of my domesticks held it in his hand; who coming presently to shew it me, I suspected the ice might have come from, or rather with the water, that was poured into the glass, but upon inquiring was assured of the contrary.

9. BUT here I must not omit another trial relating to the former experiments, which may seem somewhat odd, if its event prove constantly the same, as when we tried it. For after these and divers other experiments made with frozen eggs and apples, we thought it might be worth the examining, whether or no ice and the liquors of these concretes would produce the like effects, as frozen eggs and apples. And because it is usually an easier way than that, which is more common, of bringing bodies, whose degree of cold is more languid, to freeze water, to include them with ice or snow in a single phial, and so put them upon acting only upon the minute, and easily congealable vapours, that wander in the air; we took that course in the trials we are mentioning: whose success is thus briefly set down in one of our notes.

[10. ICE and juice of pippins, well shaken together in a single phial, produced abundance of dew; but we could not satisfy ourselves, that it produced any ice.]

[11. ALSO ice and the white of an egg, moderately beaten into a liquor, were tried, with just the like success; but these trials having scarce been made above once, and at most but twice, are to be repeated.]

12. As for what is said, that eggs and apples thawed in the water are better preserved than thawed by the fire's side; we tried it in pippins, (for in eggs the experiment is not so easily and quickly made) and, as far as we could discern, found it true, and somewhat wondered to see, how soon, and how much putrefaction was induced into those loosely contexted bodies by an overhasty thawing.

13. IF we may believe the relations of navigators, and others of good credit, (of one or two of whom I had the opportunity to make inquiry) there may be good use made of what happens in the different ways of thawing eggs and apples, by applying the observation to other bodies, and even to men, that happen to be dangerously nipped by excessive cold. For it is a known observation among those, that have inhabited or visited the northern climates, that if those, whose hands or feet, or faces happen to be frozen, approach them too near or hastily to the fire, they are in danger of losing, or at least much prejudicing the overhastily thawed parts. 'Upon divers of us, (says Captain *James*, speaking of his companions) 'had the cold raised blisters as big as walnuts.

walnuts. This we imagined to come, by reason that they came too hastily to the fire.' And therefore they, that are more careful to be safely than quickly delivered from the painful cold, are wont, before they come near the fire, whether it be open or in stoves, either well to wash their hands, or other frozen parts, in very cold water, or else to rub them well with snow it self. And this brings into my mind, that I sometimes endeavoured to find by trial, what beef long exposed to freeze and differingly thawed would teach me, by way of confirmation of this tradition; but being then obliged to unseasonable removes from the place, where I made my trials, they did not for that reason afford me the satisfaction I desired; but meeting with an intelligent person, that had been an housekeeper in *Muscovy*, and enquiring of him, whether he had observed any thing about this matter, he told me, that having once had two very large cheeses frozen, he thawed one of them into water, and the other in a stove, but found, that thawing in water was much the better way of the two. And I was well pleased to be answered by him, that the cheese, thawed in water, did soon acquire therein a crust of ice.

14. BUT more memorable is that relation, which I remember I have read in the experienced chirurgeon *Fabricius Hildanus's* treatise of *Gangrenes*, where he relates from credible testimony, how the whole body of a man was successfully thawed, and, which is more strange, cased all over with ice, by being handled as our eggs and apples were. His own words, because the narrative may prove of some use, I shall subjoin, and they are these: *Narravit mihi vir quidam nobilis & fide dignus, se, cum eas regiones peragraret, incidisse aliquando in viatorem secundum viam frigore rigidum, ac pene mortuum, quem plastro suo impositum, cum deduxisset in diversorium, hospes illico demersit in frigidam, quo facto undequaque ita erupit gelu, ut ipsius corpus glacie, seu ferreo thorace contactum conspiceretur. Tum quoque propinatum illi agebat cyathum ampliore hydromelitis, quo illi seu potu ordinario utuntur, addito pulvere cinnamomi, caryophyllorum, & macis, unde sudor in lecto provocatus est; atque ita ægrum ad se rediisse amissis duntaxat manuum & pedum extremis articulis. Hinc intelligimus hanc methodum sanandi congelatos veram ac tutam esse, ac eam etiam probat summus philosophus, qui regiones illas frequentavit, &c.*

15. THE experiment delivered at the beginning of this title, (of speedily producing ice on the outside of frozen eggs and apples, by immersing them in cold water) I take to be one of the two or three most illustrious, I have hitherto met with about congelation; and as likely as any to assist us to investigate the causes of it. But though the phænomena seem very favourable to their hypothesis, that suppose congelation to be effected by the ingress of frigorifick atoms into the water or other bodies to be congealed; yet (for some reasons) I shall not here offer to draw any speculative inference from the experiment, contenting my self to have here, and at the beginning of this section,

hinted *in transitu* the hopefulness of its proving luciferous.

16. BUT I remember, that the title of this section promises something concerning the preservation and destruction of other inanimate bodies, as well as eggs and apples, by cold; but as that intimated promise makes the last part of the title, so what I have to deliver on this subject must not be expected to be other than the last part of this section. And indeed to be able to add much to that little, which is generally known about this subject, I should either have lived in colder climates than ours, or have had, which I had not, the opportunity of making experiments, that require length of time. And therefore I shall only propose a general consideration about this matter, and subjoin a few of the chief observations I have met with in navigators or others about it. That then, which I would premise in general, is only this; that whether bodies be frozen by the ingress of frigorifick atoms, which by their intruding in swarms can scarce avoid discomposing the texture of the body; or whether it be made by the recess of some matter, that did, before congelation, more strongly agitate its parts; which way soever, I say, freezing is effected, it is manifest, that the nature of a frozen body is, at least for the time, much altered; and therefore we thought fit to place it among our general articles of inquiry about cold, what the effects of it may be as to the conservation or destruction of the texture of bodies. But as for the duly prosecuting this inquiry, we do, as we lately intimated, want the time and convenience, we judge needful for such a work; the matter seeming to require, that it be watchfully and considerately managed, and that both the nature of particular bodies, and the differing degrees of cold, and the differing times, wherein the condition of the exposed body is estimated, be taken into consideration. For we find, that a moderate degree of cold preserves many bodies, and that glaciation destroys, or at least prejudices most others (probably by discomposing or vitiating their texture) when they come to be thawed, though whilst the frost is in them, it keep almost all bodies from disclosing any putrefaction.

17. THIS being the general consideration I intended to propose, it remains, that I add out of credible writers, or other relaters, some observations to illustrate and confirm the chief particulars comprehended in it.

AND first, that a moderate degree of cold conduces much to the preservation of the greatest part of inanimate bodies, is a thing vulgarly taken notice of and acknowledged. And I do not readily remember any instances, that manifest, that any degree of cold, though more than moderate, provided it fall short of freezing the bodies exposed to it, does spoil them. *Regii Mutinenses* (says the industrious *Bartholinus*,) *nivem hoc fine arte compactam servant in cellis nivariis, in quibus fervente æstate vidi carnes mactatorum animalium à putredine diu se conservasse.* The next thing I shall mention to our present purpose, is a memorable passage in captain *James's* voyage; which shews, that so great

Gulielmus Fabricius Hildanus de Gangr. & Sphacelo, Chap. 101

Barthol. de usu Nivis, pag. 80.

great a degree of cold, as may be supposed to have reigned in his ship, that was frozen up all the winter in one of the coldest regions of the world, was not great enough to spoil the meat and drink, that had laid all that time under water, because it seems by the story, that they were not actually frozen; the words of his journal are these: "By the ninth of May we were come to, and got up our five barrels of beef and pork, and had four butts of beer, and one of cyder, which God had preserved for us: it had lain under water all the winter; yet we could not perceive, that it was any thing the worse." Which is the more remarkable, because of what we shall note by and by, both out of other books, and even out of this, about what became of a stronger liquor than beer, once brought to glaciation; and it seems our navigator found cold, if extremely intended, so destructive a thing, that he thought fit to take notice in his journal, that even a cable having lain under the ice all the winter, was not in June found a jot the worse.

18. AND it seems by a passage in *Simlerus's* account of the *Alps*, that even intire bodies may be very long preserved by snow, and, as far as I can guess by the story, without glaciation. Refert *Barthol. de figura nivis* apud *Rinwaldios*, *nivium è monte ruentium moles sylvam & proceras abietes dejecisse; accidisse etiam Helvetio militie per Alpes iter faciente, ut 60 homines & plures eadem nivis conglobatione opprimerentur. Hoc igitur nivium tumulo sepulti, ad tempus æstatis delitescunt, quo soluta nonnihil nive decidua, corpora mortua inviolata patent, si ab amicis, vel transeuntibus querantur. Vidimus ipsi triste hoc spectaculum, &c.*

19. SECONDLY, I could alledge many instances to shew, that many, if not most inanimate bodies, (I say inanimate, because of the gangrenes and sphacelations that often rob living men of frozen toes, noses, and sometimes other parts) if they be actually frozen, will not disclose any putrifaction, whilst they continue in that state. Nor is this much to be wondered at, since whether he will suppose, that in glaciation the moist and fluid parts are wedged in by intruding swarms of frigorifick atoms, or that those restless particles, that were wont to keep the body fluid or soft, are called forth of it, be the cause of glaciation; which soever of these two ways we pitch upon, we must in frozen bodies conceive an unwonted rest to be produced of those moveable particles, whose internal commotions, and disorderly coalitions and avolutions, are either the causes or the necessary concomitants of corruption.

20. ON this occasion I remember, that meeting with a knowing man, whose affairs stopped him during the winter upon the coasts of *Sweden* and *Denmark*, being desirous to learn of him, how long they could in those colder climates preserve in winter dead bodies unburied, and yet uncorrupted, he told me, he had opportunity to observe, that though the frost lasted, as it usually did in that season, three or four months together, or longer, the bodies might without any embalming, or other

artificial way of preservation, be kept untainted by the bare coldness of the air. Of bodies lasting long unputrified in ice, navigators and others have afforded us several instances; but we will mention two, because they contain something more remarkable than the rest. The one is thus delivered by *Bartholinus*: *Notandum, corpora occisorum hyeme eodem positu, eademque figura permanere rigida, quæ ante eadem deprebensa sunt. Visum id extra urbem nostram, quum 11 Feb. 1659. oppugnantes hostes repellerentur, magnaque strage occumberent: alii enim rigidi iratum vultum ostendebant, alii oculos elatos, alii ore diducto ringentes, alii brachiis extensis gladium minari, alii alio situ prostrati jacebant. Imo ex mari gelato, primo vere resoluta, eques equo suo insidens integer emerfit, nescio quid manibus tenens.* The other instance is afforded us by captain *James's* Journal, and is by him thus delivered: "In the evening

(of the 18th of May) the master of our ship, after burial returned aboard ship, and looking about her, discovered some part of our gunner under the gun-room ports. This man we had committed to sea at a good distance from the ship, and in deep water near six months before. The 19th in the morning I sent men to dig him out, he was fast in the ice, his head downwards, and his heel upwards, for he had but one leg; and the plaister was as yet at his wound: in the afternoon they digged him clear out, after all which time he was as free from noisomeness, as when we first committed him to sea. This alteration had the ice and water and time only wrought on him, that his flesh would slip up and down upon his bones like a glove on a man's hand." But there is one pertinent particular more, which, if it be strictly true, is so very remarkable, that I cannot on this occasion forbear to annex it; which is, That according to the relation of the merchants of *Copenhagen*, that returned thither from *Spitzberg*, a place in *Greenland*, the extreme cold will there suffer nothing to putrify and corrupt, infomuch that buried bodies are preserved thirty years intire and inviolated by any rottenness.

21. THIRDLY, though whilst bodies continue frozen, the cold (as may be supposed) by arresting the insensible particles, from whose tumultuary motions, and disorderly avolutions corruption is wont to proceed, may keep the ill operations of cold upon the violated textures of bodies from appearing; yet when once that impediment is removed, divers bodies make haste to discover, that their texture was discomposed, if not quite vitiated by the excessive cold. I might alledge on this occasion, that I have shewn divers ingenious men by an experiment that I have taught in another treatise, that the change produced in the textures of some bodies by glaciation, may be made manifest even to the sight. For by freezing an ox's eye, the crystalline humour, which in its natural state is transparent enough, to deserve its name of crystalline, though not fluid enough to deserve the name of humour, lost with its former texture all its diaphaneity, and being

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Bartho. de figura nivis pag. 79

Barthol. de usu nivis, p. 83.

Capt. James's travels, p. 70.

Barthol. de usu nivis, c. 12.

* Of the usefulness of Experimental Philosophy.

being cut in two with a sharp knife, appeared quite throughout very white. But for confirmation of this I shall rather add, that I remember, that the person formerly mentioned, that had made trial of the two cheeses, confessed to me, That, though that, which had been thawed in cold water, was very much the less spoiled, yet they were both of them manifestly impaired (and the other of them was so in its very consistence) by the frost, though the bulk of the cheeses was very considerable, and though they were both of them, of a more than ordinarily good and durable sort.

22. THE next thing I shall alledge to this purpose, is the observation of the *Hollanders*, even by such a degree of cold as they met with in *Nova Zembla*, before the middle of *October*, at which time their strong beer, by being partly frozen, had its texture so vitiated, that the reunion of its unfrozen to its thawed parts could not restore any thing near such a spirituous liquor, as it was before. "We were forced (says *Gerat de Veer*, that wrote the story) to melt the beer, for there was scarce any unfrozen beer in the barrel, but in that thick yeast, that was unfrozen, lay the strength of the beer, so that it was too strong to drink alone; and that which was frozen tasted like water, and being melted, we mixed one with the other, and so drank it, but it had neither strength nor taste." And in the next month's journal he tells us, that their best beer was for the most part wholly without strength, so that it had no favour at all. But a more remarkable instance to our present purpose is afforded us by our countryman captain *James*, because it manifests the cold to have the same effect upon a much stronger and more spirituous liquor. "I ever doubted (says he in his journal) that we should be weakest in spring, and therefore had I reserved a tun of *Alicant* wine unto this time. Of this, by putting seven parts of water to one of wine, we made some weak beverage, which (by reason that the wine by being frozen, had lost his virtue) was little better than water."

23. AND I remember, that a learned man, whom I asked some questions concerning this matter, told me, that in a northern country, less cold than *Muscovy*, he had observed, that beef having been very long frozen, when it came afterwards to be eaten, was almost insipid; and being boiled, afforded a broth little better than common water.

24. IF I had not wanted opportunity, I should here subjoin an account of some trials, for which I made provision, as thinking them not absolutely unworthy the making, though extravagant enough not to be likely to succeed. For I had a mind to try, not only whether some plants, and other medicinal things, whose specifick virtues I was acquainted with, would lose their peculiar qualities by being thoroughly congealed, and (several ways) thawed; and whether thawed hartshorn, of which the quantity of salt and saline spirit of such a determinate strength should beforehand be tried by distillation, would, after having been long congealed, yield by the same way of distilla-

tion the same quantity of those actual substances, as if the hartshorn had not been frozen at all. But I had also thoughts to try, whether the electrical faculty of amber, (both the natural, and that factitious imitation of it I elsewhere teach) and whether the attractive or directive virtue of loadstones, especially very weak ones, would be either impaired, or any ways altered by being very long exposed to the intensest degrees of cold within my power of producing. But to have named such extravagancies, is that, which I think enough, and others I fear may think too much.

25. YET some few things I shall subjoin on this occasion, because it will add somewhat not impertinent to the design of this treatise (which is to deliver the phenomena of cold) as well as countenance what I have been proposing; and those things are, that I can by very credible testimony make it appear, that an intense cold may have a greater operation upon the texture even of solid and durable bodies, than we in this temperate climate are commonly aware of. I shall not urge, that even here in *England* it is generally believed, that men's bones are more apt to break upon falls in frosty, than in other weather, because that may possibly be imputed to the hardness of the frozen ground. Nor, that I remember, when I was wont to make use of stone-bows, I found it a common observation, that in frosty weather the laths, though of steel, would, by the cold, be made so brittle, that unless extraordinary care were had of them, or some expedients were used about them, they would be apt to break. Nor yet, that an ingenious overseer of great buildings has informed me, that those that deal in timber and other wood, find it much more easy to be cleft in hard frosts, than in ordinary weather. These and the like instances I do, as I was intimating, forbear to urge, because these effects of cold are much inferior to those that have been met with in more intemperate regions.

26. AND to begin with its operation upon what we were last treating of, wood. Of *Charleton*-island, captain *James* has this passage about the timber, they employed upon their works: 'The boys (say he) with cuttle-axes must cut boughs for the carpenter; for every piece of timber, that he did work, must first be thawed in the fire.' And a little before, he tells us, that even when they found a standing tree, they must make a fire to it to thaw it, otherwise it could not be cut.'

27. AND I remember, that two several persons, both of them scholars, and strangers to one another, that had occasion to travel as far as *Moscow*, assured me, that they divers times observed in extreme frosts, that the timber-work (whether the boards or the beams) of some houses, which, according to the custom of that country, were made of wood, and perhaps, not well seasoned, would, by the operation of the cold, be made to crack in divers places, with a noise, which was surprizing enough to them, especially in the night.

28. I REMEMBER also, that a physician, who lived for some years in one of the coldest plantations of the *West-Indies*, related to me, that

Purch.
Lib. 3. cap.
5. sect. 2.
pag. 493.

Pag. 73.

Pag. 67.

that he had observed the bricks, he had employed about building, to be very apt to be spoiled by the long and vehement frosts of the winters there; where he likewise said, that it was a usual thing for the houses builded of brick, to decay in fewer years by far, than here in *England*; which he said was generally, and, as he thought, truly imputed to the excessive cold, which made the bricks apt to crumble, and moulder away. But though I dare not lay much weight on this observation, unless I knew, whether the bricks were sufficiently burned, and free from pebbles, calcinable by the heat that burned the bricks; yet we must not deny, that extreme colds may be able to shatter or dissolve the texture of as close and solid bodies as bricks, especially if the aqueous moisture be not sufficiently driven away; if we will admit, what I remember I have mentioned in another treatise, out of a very learned and credible author, of the power, that a freezing degree of cold has had to break even solid marble. And much less shall we doubt the possibility of what the physician related, if we will not reject the testimony of the learned *Olaus Wormius*, according to which, instruments made even of so hard a metal as brass are not privileged from the destructive operations of some degrees of cold. For, *Ex are facta opera* (says he in his curious *Museum*) *vi frigoris quandoque rumpuntur, quod tamen pauci credunt, id tamen expertus est Eratosthenes, & nostras Johannes Munckius in difficillimo suo itinere, quo per fretum Christianum transitum in mare Australe invenire moliebatur.* To which, perhaps most writers would, if they met with it, add this passage out of the Dutch-mens voyage to *Nova Zembla*: ‘The 20th (of *October*) it was calm & sunshiny weather, and then again we saw the sea open, at which time we went on board, to fetch the rest of our beer out of the ship, where we found some of the barrels frozen in pieces, and the iron hoops, that were upon the same barrels, were also frozen in pieces.’ But though this testimony seems to prove, that extreme cold may break even iron it self, and though possibly such an affirmation might in the general not be erroneous, yet I shall forbear to draw that inference from this passage, because I suspect, that since the irons, that were broken, were hoops, and since it seems probable by the story, that there were barrels not hooped with iron broken also by the same frost; the breaking of the hoops may have been the effect, not of the violence of the cold, as acting immediately upon the iron, but of the liquor in the vessels, which being, by the cold that froze it, turned into ice, was so forcibly expanded, as to burst whatever opposed its dilatation, according to what we shall have occasion in its due place more fully to deliver.

An Appendix to the VIth title.

INQUIRING of the formerly mentioned physician to the Russian emperor, what experience teaches about some of the matters treated of in this (sixth) title, in those cold climates, where the effects of freezing are more notable;

he told me, that the tradition (mentioned above, touching the safest way of thawing) is in *Muscovy* generally received; and that it is usual for men, that have their cheeks and noses frozen, to rub them well with snow, and escape unharmed; whereas if they go immediately into their stoves, they often lose the tops of their noses, and introduce into their cheeks a kind of paralytick distemper, or benumbedness, that they cannot get rid of in many months.

AND having also inquired of the same ingenious person, whether wine frozen, and then permitted to thaw, till the unfrozen liquor had quite resolved the ice, was not thereby spoiled by having its texture vitiated, he answered, that in very strong claret-wine he found the colour scarce at all destroyed, nor the liquor otherwise much impaired; but that in weaker claret-wine the colour was spoiled, and the liquor was otherwise much the worse. But note, that in the French wine there remained a third part or more unfrozen, so that it seems not to have been exposed to near so extreme a cold, as that of the *Hollanders*, or of captain *James*; and that physician likewise told me, that of some very strong beer, that he had in great part frozen, the ice had some taste of the hops, but was dispirited like phlegm.

HAVING inquired how long dead bodies would keep, he told me, that if they were thoroughly frozen, they would be preserved incorrupted till the thaw, though that perhaps might not happen within four or five months after the death of the man. He added, that he had the venison of elks sent him unsalted, and yet untainted, out of *Siberia*, (which is some hundreds of leagues distant from *Moscow*;) and that beef and other flesh well frozen, would keep unputrified for a very long time. And when I asked, whether the freezing did not impair it, he answered, that with long keeping it congealed, it will grow very dry and be impaired in taste, and will not make so good broth as meat that was never frozen. And he further told me, that in case frozen meat were leisurely thawed, it would be far the less impaired, and might be well roasted; but if before it was thawed, it were laid down to the fire, it would not ever be well roasted, and would eat very scurvily: and though a shoulder of mutton, for instance, were kept very many hours turning before the fire, yet it would continue raw in the middle.

HAVING inquired about the rubbing bodies with snow to unfreeze them, he told me (agreeable to what I noted him to have said above) that he had seen several persons, that had been frozen, and that when a man is told, that he is frozen, and having asked whereabouts (for the party himself usually knows it not) is informed, that it is in this, or that place, which is commonly the nose or the upper part of the cheek, or perhaps the tip of the ear; he usually rubs the part very well with snow, and lets it thaw by degrees; else, if without that preparation he should go immediately into the stove, he would be in danger to lose his nose, or other frozen part. The doctor added, that they use to rub the frozen meat and fish with snow, and

and that he once examined a man, who in his youth had been frozen all over, and informed the doctor, that having had occasion in a journey to quit his sled for a while, and do some exercise, that had almost made him sweat, being careless of himself, when he returned to the sled again, he was frozen all over, and had so died, had not the company by accident taken notice of him, and by rubbing him over with snow, and by the use of the like means recovered him again; but he told the doctor, that by this whole accident he was put to no pain, save that when he came to himself again, he felt such a pricking all his body over, as men are wont to find in an arm or leg benumbed, by having been long leaned upon.

WHEN I asked, whether the sharpness of the cold did not work upon the stones, he answered, that as to flints he could not tell; but as to other stones, and such as are oftentimes used for building, the violence of the cold made them frequently moulder into dust. And to satisfy my curiosity about the effect of cold upon wood, he told me, that he had very often in the night, especially when their keen frosts were unaccompanied with snow, heard the trees cleave and crack with very great and sometimes frightful noises; and that the outside of the fir-trees, that were laid upon one another in their buildings, and was exposed to the air, would do the like; and that he had often seen the gaping clefts sometimes wide enough to put in his fingers, which would remain in the trees, and in the fir-wood, till the thaw, after which they would pretty well close of themselves.

T I T L E VII.

Experiments touching the expansion of water, and aqueous liquors, by freezing.

1. **T**HAT water and other liquors are condensed by cold, and so much the more condensed, by how much the greater the degree of cold is that condenses them, has been for many ages generally taught by the schools, and taken for granted among men, till of late some more speculative than the rest, have called it in question upon the account of the levity of ice; since which, I have met with two modern writers, that have incidentally endeavoured to prove, that ice is water, not condensed, but rarified by the intumescence of water exposed to freezing in vessels fitly shaped.

THESE attempts of these learned men putting me in mind of what I had tried to this purpose, when I was scarce more than a boy, invited me to consider, that by the usual ways of glaciation, such as these ingenious men employed, the experiment is wont to meet with a disaster, by the breaking of the glasses, which not only makes the event liable to some objections of theirs, that befriend the common opinion, but (which is more considerable) hinders them from judging what this expansion of water, that is made by freezing, may amount to. Wherefore we will now set down what we have done to ascertain (and yet limit) the experiment, as also to advance it further.

2. **W**HEREAS then these two learned men, <sup>Nicholaus
Zacchini,
& Melchior
or Cornarus.</sup> we have been mentioning, do so expose the water to freeze, that it is turned into ice at the top as soon as elsewhere; the inconveniences of which way, we have already noted; we, by freezing the water, as we have formerly taught from the bottom upwards, can easily preserve our glasses intire, and yet turn the whole contained water into ice: so that if according to this way you so place a bolt-head or a glass-egg, in whose cavity the water ascends to the height of an inch, or thereabouts, within the stem or shank, in a mixture of ice, or snow and salt, as that the water is first turned into ice at the bottom and sides, and not till the very last at the top, you shall manifestly see, that the ice will reach a good way higher in the neck, than the fluid water did, and that upon a gentle thaw of the ice, the water it returns to, will rest at the same height in the stem, to which it reached, before it was exposed to be frozen.

3. **W**E have likewise used other ways unspoken of by the lately mentioned writers, to evince, that water is expanded by being frozen; as first, that we took a strong earthen vessel of a cylindrical form, and filling it with water to a certain height, we exposed it unstopped, both to the open air in frosty nights, and to the operation of snow and salt, and found that the ice did manifestly reach higher than the water did, before it was congealed.

BESIDES, if a hollow pipe or cylinder, made of some compact matter, be stopped at one end with wax, or some things else, which it may be more easy to drive out, than to burst the cylinder; and if at the other end it be filled with water, and that orifice also be stopped after the same manner; this pipe, suspended in a sufficiently cold air will have the included water frozen, and by that change, if the experiment have been rightly made, the water will upon congelation take up so much more room than it did before, that the above-mentioned stopples, or at least one of them, will be thrust out, and there will be produced a rod of ice a good deal longer than the pipe, at each of whose ends (or at least at one of them) a cylindrical piece of ice of a pretty length may be broken off, without meddling with the pipe, or the ice that fills it.

DIVERS other ways of proving the same truth might be here alledged, but that, though these were not, as they are, sufficient, the matter would yet be abundantly confirmed by divers of the experiments, that will here and there come in more opportunely in the following part of this treatise.

4. **B**UT here it will not be altogether impertinent or unseasonable to take notice, that not only those school-philosophers, who have considered the breaking of well-stopt glasses in frosty weather, (an accident but too frequent in apothecaries shops, and laboratories) but divers modern virtuosi, are wont to ascribe the phenomenon to this, that the cold of the external air, contracting the air and liquor within, the ambient air must break the sides of the glass to fill that space, which being deserted

fetted upon the condensation of the included air, the liquor would otherwise leave a vacuum abhorred by nature; and even those few moderns, that are loth to ascribe this phænomenon to nature's abhorrency of a vacuum, either not being acquainted with the weight of the air, know not what probable account to give of it; or if they acknowledge that weight, are wont to ascribe it to that, and to the great contraction of the internal air, made by the cold of the external.

5. BUT as for the Peripateticks, the above-mentioned experiments sufficiently evince, that in many cases, it is not the shrinking, but the expansion of the liquors contained in the stopt vessels, that occasions their bursting; and therefore in these cases, we need not, nor cannot fly to, I know not what *fuga vacui* for an account of the phænomenon. And whereas it may be objected, that even glasses not half full of distilled waters, if they be exactly stopt, are often broken in apothecaries shops: I answer, That neither in this case do I see any need of having any recourse, either to the *fuga vacui*, or to the weight of external air; for even here the expansion of the freezing liquor may serve the turn; for in such inartificial glaciations the liquor begins to freeze at the top, and the ice there generated, fastening it self (as on other occasions we declare) very strongly to the sides of the glasses, contiguous to its edge, as the liquor freezes deeper and deeper, this crust of ice increases in thickness and strength, so that the water is included, as in a vessel hermetically sealed betwixt this ice at the upper part, and the sides and bottom of the glass every where else; and consequently, the remaining water being undapable of congelation without expansion, when the ice is grown strong enough at the top, to make it easier for the expansive endeavour of the freezing water to crack the sides or bottom of the glass, than to force up that thick cake of ice, the vessel will be broken, how much soever there be of it empty above the surface of the ice. And this conjecture may be confirmed by these two particulars: the one, that when water is frozen in a broad vessel, which is too strong to be broken or stretched by the frost, the surface of the ice contiguous to the air will be convex or protuberant, because, that though the glaciation began at the top, the thickness and compactness of the vessel makes it easier for the expansive endeavour to thrust up that cake of ice in those parts of it, that are the remotest from the sides, whereunto they are strongly fastened, than to break so solid a vessel.

6. THE other particular is afforded us by that experiment of ours, (mentioned in the fifth title foregoing) wherein if a vessel half full of water be made to freeze, not first at the top, but at the bottom, that liquor may be turned into ice without danger to the glass. But we will now add an experiment, on whose occasion we have set down those considerations. For being inclined to think, that the spring of the air, shut up in a vessel stopt, will preserve it expanded, or at least keep it from considerably shrinking, notwithstanding a very great degree of cold, in case the vessel be strong and close e-

nough to fence it from the pressure of the external air, we conjectured; that the bare weight of the outward air, added to the refrigeration of the included air, would not be sufficient to break much weaker glasses, than those we have been speaking of. And therefore partly to satisfy some ingenious men, that this conjecture made me dissent from, and partly to shew the Peripateticks, and those that adhere to them in the question under consideration, that either the cold alone cannot always, as they teach us, contract the air, or that, if it do, the breaking of well-stopped glasses in frosty weather is much fitter to evince, that there may be a vacuum, than that there can be none, we made the following experiment.

7. WE took three glass-bubbles of differing shapes and sizes, which we caused to be blown with a lamp, that, to make the experiment very favourable for our adversaries, we might have them much thinner, and consequently, weaker than those glasses, that are wont to be made use of to keep liquors in, and which, notwithstanding, are wont to be broken, though they be not full, by the frost.

THESE bubbles, when the air was at a convenient temper within, were (as easily they might be) nimbly sealed up with care, to avoid the heating of the air in them; and being afterwards exposed sometimes to the air it self in very frosty weather, and sometimes to that greater cold, which is produced by the placing them in a mixture of snow and salt, we could not nevertheless find, that any one of the three was at all broken or cracked; so that in case the included air were condensed into a lesser room, the space it deserted may be concluded empty, or else it will hardly appear, what necessity there can be, that nature should break, as the Peripateticks pretend, very much stronger glasses in apothecaries shops, to prevent a vacuum.

8. HAVING shewn, that water it self acquires a considerable expansion by cold, we will next shew, that aqueous bodies, or those that abound with waterish parts, do divers, if not all of them, the like.

WE took eggs, and exposing them to a sufficient degree of cold, we observed, that when the contained liquors were turned into ice, they burst the shells asunder; so that divers gaping cracks were to be seen in them, as long as they continued frozen.

9. MILK, urine, Rhenish-wine, and good spirit of wine, being set to freeze in distinct glass eggs, neither of the three former liquors was observed to subside before it began to rise. The event in sum was, that the urine was much longer, than either of the two other liquors, before it began to swell, but rose to a far greater height, than they, afterwards. The wine did not leave the mark above an inch beneath. The milk ascended about two inches, and the urine by guess six or seven.

10. A STRONG solution of *Dantzick* vitriol being put into a cylindrical pipe, sealed at one end so, that the liquor filled the pipe to the height of about six or eight inches, being frozen with snow and salt, the congealed liquor grew very opacous, and looked as if it

had been turned or shot into vitriol, save a little, that remained fluid, and transparent near the bottom. And this ice, as appeared, rose considerably higher than the liquor did before congelation.

It were perhaps worth trying, whether or no even several bodies of a stable consistence, and durable texture, might not be found to receive some, though less manifest dilatation by excessive cold. And methinks those, who attribute glaciation to the plentiful ingress of frigorifick atoms into bodies, should by their hypothesis have been invited to make some trials of this kind, since we see, that the invisible moisture of the air against rainy weather does seem manifestly enough to alter the dimensions of doors, window-shutters, and other such works made of wood not well seasoned. And even without supposing the truth of the Epicurean hypothesis, if we consider, that in bread, though we are sure, that much more water was added to the meal, or flower, than was exhaled in the oven, yet there appears not the least drop of water distinct in the concrete, and that hartshorn, sponges, and many other bodies, that seem very dry, will afford by distillation good store of phlegm or water, and more than can probably be ascribed to any transmuting operation of the fire: if, I say, we consider these and the like things, it may seem worth while to try (which I want the conveniency to do) by accurate measures, whether the invisible and interspersed water, its comminution notwithstanding, will not upon freezing swell the body, that harbours it. And I would the more gladly have been satisfied in this, because I hoped it might help me to unriddle a strange phenomenon, afforded us by the narrative of the Dutchmen's voyage to *Nova Zembla*, wherein they relate, 'that the cold was so great, that their clock was frozen, and would not go, though they hung more weight upon it than before: so that they were fain to measure their time by hour-glasses. For though this odd effect might be suspected to proceed from some little icicles sticking to some of the wheels, or the line, in regard they not far off tell us, that the steams of their bodies, and other things within their clove-house*, did so fasten themselves to the walls, to the roof, and even to their cabins, as to line them with ice, of no less than two fingers thick; yet besides that it cannot be probably supposed, that they, who had so great need of their clock, during the tedious absence of the sun for many weeks together, should not all the winter long be aware of this; besides this, I say, I find, that in captain *James's* wintering at *Charleton*, his clock and watch were so frozen too, that they could not go, notwithstanding they were still kept by the fire-side in a chest, wrapt in cloths.' So that in case it appear, that, according to what we formerly noted out of *Wormius*, the frost can get into metals, it can also distend them; and other fitable bodies; we might conceive, that the stopping of the clocks might proceed from

the stiffness, or the swelling of the line, to which the weight was fastned, or a swelling even of some of the wheels, or other metalline parts of the clock, that may spoil the necessary congruity between the teeth, &c. as I have tried, that some parts of an iron instrument, I caused to be made, would by no means fit one within another, when expanded by much heat, (and though cold be the cause of the expansion, the effect may be the same) though at other times they would. And if we knew, whether springs lose any thing of their elasticity by the violence of the cold, we might thence also be assisted to guess, whether the frost's operation upon the spring of captain *James's* watch (for he mentions that, as distinct from his clock) might contribute any thing to the forcing it to stand still. But these are bare conjectures, from which I will therefore pass on to the following section.

T I T L E VIII.

Experiments touching the contraction of liquors by cold.

1. **B**UT notwithstanding all the former experiments, we must not conclude universally, that all liquors are disposed to be expanded by cold, neither by a moderate degree, nor even by so intense a degree of it as suffices to freeze or congeal the liquors exposed to it. This we have tried, not only in spirit of wine, aqua fortis, oil of turpentine, and divers other liquors, that we could not bring to freeze; but also in oil congealed by the vehemence of cold; so that as to the change of dimensions produced in liquors by cold, there must be a great difference allowed betwixt water and aqueous liquors on the one side, and oil and divers other liquors, that are some of them of an oleaginous, and some of a very spirituous, or very highly corrosive nature, on the other side. Nor have we yet made trials enough to reduce this matter to a certainty. For though we could not bring some strong saline spirits, nor the most of chymical oils to freeze; yet in some our attempts succeeded not ill. But I remember not, in any liquor we could by cold produce any sensible expansion, but rather a manifest condensation, unless we could bring it actually to freeze.

2. THE trials we made of the efficacy of cold to condense liquors, were many; but it may, for the present, suffice to set down two or three differing ones, that occur to us in our collections.

To the entry of the experiment lately recited, of the expansion of milk, urine, and the Rhenish wine, there are subjoined these words:

[BUT the egg, that held the spirit of wine, though it were much smaller than we usually employ, and fitted with a proportionably slender stem, and though it were kept divers hours partly in ice and salt, and partly in snow and salt, yet it froze not at all, but subsided by degrees below the first mark to the quantity of $\frac{1}{2}$ of an inch in the stem; and though it afterwards

* It froze so sore within the house, that the walls and the roof thereof were frozen two fingers thick with ice, and also in our cabins, where we lay all those three days, while we could not go out. *Gerat de Veer* in his third Voyage.

afterwards seemed to rise a little, yet it never swelled up again to the said first mark.]

3. WE took a round bolt-head of about in diameter, and poured in mercury till it reached a pretty way into the neck, which was purposefully drawn more slender than ordinary; and having, without approaching it to the fire, freed it from some of the larger bubbles of air, that appeared at the sides, we put it into a mixture of ice and salt, where the cold so wrought upon it, that watching it attentively, we could discern not only its having moved, but its motion downwards, which it continued (though not visibly in the progress, as at the first) till it was subsided in the neck two inches or better, which was far more than could be attributed to the contraction of any sensible aerial particles, though they had lost not only the 30th part of their dimensions, as we have sometimes observed of the air, but had been contracted to a point; and we observed too, that the quicksilver once thus in frigidated, though not frozen, retained some of the acquired cold, for many hours after, as appeared by its keeping below the mark of its first height; though we had kept it all night in a warm room.]

[4. WE took a small egg with a proportionably slender stem, into which we poured common oil, till it rose a pretty way (but not much) above the oval part of the glass; then having put a mark upon the station of the liquor, we placed the vessel in snow and salt, and observed it not to swell as other liquors, but to subside, with cold; till being quite frozen or congealed, it appeared to be shrunk about an inch or more beneath the mark; then being thawed, it swelled again to the mark.]

5. THIS experiment was repeated the second time, with not much worse success; but we found, that if the glass were removed out of the snow into some place near the fire, the hot air would not only thaw it, but so rarify it, as to make it ascend above the mark. A third time we sealed up the same oil in the same glass, and repeated the experiment, with like success to that we had the second time; and that the frozen oil was really condensed, we found, because it would sink in oil of the same kind, cold, but unfrozen; and this, notwithstanding divers bubbles, which we observed usually to be made about each lump of congealed oil, that we cast in, upon its beginning to sink in the fluid oil. This we tried, both with oil well congealed (or if another word please better, incrassated or curled) by snow and salt, and with oil less congealed, frozen by the bare cold of the ambient air; but this latter seemed, to fight, to sink more slowly than the other, and being less congealed and ponderous, yet would not lumps of the mass of oil sink or continue immersed. I say, not in common water, but in sack or claret wine; and if thrust down into either of these liquors, they nimbly enough emerged.

6. WHETHER or no chymical oils, though, like expressed oils, they shrink with a moderate degree of cold, would by congelation be, like them, contracted, or like aqueous liquors expanded, we could not satisfy ourselves by ex-

periment, because we were unable to advance cold to a degree capable of bringing such oils to congelation; only we had thoughts to make a trial with oil of aniseeds, distilled with water in a limbeck, in regard, that though it be a very subtle liquor, and, as chymists call it, an *essential* oil; and though in the summer-time, and at some other seasons (if the weather be warm) it will remain fluid; yet in the winter, when the air is cold, it will, if it be well drawn, and genuine, easily enough lose its fluidity; and therefore we thought it might do well to pour some of it, in moderate weather, into a conveniently shaped glass, and then to freeze it externally by the application of ice and salt, that we might observe, whether upon congelation it would shrink or be expanded. And accordingly, though we were not provided with any quantity of this oil, yet in weather, that was not sharp, we did, by the help of some ice, which we procured, when the season made it a rarity, surround a glass pipe filled with fluid oil of aniseeds, and found, though the pipe were but short, yet the inclosed substance, when it had lost its fluidity, had considerably lost of the height, which it reached to before.

7. AND because the empyreumatical oils, that are driven out of the retorts by somewhat violent fires, seemed to be of a nature differing enough from those essential oils (as artists call them) which are drawn in limbecks by the help of water as well as fire; and because we observed, that some of the firmer oils may be used in physick, in much larger doses than it is thought safe to give the latter in: conjecturing from hence, that probably empyreumatical oils may be less hot, and so less indisposed to congelation, we thought fit to make trial (no body else in probability having done it) whether the cold in our climate could be brought to freeze these oils, and whether it would expand or condense them. Wherefore exposing, in conveniently shaped vessels, some good oil of guaiacum, that was diaphanous enough, though very highly coloured, to the greatest cold we could produce; we attempted, but in vain, to deprive it of its fluidity; all that we were able to effect, being to make it very manifestly shrink.

T I T L E. IX.

Experiments in consort, touching the bubbles, from which the levity of ice is supposed to proceed.

1. SINCE the first thing that made the moderns suspect, that water is expanded by freezing, is the floating of ice upon water; it will not be amiss, for confirmation of that argument, to take some notice of the levity of ice in respect of water. This is best observed in great quantities of ice; for whereas in small fragments or plates, the ice, though it sink not to the bottom of the water, will oftentimes sink so low in it, as scarce to leave any part evidently extant above the surface of the water, in vast quantities of ice, that extancy is sometimes so conspicuous, that navigators in their voyages to *Iceland, Greenland,* and other frozen regions,

regions, complain of meeting with lumps, or rather floating rocks of ice, as high as their main-masts. And if we should meet with caves, wherein we might safely suppose the ice to be as solid as entire pieces of ice are wont to be with us, and not to be made up of icy fragments cemented together, with the interception of considerable cavities filled with air, it would not be difficult for any, that understands hydrostaticks, to give a pretty near guess at the height of the extant part, by the help of what we lately observed of the measures of water's expansion, and by the knowledge of the immersed part; which supposing, that the ice were of a prismatical figure, and floated in an erected posture, would, in fresh water, amount to about eight or nine times the length of the part of the prism superiour to the surface of the water.

2. BUT because perhaps the great disparity in the degrees of cold, whereby water is in this, and in those gelid climates turned into ice, may breed a difference in the expansion of the frozen water; and because some other circumstances may be needful to be taken into consideration, about the height of floating ice above water, and these will be more properly taken notice of under the following title; I shall only upon this head (*of the levity of ice*) subjoin the ensuing transcript of one of our notes concerning that subject.

[WE found, that pieces of ice, clear and free, for aught the eye could take notice of, from bubbles, would not be made to sink in spirit of wine once distilled from brandy, and it floated likewise in strong spirit of wine drawn from quick-lime; but if the spirit of wine were well warmed, such ice, as I mentioned, would sink in it, though as it grew cold, the same ice would slowly ascend, and sometimes remain for a while, as if it were suspended without sensibly rising or falling. But all this while the ice, thawed apace in the water, whereinto it was dissolved, did manifestly seem to run down like a stream through the lighter body of the spirit of wine, the diversity of the refractions making this easy to be taken notice of; yet common water, though heated as hot as I could endure to hold the glass in my hand, would not let the fragments of the same parcel of ice sink into it; but in oil of turpentine, and in thrice rectified spirit of wine, the ice would sink like a stone.]

3. THAT the levity of ice, in respect of water, proceeds from the bubbles, that are produced in it, and make the water, when congealed, take up more room than when fluid, has scarce been doubted by any, that has considered the texture of ice, as well as taken notice of its levity. But if this be the true and only reason, we may conjecture, that there must be great store of bubbles in ice, extremely minute, and undiscerned by the naked eye. For though in very many parcels of ice, the bubbles are as well conspicuous as numerous, inasmuch that they render the ice whitish and opacous, yet we have observed, that other pieces would swim, which yet were of an almost crystalline clearness. And therefore we

thought fit to look upon some clear pieces of ice in a microscope, and we shall subjoin the event, because that when we beheld some of this ice in one of our microscopes, which has been counted by several of the curious, as a good a magnifier, as perhaps any is in the world, we could not discover such store of bubbles, as it seemed there should appear upon the supposition, that the adequate cause of the levity and expansion of frozen water is but the interspersion of such bubbles.

THE observations I have been mentioning, I find thus set down among my notes.

[A piece of ice, that to the eye looked clear like crystal, being put into the great microscope, appeared even there free from bubbles; and yet the same piece of ice being presently removed, and cast into common water, would swim at the top, and, if it were forcibly duck'd, would swiftly enough emerge.]

ANOTHER piece of ice, that to the naked eye was not so clear as the former, appeared in the same microscope to have store of bubbles, some of them appearing there no bigger than a small pin's head, and some of them being yet lesser, and scarcely visible in the microscope itself.]

AND here, because it seems a considerable doubt, and well worth the examining, whether or no water, when frozen into ice, grows heavier or lighter, not in reference to such water as it was generated of, (since it is evident, that upon that it will float) but more absolutely speaking, we judged it not amiss to examine this matter by an experiment; but we could not discover any difference between the weight of the same parcel of water fluid and frozen, as will appear by the ninth paragraph of the experiment to be a little beneath recited.

BUT since that, whether or no we allow any other cause, together with the bubbles, to the levity of ice, it seems a thing not to be doubted, that its expansion and lightness is mainly, if not only, due to the interspersion of bubbles; the generation of them seems to be one of the considerablest phenomena of cold, and the investigating by what cause those cavities are produced, and in case they be perfectly full, what substance it is that fills them, is none of the meanest enquiries, that should exercise the industry of a searcher into the nature of cold.

4. Mr. Hobbes, and some others seem to think, that the expansion of water by congelation, is caused by the intrusion of air, which constitutes those numerous bubbles wont to be observed in ice; we might here demand, why in case, that upon freezing there must be a considerable accession of air from without, when oil is frozen, it is, notwithstanding the ingress of this air, not expanded, but condensed: but because these conjecturers do not allow glass to be pervious to common air, we shall at present press them with this experiment, which we have divers times made.

WE took a glass-egg with a long stem, and filling it almost with water, we sealed it hermetically up, to exclude the pretence that some adventitious air might get in, and insinuate

nuate itself into the water, and yet such an egg being exposed to congelation, the frozen water would be manifestly expanded, and swelled by numerous bubbles, which oftentimes gave it a whitish opacity.

To which we may add, that new metalline vessels being filled with water, and carefully stopped, the liquor would nevertheless, when exposed to the cold, be thereby expanded, and turned into ice furnished with bubbles.

5. If it be objected, that in the experiment of the hermetically sealed glass, the produced bubbles might come from the air, which being sealed up together with the water, might, by the expansion of that water, be brought to mingle with it: I answer, that this is very improbable. For 1. if the bubbles must cause the expansion of the water, how shall the water be at first expanded to reduce the air to a division into bubbles? Next, it is evident by the experiments we shall ere long relate, that the air, as to the body of it, retains its station above the water, and preserves itself together in one parcel, since it suffers a compression, that oftentimes makes it break the glass that imprisons it, which it would not need to do, in case it dispersed it self into the body of the water; for then there would appear no cause, why the air and water should after congelation require more room than they did before. 3. In this experiment we usually begin to produce ice and bubbles in the water, contiguous to the bottom of the vessel (that part being by the snow and salt first refrigerated) in which case there appears no reason, why the air, which is a thousand times lighter than the water, should against its nature dive to the bottom of the water: and if it were disposed to dive, why should we not see it break through the water in bubbles, as is usual in other cases, where air penetrates water? 4. In metalline vessels, and in glasses quite filled with water, before they are stopped, there is no pretence of the diving of the air from the top, there having been none left there. 5. And lastly, if all the bubbles of ice were made by, and filled with true air descending from the upper parts of the vessels, and only dispersed through the waters; then, upon the thawing of this ice, the air would emerge, and we might recover as much of the real air as would fill the space acquired by the water upon the account of its being turned into ice, which is contrary to our experience. And this argument may also be urged against any, that should pretend, (for I expect not to see him prove it) that though air, as numerous experiments evince, cannot get out of a sealed glass, yet it may in such a case as this, get into it. But we find upon trials, that the cavities of these bubbles are not any thing near filled with air, if they have in them any more air at all, than that little, which is wont, as we have elsewhere shewn, to lurk in the particles of water, and other liquors. And the making good of this leads us to the second enquiry, we were proposing about these bubbles; namely, whether or no their cavities be filled, and filled with air.

6. THE full resolution of this whole difficulty

would be no easy matter, nor well to be dispatched with so much brevity as my occasions exact. For it would require satisfactory answers to more than one or two questions, since, for aught I know; it may lead us to the debate of those two grand queries; whether or no nature admit a vacuum, and whether a great part of the universe consist of a certain ethereal matter, subtil enough to pass through the pores, not only of liquors; but of compact bodies, and even of glass itself. We should also be obliged to enquire; whether or no air, I mean true and permanent air; can be generated anew, as well out of common water, as many other liquors, and whether it may be generated by cold itself; and perhaps we should be obliged to inquire into the *modus* of this production, and engage ourselves in divers other difficulties; whose full prosecution, besides that they would as much exceed our present leisure, as abilities; seems more properly to belong to the more general part of physicks, where such kind of general questions are fittest to be handled.

WHEREFORE we will now only consider this particular question, whether or no the cavities of the bubbles, wont to abound in ice, be filled with common air; and even this question, though it seem but one, comprizes two: for to resolve it, we must determine, whether there be any true air contained in those cavities, and whether in case there be, they be adequately filled with that air, (by true air I mean such an invisible fluid, as does permanently retain a spring like the common air.).

7. THE former of these two questions, I must confess myself not yet resolved about, my experiments having not hitherto succeeded uniformly enough to satisfy so jealous an observer. But yet I shall annex our trials, not only because the thing has not been, that we know of, so much as attempted by others, and our ways of experimenting, if they be duly prosecuted, seem as promising and hopeful if the question be reducible to any certain decision) as perhaps will be easily lighted on; but because also we have, if we mistake not, resolved the second question, by shewing, that there is but a small part of true air contained in the bubbles of ice, whatever ingenious men, that rely upon probable conjectures, without consulting experience, have been pleased to believe to the contrary.

THAT the bubbles observed in ice cannot all be filled with the aerial particles lurking in the water, seems evident enough by the expansion of the water, and the quantity of space taken up by those bubbles; which how the interspersed, and formerly latent air, can adequately fill, unless the same parcel of matter could truly fill much more space at one time than at another, (which I take to be physically impossible) I do not yet apprehend.

BUT two ways of trial there are, which we employed to shew, that the icy bubbles are nothing near filled with true air, whether men will have that pre-existent in the water, or stolen in from without, or generated anew; the former of the two ways of trials probably arguing, that these bubbles proceed not *only* (for that they may proceed *partly*, we do not

at all deny) from the air pre-existent in the water, and the latter concluding more generally, that but a small part of the icy bubbles are filled with genuine air.

8. AND I. we were invited to conjecture, both, that sometimes, or in some cases, the air latent in the water might contribute to generate icy bubbles, though it was unable adequately to fill them; and again, that sometimes or in other cases such bubbles would be almost as numerously generated, notwithstanding the recess of far the greatest part of that latent air, by the three following experiments taken *verbatim* out of our collections.

I. WE took fair water, and having kept it in the exhausted receiver of our pneumatical engine for a good while, till we perceived it not to send up any more bubbles, we presently transferred it into snow and salt, where it was long enough before it began to freeze; and then we observed, that the water did not swell near so much as common water is wont to do, and the ice seemed to have few or no bubbles worth taking notice of. But when I afterwards placed it between my eye and the vigorous flame of a candle, I could perceive, that it was not quite destitute of bubbles, though they were extremely small, in comparison of those, that would probably have appeared in ordinary water.

THUS far the first experiment; the second follows, which was made at another time.

II. THE water, that had been freed from the bubbles in the receiver, though it afforded an ice, that seemed to have smaller bubbles, yet this ice being thawed, part of the water was gently poured into a pipe of glass, wherein being frozen, it swelled considerably enough above its first level, and besides burst the glass, being also very opacous by reason of the bubbles.

THE third experiment was more industriously prosecuted, as may appear by this ample narrative of it, transcribed out of our Collections.

III. WE took a small egg with a pretty long neck, and pouring in water till it reached an inch within the stem, conveyed it into a long slender cylindrical receiver, provided on purpose to make trials with such tall glasses; the air being by degrees drawn out of the bubbles, appeared from time to time greater and greater, and when the receiver was well exhausted, the water seemed to boil a longer time than one would have expected; and sometimes the bubbles ascended so fast and great, that we were in doubt, whether the water did not boil over the top of the pipe. The exhausted receiver was permitted to be so for a good while, till the water had discharged it self in bubbles of its air, and then the glass-egg was removed into a vessel furnished with ice and salt, and there left ten or twelve hours, that all the water, save that in the neck, might be thoroughly frozen; and then we found it to have risen a great way above its first height: and removing it into an air tempered like that, wherein the first part of the experiment was made, and having left it there in a quiet place for ten or twelve hours to thaw leisurely, (lest too warm an air, or too much stirring the glass, might be an occasion of generating new bubbles,) in the

exterior part of the ice near the glass, we saw pretty store of bubbles; but when that was thawed, the rest of the ice appeared of a peculiar and unusual texture, having no determinate bubbles, that I could easily distinguish, but seeming almost like a piece of frosted glass, where the parts, that made the asperity, were exceeding thick set; but this ice swam in the water, whereinto the rest had been dissolved before it was all thawed. When there yet remained a lump about the bigness of a small walnut, we reconveyed it into the receiver, to try whether, upon the exsuction of the air, the ice would be presently melted; but the alteration produced was so small, if any, that we durst not ground any thing upon it. The receiver being exhausted, there did at length appear some bubbles in the water, but they were not numerous, and a hundred of them seemed not to amount to one of those larger ones, the same water had yielded us the first time it was put in. In the ice also some small bubbles disclosed themselves, which we did not perceive there before; wherefore we took out the egg, and found (the ice being now thawed) that the water was subsided to the mark we had made, before it was exposed to congelation, if not some very little way beneath it. Then we went about to find the proportion, wherein this dispirited water was expanded by glaciation; but in pursuing this, there happened a mischance to the glass, which kept the experiment from being so accurate as we designed. And therefore, though it seemed to us, that it amounted to about the twelfth part, which is less than that of the undispirited water, yet we designed the repetition of the experiment. Only in this we could not be mistaken, that the expansion was considerable, since the water rose three inches and a half in the stem, though the whole water in the egg and stem too weighed but two ounces and a half. If the vessel had not been unluckily cracked, we should have frozen the water once more; and then sealing up the glass hermetically, and suffering the ice leisurely to thaw, should have inverted it, and broken it under water, and have proceeded with it as we had done with some other glasses in the formerly mentioned experiments.

9. [A LITTLE glass cylinder open only at one end, of a convenient length, was thrust into a deep and wide-mouthed glass, about half filled with a mixture of ice and salt: but the cylinder was neither so quite filled, that the water should run over, nor yet far short of being so; that (for all the opacous mixture of ice and salt) we might guess at the freezing of that part of the water, that we could not see by the changes appearing in the other. Then conveying all into a receiver, that we had in readiness beforehand, we quickly pumped out the air, upon which there came, both from the upper and lower parts of the water, great store of bubbles to the top, where most of them brake into a receiver. Having found, upon trials purposely made, that the engine had continued stanch all the while, and perceiving by the intumescence of the superiour parts of the water, that the other were frozen, we let in the external air, and having removed the receiver,

and

and taken out the mixture, before the ice was half melted, we found the water, as high as the mixture reached, to be turned into ice, which, besides some large and conspicuous bubbles, had small ones enough to render it opacous; and upon the account of this expansion it was, that the water did in the free air continue a good deal higher than the mark, it was but level with, when the cylinder was exposed to freeze.]

10. THE other way we employed to examine what was contained in icy bubbles, and which seemed clearly enough to manifest, that they are very far from being filled with true and springy air, is intimated in the last clause of the foregoing narrative, but will be best understood by the annexed experiments, transcribed just as I find them registered in my collections. And though they be prolix, and contain some few particulars, that make not directly for the purpose I alledge them for, yet I think not fit to dismember or to epitomize them, or otherwise to alter any thing in them; partly, that the inference I make from them may be the less mistrusted; partly, because the way of experimenting being altogether new will be best apprehended by the subjoined examples; and partly too, because those particulars, that relate not directly to the occasion of our mentioning these trials, may be useful to illustrate or confirm something, that is already delivered, or is hereafter to be delivered in the present history of cold.

11. [WE took this day a glass of the form of an egg, but of double the capacity, out of whose obtuse end rose up a cylindrical neck, capable to receive the end of my little finger, and no more; this being filled with common water, till the liquor reached a pretty way within the pipe, and the surface of the water being carefully marked on the outside, was placed in a vessel, wherein ice very grossly beaten, was mingled with a convenient proportion of salt, (according to our way of glaciation) the mixture not reaching up to the mark by above an inch. The experiment afforded us these particulars.

I. A HEEDFUL eye did not perceive the water sensibly to subside, before it began to freeze.

II. THE water began to swell, and some parts of it next the side or bottom of the glass, to freeze within a quarter of an hour.

III. THE ascent of the water in the pipe increased so fast, that, within an hour, from the time the glass was put in, it did rise four inches and $\frac{2}{3}$ above the mark; and afterwards the swelling continued so, that we took it out, though a good part of the water remained unfrozen, it had reached five inches and somewhat more than a half above the first mark.

IV. THE ice and salt being purposely kept always beneath the surface of the water, the lower parts of the water were frozen, and never the upper surface.

V. DURING all this great elevation of the water, there appeared no bubbles worth taking notice of in the unfrozen parts of the liquor, but the ice was very full of them, divers of which toward the latter end of the ex-

periment were very large bubbles, (but not all of them round) some being about the bigness of hail-shot, some small like mustard-seed, and others again not much inferiour to little pease.

VI. HAVING taken out the glass, when the water was at the highest mark, we did, upon a certain design, pour in as much faller-oil as swam about two inches above it, and then the glass was nimbly at the flame of a lamp sealed up, during which time the included water subsided a little; but the glass being again put into the ice and salt, the cold quickly restored the water to its former height, and there remained about an inch and half of the sealed glass unpossessed by the two contained liquors.

VII. THEN with a good pair of scales we weighed the glass-egg first in the air, and then in the water, (the better to discern, whether any shrinking of the glass intervened in the case,) where it hung freely, and was left hanging in its æquilibrium with its opposite weight.

VIII. WHILST it thus hung, upon the thawing of the ice many bubbles great and small ascended (the great ones with a wriggling motion) and vanished at the top.

IX. As the ice thawed, the water and oil descended, till the whole ice was returned to water; at which time we observed these two remarkable things; the one, that the æquilibrium remained the same; the other, (which was more considerable) that the water was subsided again as low as the first mark, with which it was level before it began to swell, without falling beneath it, notwithstanding the recess of such a multitude of bubbles, divers of which were very large.

X. THE glass being inverted, the sealed end, which was drawn slender, was gently broken under water, of which some, being impelled in, did sensibly reduce the air at the opposite end into a narrower room; and, as one of the spectators observed, into a much narrower, which is consonant enough to reason.

XI. THE glass being again inverted, and held till it was settled, we found, that the water drawn in together with the water it found there, and the oil, possessed the same places, (as appeared by the marks in the cavity of the receiver,) that they did, when it was sealed up.

XII. AND lastly, having thrown out the oil, and employing, where need was, a little water of the same kind we had made use of all this while, we found the glass filled to the highest mark, to weigh 4374 grains; when it was filled but to the lowest mark, 4152 grains; and when quite emptied, 1032. So that the water contained betwixt the highest and lowest mark; and raised by the glaciation, was about a fifteenth part of the water set to freeze; and probably would have amounted to much more, if the water had been all frozen.

12. [A LARGE glass-egg being taken with a proportionably big stem, we poured water into it, till it reached about an inch above the bottom of the stem, and fastening a mark there, we exposed it all night to freeze in snow and salt; which was so placed, as not to reach so high

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high as the bottom of the stem. The next day about ten of the clock we found the water risen in the stem about 15 inches above the mark, the whole cylinder of water being fluid by reason of the snow's not reaching to it. (Then upon a design, to be elsewhere mentioned, we sealed up the glass by a very slender pipe, that had been before purposely drawn out to a pretty distance from the body of the cylinder, that the glass might be sealed in a trice, before the flame of a candle could sensibly rarify the air, and after a while we broke off the apex of this slender pipe in prosecution of our former design.) Then suffering the water to swell freely, within seven or eight hours it reached the very top of the glass, a drop or two running over at the slender orifice thereof; so that in all, the water ascended about 19 inches above the first mark. Then we tried by the flame of a candle to seal the glass, but by reason of the rarification of some of the water, by the heat, into vapours, by which some of the other water was, from time to time, spurted against the flame of the candle, we found it troublesome enough to seal it up, the vessel being removed into a warm place, till next morning; and all the ice in the belly of it (for the water in the stem continued fluid) being thawed, the water subsided, not only to its first mark, but a little beneath it, by reason of that which was thrown out, upon occasion of the sealing of the glass. But when we came to invert this, after the manner above mentioned, into a vessel of water, to see how much of the space deserted by the thawed ice was filled with air, and how much was filled with a subtiler substance, or empty, just then a mischance frustrated our expectation.]

Decemb.

13. [AN egg about the same bigness with the former was placed to freeze in beaten ice and salt, and in less than an hour, it was risen near an inch above the mark, where the surface of the water was at the first, and the water in the ball and the joining of the neck was frozen into *laminae*. After an hour and a quarter, those *laminae*, that before appeared in the beginning of the neck, now disappeared; but the ball seemed frozen into a white ice, and the water in the neck was risen above the first mark four inches and a half. There now appeared abundance of small bubbles, continually ascending through the neck, (which so continued all the time after, till it was quite thawed) and the white ice appeared full of bubbles. The experiment being further pursued, the water ascended higher and higher, till it had reached about eight inches above the first mark: then the top of the pipe being with a lamp drawn out into a very slender cylinder (for the conveniency of sealing up) the glass was again put into the ice, that the air heated by the lamp might cool; upon which the water continued swelling, till it began to run over at the orifice of the slender pipe, which being held by, in the flame of a candle, was in a trice sealed up; so that the whole glass appeared full of water, bating an inconsiderable quantity of rarified air, (not amounting to the bigness of half a small pea) that remained con-

tiguous to the sealed part. The egg being brought into a warm room, was kept there all night, and a good part of the next morning, before the ice was quite thawed; which when it was, the water was found subsided to the first mark, and which being done, the glass was inverted, and the sealed end immersed a good way under water; where being broken, the external air impelled the water in the basin into the cavity of the pipe, insomuch, that when we took it out, which we did, as soon as we thought no more water was impelled up, re-inverting the glass, we found, that the admitted water reached seven inches above the first mark, and left an inch and an half of the stem, before it began to be wire-drawn, besides as much of the slender part of the stem, as by guess amounted to a quarter of an inch more: so that it seemed, that the bubbles, which made the water swell, and appeared in the ice, amounted to an inch and three quarters of air, which consequently seemed to be for the most part generated by this operation, and to seven inches either of a vacuum, or some subtiler substance, which by its having no spring to resist the pressure of the outward air, appeared not to be air. We could not exactly measure the quantity of water we had in all, and the proportion of it betwixt the marks, because having left the glass in the window, to try whether time or cold would make the admitted water shrink (which we did not find it to do) the weather was too sharp, that beginning (as we concluded) to freeze the water in the stem, the increasing ice burst out the belly of the glass into many pieces.]

Another time.

14. [A sealed glass being broken under water, there was impelled into the cylinder ten inches and a little above a half. And the mark it should have risen to, was eleven inches and a quarter above the first and lowest mark.]

Another time.

15. [IN the same bolt-head, wherein the Decemb. greatest condensation of the air was tried, the water was by the cold made to swell very near a foot above the mark it rested at, when it began to freeze; then the glass being nip'd up, the contained water was removed, and suffered leisurely to thaw, and upon the dissolution of the ice, the water fell back to the former mark. Lastly, the glass being inverted, the apex was broken off under water, and the water in the stem was, by the outward air pressing, upon the water in the basin, with some impetus and noise driven up into the cavity of the glass; and, the glass being seasonably and warily removed from the basin, we found there had been impelled up of the water in the basin, a little more than eleven inches; so that there seemed to be near $\frac{7}{8}$ of an inch of air generated or separated by the former operation.]

Another time.

16. IN the same glass we made the water Decemb. to swell about ten inches, and inverting the stem, 17. and

and breaking the neb under water, we found about ten inches of water to have been impelled into the stem; so that in this there seemed no generation of air.]

17. To all these experiments we shall subjoin, in two words, that as in water, so in some aqueous liquors we found, that the icy bubbles were not filled with air (though we did not think fit to take the pains to measure their respective expansions by being congealed:) for in that elsewhere mentioned experiment, where we exposed milk, urine, and Rhenish-wine to freeze, when all those liquors were risen above their former marks, as is there related, our notes inform us, that the experiment was thus prosecuted.

18. [BEING sealed up (the foregoing words mentioned the above-named expanded liquors) and suffered to thaw, the several liquors subsided to their first marks or thereabouts, and the glasses being inverted and broken under water, we were, by an accident, hindered from observing what we desired in that, which had the wine, though when it was taken out of the freezing pot, it had ice, but not much, swimming in it. But into the glass, that had the milk, the water was manifestly impelled by the outward air; and so it was into the glass, that had the urine, which being removed from the basin, and reinverted, appeared to have as much new liquor in its stem, as amounted by guess to five or six inches.]

19. To which experiment we may add, that another time a sealed glass of partly frozen claret-wine being broken under water, the water was impelled up between half an inch, and an inch above the mark, beyond which it would not have ascended, if the bubbles had been full of true and permanent air.

20. If it be said, that though I have delivered too many particulars about so empty and slight a theme as bubbles, I have this to answer, that possibly all these experiments have rather shewed us, what it is not, that fills them, than what it is; so that more than all these experiments appearing requisite to clear up the difficulties about them, I shall not think I have altogether mis-spent my time, especially if so many past experiments, both new, and not altogether impertinent, by their not having taught us enough about so despicable a subject as a bubble, shall, as they justly may, teach us humility.

T I T L E X.

Experiments about the measure of the expansion and the contraction of liquors by cold.

1. **T**O the experiments (mentioned in the seventh and ninth titles) which shew, that water has an expansion, it will be proper to subjoin some of those, whereby we endeavoured to measure that expansion. And here we shall not content ourselves to say, that whereas the authors we had formerly occasion to point at, take notice of their having raised water in a bolt-head half an inch or an inch by freezing, we have made it ascend a foot and a half and more; this, I say, we shall pass by, be-

V O L. II.

cause that though by such experiments we have very clearly and undeniably manifested the expansion of the water, yet unless the capacity of the vessel be known, they will signify but little towards the determining the quantity of that expansion, which yet is the thing we are enquiring after: wherefore we shall add, that we employed two differing ways to measure this expansion.

2. **T**HE one was, by putting in, by weight, such a number of ounces of water into a bolt-head, till the water was risen a pretty way in the long stem wherewith it was filled; then marking on the outside, to what height every freshly added ounce of water reached in the stem, we afterwards poured out a convenient quantity of the liquor, (yet leaving enough to fill the whole cavity of the spherical or obtuse end of the vessel, and of the lower part of the stem;) then leisurely freezing this remaining water from the bottom upwards, we observed, that when it was frozen, the ice, that was made of 82 parts of water, filled, as one of our notes inform us, the space of 91, and (if I mistake not the character) an eighth; so that by this troublesome way of examination, we found, that the water, by the expansion it received from cold, was made to possess about a ninth part more space than it did before congelation.

[3. In another of our notes, we find as follows, 55 parts of water extended themselves by freezing into 60 and $\frac{1}{2}$, about 6 of those parts remaining unfrozen; so that in this experiment the water's expansion was not much (though somewhat) differing from what it was in that last mentioned.]

4. **T**HE other way we made use of to measure the dimensions, that water gains by freezing, was to take a cylindrical pipe of glass, sealed at one end, and left open at the other; at which we filled it with water to a certain height, that we took notice of, by a mark applied to the outside, and then keeping it in an erected posture, and freezing it from the bottom upwards, we found, that it had acquired by a tenth part, or thereabouts, greater dimensions in the form of ice, than it possessed in the form of water. But the nature of the particular parcel of liquor exposed to the cold, (for it is not necessary, that all waters should be equally disposed to be expanded by freezing) and some other circumstances, not now to be discoursed of, may well beget some little variety in the success of this sort of trials. For in one, that we made carefully, we found the expansion somewhat greater, than that last mentioned, as may appear by the following note; which, compared with what was lately delivered, of the trials we made by weight of the water's expansion, may invite us to think, that we cannot much err by estimating in general, that the room, that ice takes up more than water, amounts to about a ninth part of the space possessed by the same water, before it was turned into ice. The note we were speaking of, is this:

[5. In a more than ordinarily even cylindrical glass, we exposed some water to freeze,

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to

to measure its intumescence, and found, that it expanded itself to about an eighth part, or at least a ninth upon glaciation; this we tried twice, and thought, that the intumescence might have been more considerable, but that in a cylinder the freezing did not seem to succeed so well.]

BUT here we must resolve a difficulty, which, though ordinary readers may take no notice of, yet may breed a scruple in the minds of those, that are acquainted with hydrostatics. For to such readers this account of ours may seem to be contrary to the experience of navigators into cold climates, who tell us (as we shall have occasion to take notice of in due place) of vast pieces of ice, as high, not only as the poops of their ships, but as the masts of them; and yet the depth of these stupendous pieces of ice seems not at all answerable to what it may be supposed to be, in case we compare together the estimate above delivered of the expansion of water, and that grand hydrostatical theorem demonstrated by *Archimedes* and *Stevinus*, 'That floating bodies will so far, and but so far, sink in the liquor, that supports them, till the immersed part of the body be equal to a bulk of water, weighing as much as the whole body.' For Captain *James*, in his often-cited voyage, makes mention of great pieces of ice, that were twice as high as the top-mast-head of his ship.

6. AND the *Hollanders*, in their famous voyage to *Nova Zembla*, mention one stupendous hill of ice; which I therefore take notice of here, not only because it has been thought the greatest, that men have met with, but because they deliver its dimensions, not as Captain *James* and navigators are wont to do, by comparison with the unknown heights of some of the masts of their ships, but by certain and determinate measures, which, in the icy island we are speaking of, were so divided by the surface of the water, that there was 16 fathom extant above it, though there were but 36 beneath it; which, though a vast depth in itself, yet does but little exceed double the height.

Barthol.
de nivis
usu, Cap. 6.
And the Danish navigator *Janus Munckius*, employed by his king to bring him an account of *Greenland*, mentions some floating pieces of ice, that he met with and observed in that sea, which, though but somewhat above 40 fathom under water, were extant 20 fathom, (that is, near half as much) above water; whereas it seems, that, according to our above-mentioned computation of the expansion of water, the part under the water ought to be eight or nine times as deep as that above the water is high.

7. To clear this difficulty, I shall represent these three particulars:

FIRST, that in our computation, the ice, that sinks so deep, is supposed to float in fresh water; whereas, in the observations of the above-named navigators, those vast pieces of ice floated on the sea-water, which by reason of its saltness, being heavier than fresh water, ice will not sink so deep into that, as into this. And that salt may hugely increase the weight

of the water, wherein it is dissolved, may be clearly gathered from the ponderousness of common brine, and from the practice of several sorts of tradesmen, who, to examine the strength of their lixiviums, and other saline liquors, are wont to try, whether they will keep an egg floating, which we know common water will not do. And I have also, by the resolution of some metalline bodies in fit menstruums, made liquors, that are yet much more ponderous, than is sufficient for the support of eggs.

BUT yet we must be so candid, as to take notice of what some modern geographers deliver with probability enough; namely, that nearer the poles the seas are not wont to be so salt, as in the temperate and the torrid zones: and those northern being not so salt as our seas, there is the less to be allowed for the difference in gravity (and consequently in the power to keep ice from sinking) betwixt those seas and ours.

8. BUT secondly, this lesser saltness of the water in the northern seas may, as to our case, be recompensed by the greater coldness of it. For though, as we have formerly observed, the condensation of fresh water, effected here by a degree of cold capable to make it begin to freeze, is not so great as most men would imagine; yet besides that I have often taken pleasure to make the same body to sink or ascend in the same water, by a much less variation of cold than that we have been mentioning; it is to be considered, that the degree of cold, to which water was brought in the experiment delivered in the fourth section, to which we are now looking back, was but such a degree, as would make fresh water begin to freeze: whereas the salt sea-water, being indisposed to congelation, may, by so vehement a cold as reigns in the winter-season in those gelid climates, be far more intensely refrigerated, and thereby more condensed than common water is here, by such a measure of cold, as may begin to freeze small portions of it. But though what we have hitherto represented, may well be looked upon as not inconsiderable to the purpose, for which it has been alledged, yet the main thing, that is to remove the scruple suggested by the height of icy hills above the water, is,

9. THIRDLY, that such hills of ice are not to be looked upon as intire and solid ones, but as vast piles or lumps, and masses of ice, casually and rudely heaped up and cemented by the excessive cold, freezing them together by the intervention of the water, that washes them; which piles of many pieces of ice are not made without great cavities intercepted, and filled only with air, between the more solid cakes or lumps: so that the weight of these stupendous pieces of ice is not to be estimated by the bigness they appear of at a distance from the eye, but considering how much air there is intercepted between the icy bodies, of which they are compiled, there may be a hollow structure of ice reaching high into the air, and yet the whole aggregate or icy pile, will press the subjacent water on which it leans, no more than would

would as much water, as were equal in bulk only to the immerfed parts; as we fee in barges loaden with boards, which, though piled up to a great height above the water, make not the vefsel to fink more than a lading, that would make a far lefs fhew, and oftentimes be all contained within the cavity of the vefsel, provided it be more ponderous *in specie*. But to enter into any further confideration of thefe hydroftatical matters, would be improper in this place, especially fince we have * elfewhere treated of them. And that thefe floating hills and iflands of ice are not intire and folid pieces of it, we fhall otherwhere have occafion to fhew out of navigators, and even in the obfervation we have mentioned out of *Janus Munck*, the learned relator of it. *Bartholinus* takes notice, that thofe vaft pieces of ice (we have been mentioning) that reached 20 fathom above water, were compiled of ftore of fnow frozen together.

* In our Hydroftatical Paradoxes.

Ex nive copiofa glaciata compacta.

10. THESE confiderations may ferve to render fome account of thofe ftupendoufly tall pieces of ice, whofe extant parts bear fo great a proportion to the immerfed part, when the whole mafs does really float. But I confefs I doubt, that not only in the examples we have alledged, but in other eminent ones of mountains of ice, if I may fo call them, there may be a miftake; and that the height of them above the water would be far lefs, and the depth under water far greater, if the ice had water enough to fwim freely. For feamen, by reafon of the difficulty, are not wont to meafure the height of thofe pieces, that float at liberty in the fea. And as for thofe, that are on ground, as their heights lie far more convenient to be meafured, fo the meafurers not knowing how long they have been on ground, for aught I know, much of that admired height may be attributed to the fnows, that from time to time fall very plentifully in thofe frozen regions, and are compacted together, either by the fun, whofe beams fometimes begin to thaw it, and fometimes by the water of the waves that beat againft the ice, and being congealed with the fnow, does as it were cement the parts of it together, and fometimes by both of thefe caufes. So in the instance alledged out of Captain *James*, page 14. of pieces of ice, that were twice as high as his topmastehead; it is faid alfo, that they were on ground in 40 fathom. And in the other example mentioned out of *Bartholinus*, though there be 40 fathom attributed to the immerfed part of the ice, yet that meafure is not exclufive of a greater; for it is faid, that the ice reached downwards above 40 fathom; and how much downwards, and whether as far as the ground, we are left at liberty to guefs. And in that ftupendous piece of ice recorded in the *Nova Zembla* voyage, to have been in all 52 fathom, that is 300 and twelve foot deep, though it be granted what they affirm, that it was 16 fathom above the water, which is almoft a third part of the whole depth; yet I obferve, that of this icy mountain it is faid, that *it lay faft on the ground*. So that as on the one fide it feems probable, that the

upper part of iflands of ice may be increafed by fnow; and, as I remember, that in that famoufly inquifitive navigator Mr. *Hudfon's* voyage for the difcovery of the North-weft paffage, it is related, that his company was * fo well acquainted with the ice, that when night, or foggy or foul weather took them, they would feek out the broadeft iflands of ice, and there come to anchor, and ruin and fport, and fill water that flood on the ice in ponds very fresh and good.' So on the other fide we know not, how much lower the Dutchmen's ice and Captain *James's* would have reached into the fea, in cafe the ground they refted on, had not hindred them. For though one might probably think, that thefe are the greateft depths, that any hills of ice have been obferved to attain, (that mentioned by the *Hollanders* reaching 36 fathom beneath the water, and that mentioned by Captain *James*, no lefs than 40 fathom) yet I find in Mr. *Hudfon's* voyage, that the Englifh, in the bay that bears his name, met with more than one or two iflands of ice, of a far greater depth under water. For among other things, the relator has this memorable paffage; 'In this bay, where we were thus troubled with ice, we faw many of thofe mountains of ice aground, in fix or feven fcore fathom water.' And if the fea had been deep enough, even thefe ftupendous moles of ice would probably have funk much lower, and fo have leffened the heights of the mountains.

* Mr. Hudfon's voyage for the difcovery of the North-weft paffage, written partly by Mr. Atcuck Pricket.

11. I KNOW, that delivering the meafure of the expansion of water alone, I have not faid all, that may be faid about the expansion of liquors; but becaufe, as it has not yet appeared to me, that any liquor is expanded by cold, unlefs by actual freezing; I doubted, whether aqueous liquors, as wine, milk, urine, &c. were otherwife expanded by congelation, than upon the account of the water or phlegmatick (and, in a ftrict fenfe, congealable) part contained in them; and whether it were worth while, for a man in hafte, to examine their particular expansions. Notwithftanding which, I would not difcourage any from trying, whether or no, by the differing dilations or aqueous liquors, fome of them of the fame, and fome of them of differing kinds, we may be affifted to make any eftimate of the differing proportions they contain, of phlegm, and of more fpirituous or ufeul ingredients.

12. AFTER what has been hitherto delivered concerning the expansion of liquors by cold, it may be expected we fhould fay fomething of the meafure of their contraction by the fame quality. But as for water, which is the principal liquor, whofe dimensions are to be confidered, I have formerly declared, that I could feldom or never find its contraction (in the winter feafon when I tried it) to be at all confiderable. And I fhall now add, that having, for greater certainty, procured the experiment to be made by another alfo, in a bolt-head, the account I received of it was, that he could fcarce difcern the water in the ftem to fall beneath its ftation, (marked at the upper part of the pipe;) when the water in the ball was fo far infligridated

dated as to begin to freeze. Though I will not deny, that in warmer climates, as *Italy* or *Spain*, the contraction of the water, a little before glaciation begins, may be somewhat considerable, especially if the experiment be made in summer, or in case (either there or here) the water exposed to freeze be put into a vessel very advantageously shaped, or brought out of some warm chamber or other place, where the heat of the air, that surrounded it, had rarified it. But to examine the measures of contraction in the several liquors, and with the nice observations, that such a work, to be accurately prosecuted, would require, would have taken up much more of my time than I was willing to employ about a work, which I looked not on as important enough to deserve it. And therefore I shall here add nothing to what I have said under the title of the *Degrees of Cold*, touching the contraction of spirit of wine and oil of turpentine, by the differing degrees of that quality; and as for the condensation of air, the vastest fluid we deal with, I did indeed think fit to measure how much cold condenses it. But the account of that experiment will be more opportunely delivered in * one of the following discourses.

* In the
sect. about
the temper-
ature of
the air.

T I T L E X I.

Experiments touching the expansive force of freezing water.

1. **H**AVING shewn, that there is an expansion made of water, and aqueous bodies, by congelation, let us now examine how strong this expansion is, and the rather because no body has yet, that we know of, made any particular trials on purpose to make discoveries in this matter; so that although some unhappy accidents have kept our experiments from being as accurate as we designed, (and as, God assisting, we may hereafter make them) yet at least we shall shew this expansion to be more forcible, than has hitherto been commonly taken notice of, and assist men to make a somewhat less uncertain estimate of the force of it, than they seem to have yet endeavoured to enable themselves to make.

2. AND (1.) we shall mention some experiments, that do in general shew, that the expansion of freezing water is considerably strong.

WE took a new pewter bottle, capable to contain, as we guessed, about half a pint of water, and having filled it top full with that liquor, we screwed on the stopple, and exposed it during a very frosty night, to the cold air; and the next morning the water appeared to have burst the bottle, though its matter were metalline, and though purposely for this trial we had chosen it quite new, the crack appeared to be in the very substance of the pewter. This experiment we repeated; and it was one of those bottles filled with ice, that had cracked it, which a noble virtuoso would needs make me (who should else have scrupled to amuse, with such a trifle, so great a monarch, and so great a virtuoso) bring to his Majesty, to satisfy him, by the wideness of the crack, and the protuberance of the ice, that shewed it self in

it, that the water had been really expanded by congelation.

3. We also tried, whether or no a much smaller quantity of water would not, if frozen, have the like effect; and accordingly, filling with about an ounce of water a skrewed pewter box (such as many use to keep treacle and salves in) quite new, and of a considerable thickness, we found, that upon the freezing of the included water, the vessel was very much burst.

AFTERWARDS filling a quart bottle (if I mistake not the capacity) with a congealable liquor, and tying down the cork very hard with strong packthread, we found, that the frost made the liquor force out the stopple, in spite of all the care we had taken to keep it down.

BUT afterwards we so well fastened a cork to the neck of a quart bottle of glass, that it was easier for the congealing liquor to break the vessel, than to thrust out the stopple; and having for a great many hours exposed this to an exceeding sharp air, we found at length the bottle burst, although it were so thick and strong, that we were invited to measure the breadth of the sides, and found that the thinnest place, where it was broken by the ice, was $\frac{1}{4}$ of an inch, and the thickest $\frac{3}{8}$, that is, twice as much: we also by the help of the frost broke an earthen bottle of strong *Flanders* metal, of which the thinnest part, that was broken, was equal, by measure, to the thinnest part of the other.

4. BUT the above mentioned instances serving only to declare in general, that the expansion of water by cold is very forcible, I thought fit to attempt the reducing of the matter somewhat nearer an estimate less remote from being determinate; and because the water exposed to congelation may be probably supposed to be homogeneous, we judged, that the quantity of it, may very much vary its degree of force; and because some may suspect, that the figure also may not be inconsiderable in this matter, we thought fit to make our trials in a brass vessel, whose cavity was cylindrical, and which, to make it stronger, had an orifice but at one of its ends; and whose thickness was such, that we had reason to expect, that whilst the top remained covered, but with a reasonable weight, the included water would find it more easy to lift up that weight, than break the sides. To this cylinder we fitted a cover of the same metal that was flat, and went a little way into the cavity, leaning also upon the edges of the sides for the more closer stopping of the orifice: the cavity of this cylinder was in length about five inches, and in breadth about an inch and three quarters. This cylinder being filled top-full with water, and the cover being carefully put on, was fastened into an iron frame, that held it erected, and allowed us to place an iron weight, amounting to 56 pound, or half a hundred of common English weight; which circumstance I mention (because the common hundred, that our carriers, &c. use, exceeds five score by twelve.) But this vessel being exposed in a frosty night to the cold air, the contained water did not the next morning appear to be frozen, and the trial

trial was another time that way repeated with no better success, as if either the thickness or clearness of the metal had broken the violence of the external air's frigeactive power, or the weight, that oppressed the cover, had hindered that expansion of the water, which is wont to accompany its glaciation.

WHEREFORE we thought it requisite to apply to the outside of the vessel a mixture of salt, with ice or snow, as that, which we had observed to introduce a higher degree of cold than the air alone, even in very frosty nights; and though this way it self, the glaciation proceeded very slowly, and sometimes scarce at all, yet at length we found, that the water was by this means brought so far to freeze, that on the morrow the ice had on one side swelled above the top of the cylinder, and by lifting the cover on that side, had thrown down the incumbent weight; but in this trial the cover having been uniformly, or every where lifted up above the upper orifice of the cylinder, we repeated the experiment divers times, as we could get opportunity, sometimes with success, and sometimes without it; and of one of the chief of our experiments of this sort, we find the following account among our collections.

5. [THE hollow brass weight, being about one inch and three quarters in diameter, and the brass cover put on, was loaded with a weight of 56 pound upon the cover and exposed to an excessively sharp night: the next morning the cover and the weight were found visibly lifted up, though not above (that we could discern) a small barley-corn's breadth, but the thickness of the brass cover was not here estimated, which was much less than half an inch, which, according to former observations, one might expect to see the ice ascend. But that, which we took particular notice of, was, that the inclosed cylinder of ice, being by a gentle thaw of the superficial parts taken out, appeared so full of bubbles, as to be thereby made opacous. Also when in the morning the cylinder was brought into my chamber, before the fire was made, the 56 pound weight being newly taken off, at a little hole, that seemed to be between the edge of the brass and ice, there came out a great many drops of water, dilated into numerous bubbles, and reduced in a kind of froth, as if upon the removal of the oppressing weight the bubbles of the water had got liberty to expand themselves; but this lasted but a little while.]

6. AFTER this the difficulty we have often met with in the placing of great weights conveniently upon the cover of a cylinder, and the expectation we had to find the quantity of the water we made use of, capable, upon its congelation, to lift up a much greater weight, invited us to make trial of its expansive force, by somewhat a differing way; which was, to fit a wooden plug to the cavity of the cylinder, (after we had suffered it to soak a convenient time in water, that, swelling as much as it would before, it might be made to swell no more by the water, which would lie contiguous to it in the vessel) and then to

drive it forcibly in, till by considerable weights appended to the extant part of the plug, when the cylinder was inverted, we could not draw it out. The success of one of these trials is thus set down in our collections:

7. [A PLUG was driven into the cavity of a brass cylinder, first filled with water, the plug being also well soaked; then the cylinder being inverted, the plug took up half a hundred and a quarter of a hundred weight, and would possibly have taken up much more, and being exposed to a very sharp night, the freezing water thrust out the plug about a barley-corn's breadth, quite round above the upper edge of the cylinder; and it freezing all that day and the next night, it was again exposed, the plug not being yet taken out, and then the plug was beaten out a little more, namely, (in all) near a quarter of an inch.]

8. THUS we see, that the expansive endeavour of the water forced a resistance, at least equal to that, which would have been made by a weight of 74 pound; and probably, as the note intimates, would have appeared able to do more, if we had had convenient weights and instruments, wherewith to have measured the strength of the water's endeavour outwards, which some subsequent trials made us think very considerable; though not finding their events set down in our notes, we think it fit at present to leave them unmentioned.

BUT one thing there is in these trials, that I think not unworthy a philosopher's notice, and his considering; namely, that this endeavour of the water to expand it self is thus vigorous, though the uttermost term, to which it would expand it self, in case it were not at all resisted, would be but to about a ninth, or at most an eighth part of the space it possess before it began to freeze, whereas air may by heat (which *yet,* New Ex-periment's we have elsewhere shewn, will not reduce it Physico-mech. Ex-per. 6. to any thing near its utmost expansion) be brought to possess (though not to fill) according to the diligent † *Merfennus's* observation, seventy times the dimensions it had before See the fore-cited place. rarefaction; and consequently the air expanded by heat does by its endeavours tend to acquire above 60 times the space, that the water does, when expanded by so high a degree of cold, as is capable to turn it all into ice: not to mention, that the expansion, to which the air tends upon the account of its own spring, is, (as we shew in another † place) many times † The Appendix to the Physico-mechanical Experiments. greater than that, to which *Merfennus* could bring it upon the bare account of heat.

9. THERE remains yet one way, whereby we hoped, though not to measure the expansive force of freezing water, yet to manifest it to be prodigiously great; or in case we failed of this aim, to produce at least some other phænomena relating to cold, that would not be inconsiderable. And though our endeavours succeeded not, yet because a happier opportunity may bring them to be one way or other successful, we shall annex, that we caused to be made an iron ball of between two and three inches diameter; which ball was solid, save that in the midst there was a small cavity left to place a little water in, together with a female screw,

as they call it, reaching from the outward surface of that internal cavity; and to this was applied a strong iron screw, so fitted to the internal cavity of the other screw, as to fill it with as much exactness as could be obtained. And this screw was made to go so hard, that it required to be screwed in by the help of a vice, that it might not be forced out, without breaking the iron itself. Our design in imploing this instrument was, that having well filled the internal cavity with water, and forced in the screw as far as it could be made to go, the instrument thus charged with water might be exposed to the highest degree of cold we could produce. For having thus ordered the matter, we thought we might expect, either that the water, how much soever we heightened and lengthened the cold, would not freeze at all, being hindered from the expansion belonging to ice in comparison of water; or, if it did freeze, that one of these two things would happen, either that the expansive force of that little water would, by forcing such an iron instrument, manifest its strength to be stupendous; or, by not breaking it, present us with ice without bubbles, or at least not rarer and lighter, than the water it was made of: but for want of a sufficient cold, our designs succeeded not, so as to satisfy us, though we more than once attempted it. For the great thickness of the iron being considered, we were not sure, that the waters not freezing might not proceed rather from the thickness and compactness of the metal, than from its resistance to the expansion of water. And therefore we must suspend the inferences, this experiment may afford us, till we have opportunity to make trial of it, with a cold not only very intense, but durable enough; the want of which last circumstance keeps us from daring to build any thing on our experiment.

10. AND here we may take notice, that it may be an inquiry, more worthy a philosopher, than easy for him, whence this prodigious force, we have observed in water, expanded by glaciation, should proceed. For if cold be but, as the Cartesians would have, a privation of heat, though by the recess of that ethereal substance, which agitated the little eel-like particles of the water, and thereby made them compose a fluid body; it may easily enough be conceived, that they should remain rigid in the postures, wherein the ethereal substance quitted them, and thereby compose an unfluid body like ice: yet how these little eels should by that recess acquire as strong an endeavour outwards, as if they were so many little springs, and expand themselves too with so stupendous a force, is that, which does not so readily appear. And on the other side, in the Epicurean way of explicating cold, though the phenomenon seems somewhat less difficult, yet it is not at all easy to be solved: for though, granting the ingress of swarms of cold corpuscles, the body of water may be supposed to be thereby much swelled and expanded, yet besides that these corpuscles, stealing insensibly into the liquors they insinuate themselves into, without any shew of boisterousness or violence, it is

not so easy to conceive, how they should display so strange a force against the sides of those strong vessels, that they break, when they may as freely permeate or enter them: besides this, I say, we observe, that in oil, which requires a far greater degree of cold to be congealed to a good degree of hardness, the swarms of frigorifick atoms, that invade it, are so far from making it take up more room than before, that they reduce it into less, as may appear by those former experiments, which manifested, that cold does not expand, either oil or uncongealable liquors, but condense them.

11. AFTER what I have thus largely delivered, concerning the expansive endeavour of freezing water, I hope I may be allowed to leave to others (if they shall think it worth the labour) the prosecution of the like experiments upon wine, milk, urine, and other liquors abounding with aqueous parts; concerning which, we shall only in general remind those, that may have forgotten it, that by some of our experiments it appears, that such aqueous liquors are expanded by congelation, and that their endeavour outward is considerably forcible, seems more than likely from what we formerly noted out of the Dutch voyage to *Nova Zembla*, where it is related, that by the extreme cold, both some of their other barrels, and some of those that were hooped with iron, were, as they speak, frozen in pieces; that is, according to our conjecture, burst together with the hoops, whether of wood or iron, by the expansive force of the imprisoned liquors brought to freeze.

12. To which I shall add, that when I asked an ingenious person, whether in *Russia*, where he lived a good while, beer and wine did not, when brought to congelation, break the vessels they were frozen in; he answered, that he had not observed wooden vessels to have been broken by them, (perhaps because of their yielding) but glass and stone bottles often.

TITLE XII.

Experiments touching a new way of estimating the expansive force of congelation, and of highly compressing air without engines.

1. THERE is yet another way, that I bethought my self of, at once to measure the force, wherewith freezing water expands it self, and to reduce the air to a greater degree of condensation, than I have as yet found it brought to by any unquestionable way of compressing it. But whereas by this method, to determine exactly the expansive force of the water, it were requisite not only to know the quantity of the water, and that of the air exposed to the cold, but to make the experiment in vessels conveniently shaped to measure the dilatation of the one, and the compression of the other; our experiments being made in a place, where we were not provided of such glasses, we were not able to make our trials so instructive and satisfactory, as else we might have done. Nevertheless, we shall not scruple to subjoin those of them, that we find noted down among our collections, allowing our selves to hope, that will

will not be unacceptable or appear impertinent, not only upon the account of their novelty, but for two other reasons,

2. THE first, because though they do not accurately define the expansive force of freezing water, yet they manifest, that it is wonderfully great, better perhaps than any experiment, that has been hitherto practised, (not, to say, thought of;) as may appear by comparing what we have delivered in another treatise, of the great force requisite to compress air considerably, with the great compression of air, that has already been this way effected.

3. THE second, because this new way affords us one of condensing the air much farther than hitherto it has, by any method I have heard of, been unquestionably reduced; I say, unquestionably, because though the diligent *Mersennus*, and others, seem to have conceived himself to have reduced it in the wind-gun into a very narrow room; yet besides that, by our expedient, we have compressed it beyond what these ingenious men pretend to; besides this, I say, I have long much questioned, whether the way of compressing air in a wind-gun, which both they and we have employed, may safely be relied on. For the oil or some other analogous thing, that is wont this way to be employed, and the overlooking of several circumstances, that are more necessary to be taken into diligent consideration, than wont to be so, may easily enough occasion no small mistake in assigning so great a degree to the compression of the air; but our exceptions against this way of measuring it may be more opportunely discoursed of in another place. And therefore we will now proceed to take notice, that of the two known ways of compressing air, the clearest and most satisfactory seems to be that, which is performed in the wind-fountain, as it is commonly called, where yet I have seldom, if ever, seen the air, (that I remember) by all the violence men could use to syringe in water, crowded into so little as the third part of the capacity of the vessel. And an ingenious artificer, that makes store of these fountains, being consulted by me, about the further compressing of air in them, he deterred me from venturing to try it, by affirming to me, that both he and another skilful person of my acquaintance had like to have been spoiled by such attempts: for endeavouring to urge the air beyond a moderate degree of compression, it not only burst some fountains made of glass, but when the attempt was made in a large, but thick vessel, made of strong and compact *Flanders* earth (the same with that of jugs and stone bottles) the vessel was, by the over-bent spring of the air, burst with a horrid noise, and the pieces thrown off with that violence, that if they had hit him, or his friend, that assisted him in the experiment, they might have maimed him, if not killed him out-right. So that the greatest unquestionable compression of the air seems to have been that, recorded in the fifth chapter of our defence against the learned *Linus*, where, nevertheless, we could reduce the air by the weight of a cylinder of mercury of about 100 inches,

(which consequently might near countervail a cylinder of sixscore foot of water) but into a little less than a fourth part of its usual extent; but how much further the air may be compressed by our new purposed way, it is now time to shew by the ensuing notes, of which we have not omitted any, that we could find, both that some scruples, which might else arise about the way we employed, may be prevented or satisfied; and that the way, we employed in practising this method, might by some variety of examples be the better understood.

[4. WE took a large glass-egg, with a cylindrical stem about the bigness of my little finger, ^{December} 13. and pouring in water, till it reached about a finger's breadth higher than the bottom of the stem, we set it to freeze in snow and salt, for some hours, with the stop of the stem (which was drawn out into a very slender pipe, almost at right angles with the stem) open, and there left it for some hours, and the water was risen betwixt six and a half, and seven inches. This we did in order to another experiment; but then easily and nimbly sealing up the slender pipe above-mentioned, that the air in the stem might not be heated, we let it continue in the snow some time, adding fresh for about 24 hours, to observe to what degree the water, by expanding itself, would compress the imprisoned air. The length of the cylinder of air to be condensed at the time of the sealing, was (accounting by estimation for the slender pipe newly taken-notice of) almost $9\frac{1}{2}$ inches. This space we observed the ascending water, as the ice increased below, to invade by degrees; (for we watched it, and measured it from time to time :) so much, till at length the water reached to 8 inches and $\frac{7}{8}$ almost, above the station (which we had carefully marked with a diamond) in which we found it, when the glass was sealed up, leaving but about an inch of air at the top; so that of the whole space before possessed by the air, the water had intruded into near nine parts of ten. Then being partly apprehensive the glass would hold no longer, but have its upper part blown off, as it happened to us a little before with another vessel, and partly being desirous to try that which follows, we leisurely inverted the glass, that the air might get up to the ice; for all the water in the stem had been purposely kept unfrozen: and having provided a jar to receive the water, that should be thrown out, we broke the slender pipe, which we had sealed up, and immediately, as we expected, the compressed air, with violence and noise, blew out of the stem into the jar about ten inches of water; which was somewhat more (between half an inch and a whole inch, by reason of the *impetus* of the self-expanding air) than the space possessed by the air, before it began to be compressed. And besides this, such a strange multitude of bubbles, that were formerly repressed, did now get liberty to ascend from the lower parts of the glass to the top of the remaining water, that it somewhat emulated that, which happens to bottled beer; upon the taking out of the cork, *N.B.* when the air was compressed

compressed beyond seven inches, we observed divers times, that the inside of the glass possessed by the air, and nearest to the water, was round about, to a pretty height, full of very little drops like a small dew; but when we came to break the glass, we took no such notice, whether the rising water had licked them up, or their concourse made them run down into it, or for some other reason, we determine not.]

Another.

December
13.

[5. WE took a single phial filled with water, about half an inch above the lower part of the neck, and leaving about two inches of air in the remaining part of the neck, which was drawn out in a slender pipe, like that of the glass last mentioned, we sealed it up, the air being first well cooled; and exposing it to freeze, we observed a while after, that it had by guess condensed the air into lesser room. A while after, being in another chamber, we heard a considerable noise, and imagining what it was, we went directly to the glass, whose upper part consisting of about an inch of the neck, besides the slender pipe, we found had been blown off from the table upon the ground, the body and part of the neck remaining in the snow; but this glass was of a metal, that uses to be more brittle than white glass.

Another.

[6. A ROUND white glass, almost filled with water, was sealed up with care, to avoid heating the included air, which amounted to a cylinder of about 2 inches and $\frac{2}{3}$; after a while the water swelled and compressed the air almost two inches, that is, full two thirds: and then (as we conjectured, because the snow reaching too high, froze it in the neck) we found the glass cracked in many places of the ball, and the top thrown off at some little distance from it.]

Another.

[7. A LARGE single phial sealed, in whose neck the air was not condensed to half its former room, just as we were going to break it under water, to observe the fall of the compressed air, suddenly blew off with a good noise, and threw from the table almost the whole neck of the phial in one intire piece, which is near four inches long, and at the basis above an inch broad.]

[8. A GLASS about the bigness of a turkey-egg, and of an oval form, with a neck almost cylindrical, but somewhat wider at the lower than the upper part, was filled with water, till there was left in the neck four inches and a half; whereof the last quarter of an inch, and a little more, was much narrower than the rest, being drawn into a conical shape, that it might be easily sealed at the apex; along this cylinder, from the surface of the water to the top of the glass, was pasted a list of paper, divided into inches and quarters: and then the glass being carefully and expeditiously sealed up by the flame of a candle, we observed, that by holding the glass a while in a warm hand, and a room, where there was a good fire, the

water was swelled up near a quarter of an inch; but placing the glass amongst solid pieces of ice mixt with salt, the water quickly began to subside upon the infrigidation; and a while after beginning to freeze, it began to swell, and by degrees compressed the air, till it had crouded it into less than a 17th part, by what seemed indisputable; for by estimate, it seemed to some to be crouded into less than a 20th part, if not a much lesser part, of the room it formerly possessed. Which difference of estimates, notwithstanding the divided paper, proceeded from the change of the figure of the upper end of the glass, from the cylindrical, and to shew that there was no leak at the place where the glass was sealed; besides that by prying diligently, we could discern none; besides this, I say, when the pressure of the thus crouded air grew too strong for the resistance of the glass, it burst with a noise, that made us come to it from several places of the house. The vessel broke not in the cylindrical part (as I may so speak) but in the oval, the whole pipe with the sealed end remaining entire; the ice appeared full enough of bubbles, which made it white and opacous, and the water, that had ascended into the neck, upon the breaking was all driven out of it.

THUS far our collections; but because we had in another glass, where the operation was sooner dispatched, an opportunity of watching and observing somewhat more exactly, we will add,

9. THAT the last, and possibly the best experiment we had of compressing air by freezing, was made in a short and strong glass-egg, whose ball was very great in proportion to the stem, that the expanding of the water might have the more forcible operation. This vessel being exactly sealed, and having a divided list of paper pasted along the stem, was set to freeze with snow (or ice) and salt, and the contained water did quickly begin to croud the air into a lesser room, and for a good while ascended very fast; till at length it having thrust the air into so small a part of the cavity of the pipe, that we vehemently suspected there might be some unheeded flaw or crack of the glass, at which the air had stolen out, we drew near the vessel, and attentively prying all about it, to try, if we could discover any ground of our suspicion, we found (as far as the divided list, and other circumstances could inform us) that the air (supposing none of it to have got away) was reduced by our estimate into the 19th part of the space it possessed before. And this our curiosity proved not unseasonable; for whilst we were narrowly surveying the glass, to spy out some flaw in it, we were quickly satisfied there had been none, by a huge crack made upon the eruption of the included air, whose spring being, by so great a compression, made too strong for the glass to resist, it did with a great noise break the ball of the glass into many pieces, throwing the unfrozen part of the water upon me, and also throwing off the stem of the egg, which yet I had the good fortune to recover intire, and which I yet keep by me as a rarity.

10. THUS

10. THUS far we then proceeded in compressing the air, which being done in vessels hermetically sealed, where no air can get in or out, seems to me a more unexceptionable way than those, that have hitherto been thought of. But further, we could not then prosecute it for want both of convenient glasses, and of ice or snow, of which if we were provided, and particularly of strong glasses, we should little doubt of reducing the air to a yet more considerable degree of compression.

11. WE may add on this occasion, that we looked upon the same way, as somewhat less unpromising than others, that have been hitherto used to try the compression of water: for though hitherto neither the experiments of ingenious men, nor those made by our selves, have fully satisfied us, that water admits any more compression, than it may suffer upon the account of the little parcels of air, that are wont to be dispersed among it; yet the unsuccessfulness may perhaps (for I propose it but as a mere conjecture) be imputed to the porosity of the vessels; wherein, by the ways already practised, the experiment must be made: whereas in this new way of ours, not only the force, wherewith the compressed air presses upon the water, grows at length to be exceeding great, and is applied not with a sudden impetus, as when a pewter vessel is knocked with a hammer, but by slow and regular degrees of increase; but the water is kept in a vessel impervious to its subtlest parts, so that it may indeed crack the glass, but cannot get out at the pores, as the water compressed is wont to do at those of metalline vessels. The prosecution of this experiment, to bring it to any thing of accurateness, we omitted, partly through forgetfulness and avocations, and sometimes for want of conveniency to try it. But by the first of the lately mentioned experiments, about the condensation of air, it seems by the strong multitude of bubbles, which upon the breaking of the glass appeared in the water, that had been compressed betwixt air and the ice, that those two bodies had very violently compressed it. And this we are the more apt to believe, because that another time, when we had sealed up some air and water in a glass-egg, and permitted the water to swell by the operation of the cold, but till it had reduced the air, included with it, to about three quarters of the space it posselt before; even then (I say) to try, whether the subjacent water were not also compressed by the air it urged, we broke off the sealed apex of the glass, and perceived, as we expected, the water to ascend, and that to the height of a quarter of an inch, as we found by measure. But such trials having not been, as we just now acknowledged, duly prosecuted, we shall at present content our selves to have named this way of attempting the compression of water, without grounding any inferences upon it.

TIT L E XIII.

Experiments and observations touching the sphere of activity of cold.

1. **T**HE sphere of activity of cold, or, to speak plainer, the space, to whose ex-

tremities every way the action of a cold body is able to reach, is a thing very well worth the enquiring after, but more difficult to find, than at first one would imagine. For to be able to assign the determinate limits, within which, and not beyond them, a cold body can operate, several things are to be taken into consideration: as first, what the degree of cold is, that belongs to the assigned body. For it seems rational to conceive, that if a cold body, as such, have a diffusive virtue, those, that have greater degrees of cold, as ice and snow, will be able to diffuse it to a greater distance, as we see, that a coal of fire will cast a sensible heat much further than a piece of wood, that is heated without being kindled. Secondly, the medium, through which the diffusion is made, may help to enlarge the bounds, or straighten the limits of it, as that medium is more or less disposed to receive or to transmit the action of the cold agent. Thirdly, Not only the consistence, and texture of the medium, but its motion, or rest, may be considered in this case. For in frosty and snowy weather, men observe the winds, that come from frozen lands, to blow more cold, than winds from the same quarter would do, in case there were no ice nor snow in their passage. Fourthly, There may be made very differing estimates of the diffusion of cold, according to the instrument, that is employed to receive, and acquaint us with the action of cold. For a liquor or other body may not appear cold to him, that examines it with a weather-glass, whilst he shall feel it cold with his hand; and as we elsewhere also note, to that sensory it self, as it is variously disposed, the same object will seem more or less cold; so much may the predisposition of the organ impose upon the unskilful or unwary. Fifthly, The very bulk of a cold body may very much enlarge or lessen its sphere of activity, as we may have occasion to shew ere long. And besides, there may be divers other things, that may render it very difficult to ascertain any thing in this matter. And therefore I shall reserve them for other opportunities, and observe now in general, that in such small parcels of ice itself, as in our experiments we are wont to deal with, we have found the sphere of activity of cold exceeding narrow, not only in comparison of that of heat in fire, but in comparison of the atmosphere, if I may so call it, of many odorous bodies; as musk, civet, spices, roses, wormwood, assa dulcis, assa foetida, castoreum, camphire, and the like; nay, and even in comparison of the sphere of activity of the more vigorous loadstones: insomuch that we have doubted, whether the sense could discern a cold body, otherwise than by immediate contact.

2. **A**ND to examine this, having taken a piece of ice, we did not find upon trials, that I partly made my self, and partly caused in my presence to be made by others, that if a man's eyes were close shut, he could certainly discern the approach of a moderately-sized piece of ice, though held never so near his fingers ends. Nay, which is more considerable, having had the curiosity to make the trial, with one of those very sensible thermoscopes I have

formerly mentioned (wherein a pendulous drop of liquor plays up and down in a slender pipe) I found, that by holding it very near to little masses of snow (somewhat compacted too) the moveable drop did not betray any manifest operation of so cold a neighbouring body; but if the glass were made to touch the snow, the effect would then be notable, by the hasty descent of the pendulous drop, or its motion towards the obtuse part of the instrument, in case that were not perpendicularly, but laterally applied to the snowy lumps. But this languidness of operation may perhaps proceed in great part from the smallness of the pieces of ice, that were employed; for hearing of a merchant, that had made divers observations about cold in *Greenland*, I desired, by the mediation of a very learned friend, to be informed, whether or no in the night they could perceive those vast heaps, or rather mountains of ice, that are wont to float up and down in that sea, by any new and manifest accession of cold, and was informed by way of answer to that question, that being at sea, they could know the approach of ice, as well by the increase of cold, as by the glaring light which the air seemed to receive from the neighbouring ice.

3. BUT that, which makes me suspect, that there may in this account be some mistake, is, that I have not yet met with any like observation in any of the voyages into gelid climates, that I have had occasion to peruse, though in some of them the navigators frequently mention their having met with vast raunds (as some call them) and islands of mountainous ice in the night. And it is, as I remember, the complaint of one or two, if not more of them, that the ship lay close by such vast pieces of ice, without their being aware of it, by reason of the fogs. By which it seems, that there was no sensible cold diffused to any considerable distance, whereby they might be advertised of the unwelcome neighbourhood even of so much ice, but possibly the approach of far smaller masses of ice would have been sensible to them in such a climate as ours, where the organs would not have been indisposed to feel, by a long accustomedness, any thing of near so intense a degree of cold, as that which then reigned in those northern seas.

4. WHILST we were considering the difference betwixt the operations of even the coldest bodies at the very nearest distance, and upon immediate contact, we thought it an experiment not altogether unworthy to be tried, whether, though ice and snow alone, that is, unassisted by salts, would not in some of our formerly mentioned experiments freeze water, through the thickness even of a thin glass, they may not yet do it when the water is immediately contiguous to them. And I remember, that we took a conveniently shaped glass, and having frozen the contained water for some hours, from the bottom upwards, till the ice was grown to be of a considerable thickness, we marked what part of the glass was possessed by the unfrozen water; and then removing the vessel to a little distance from the snow, and salt, it stood in before we let it rest

there, to try whether the ice would freeze any part of the contiguous and incumbent water; but some intervening accidents hindered us from being able to derive any great satisfaction one way or other from our trial.

5. WHEREFORE we shall add, by way of compensation, that the diligent *Olearius* relates, that at *Isfahan*, the capital city of *Persia*, though it be seated in a very hot climate, and though it seldom freeze there above a finger thick, and the ice melt presently at sun-rising, yet the inhabitants have conservatories, which they furnish with solid pieces of ice of a good thickness, only by pouring at night great store of water, at convenient intervals of time, upon a shelving floor of free-stone or marble; whereon, as the water runs over it, the most disposed of its parts are in their passage arrested, and frozen by the contiguous ice, which by this means (says my learned author) may be brought in two or three successive nights to a very considerable thickness.

6. WE several times gave order to have this experiment tried in *England*; but partly through the negligence of those we employed, and partly upon the score of intervening circumstances, our expectation was but ill answered. And in this case I mention *intervening circumstances*, because having caused a servant to pump in the night, upon a not very thin plate of ice, that was laid shelving upon a board, and another flat piece of ice being about the same time laid under a place, where water derived from a neighbouring spring is wont continually to drop, he brought me word, that not only in this last named place, the ice melted away, but that under the pump, instead of increasing in thickness by the water's running over it, it was thereby rather dissolved. At which somewhat wondering, I went in the morning myself to the pump, and causing a good piece of ice to be in a convenient posture placed under it, I observed the water, as it came out of the pump, and was falling on the ice, to smook, as if the depth of the well had made the water, though very cold to the touch, somewhat warm in comparison of the ice, and thereby fitter to dissolve than to increase it; (which inconvenience may be prevented by suffering the water of deep springs and wells to stand to cool in the air, before it be put to the ice :) and this, though the neighbouring air were, as I found by manifest proofs, so cold, that I was not tempted to impute the unsuccessfulness of the experiment, rather to its want of a sufficient coldness, than the water's. So that till I have an opportunity of making a further trial, I cannot say more to the *Persian* way of augmenting ice. But to proceed: Our having met with but an unsatisfactory account of this experiment, which we were the more troubled at, because this seemed a promising way of trying that, which otherwise is not so easily reduced to experiment; for the temperature of the air must be seriously considered in assigning the cause of divers trials, that may be made for the resolving of the same question: For to omit other examples, here in *England* we find, that water poured on snow is wont

to hasten the dissolution of it, and not to be congealed by it; whereas having inquired of an ingenious person, that lived a good while among the *Russians*, he informed me, that it was their usual way to turn water and snow into ice, by pouring a convenient proportion of that liquor into a great quantity of snow: and having also inquired, whether ice had not the like operation, he told me, that it was usual, and he had seen it practised in *Muscovy*, to cement ice to buildings, and other things, and also to case over bodies, as it were, with ice, by gradually throwing water upon them. But I doubt, whether that effect be to be ascribed barely to the contiguity of the ice, because I learned of him, that this way of increasing ice is practised in very frosty weather, when water thinly spread upon almost any other body would be frozen by the vehement sharpness of the air.

7. THE glaciations, that nature unguarded by art is wont to make, beginning at those parts of bodies, at which they are exposed to the air; it usually happens, that they freeze from the upper towards the lower parts. But how far in earth and water (the most considerable bodies, that are subject to be frozen) the frost will pierce downwards, though, for some hints it would afford, worth the knowing, is not easy to be defined; because the deepness of the frost may be much varied by the degree of coldness in the air, by which the glaciation seems to be produced, as also by the greater or lesser duration of the frost, by the looser or closer texture of the earth, by the nature of the juices, wherewith the earth is imbued, and by the constitution of the subjacent and more internal parts of the earth, some of which send up either actually warm, or potentially hot and resolving steams, such as those, that make corrosive liquors in the bowels of the earth; so that the frost will not seize upon, or at least cannot continue over mines. And I have seen good large scopes of land, where vast quantities of good lime-stone lay near the surface of the earth, on which I have been assured by the inhabitants, that the snow will not lie. There are divers other things, that may vary the depth, to which the frost can penetrate into the ground, (I say, into the ground, because in most cases it will pierce deeper into the water;) but yet, that we may not leave this part of the *History of Cold* altogether uncontributed to, we will add some of our notes, whereby it will appear, that in our climate the frost pierces far less into the ground, than many are pleased to think.

8. THE notes I find about this matter are these that follow, which I transcribed unaltered, because it were tedious, and not worth while to add the way we employed, and the cautions we used in making the observations; but we shall rather intimate, that the following trials were made in a village about two miles from a great city.

[I. AFTER four nights of frost, that was taken notice of for very hard, we went into an orchard, where the ground was level, and not covered with grass, and found by digging,

that the frost had scarce pierced into the ground three inches and a half. And in a garden nearer the house, we found not the earth to be frozen more than two inches beneath its surface.

II. Nine or ten nights successive frost froze the grassless ground in the garden, about six inches and a half, or better in depth, and the grassless ground in the orchard, where a wall sheltered it from the south sun, to the depth of about eight inches and a half, or better.]

[We digged in an orchard near a wall, that respects the north, and found the frost to have pierced the ground about a foot and two inches, at least above a foot: this is the eighth day since it was about eight inches and a half.]

[A slender pipe of glass, about 18 inches long, and sealed at one end, was thrust over night into a hole, purposely made with a spit straight down into the ground, the surface of the water being in the same level with that of the earth; the next morning the tube being taken out, the water appeared frozen in the whole capacity of the cylinder, but a little more than three inches. But from this stick of ice, there reached downwards a part of a cylinder of ice of about six inches in length, the rest of the water remained unfrozen, though it were an exceeding sharp night, preceded by a constitution of the air, that had been very lasting, and very bitter. The earth in the garden, where this trial was made, we guessed to be frozen eight or ten inches deep, as it was in another place about the same house. But if this tube had not been in the ground, the ambient air would have frozen it quite through.]

9. ANOTHER note much of the same import, we find in another place of our collections.

FINDING, that by reason of the mildness of our climate, I was scarce to hope for any much deeper congelation of the earth or water, I applied myself to inquire of an ingenious man, that had been at *Mosco*, whether he had observed any thing there to my present purpose, as also to find in captain *James's* voyage, whether that inquisitive navigator had taken notice of any thing, that might inform me, how far the cold was able to freeze the earth or water in the island of *Charleton*, where that quality may probably be supposed to have had as large a sphere of activity, as in almost any part of the habitable world. And by my inquiries I found, that even in frozen regions themselves, a congealing degree of cold pierces nothing near so deep into the earth or sea as one would imagine; for the traveller I spoke with, told me, that in a garden in *Mosco*, where he took notice of the thing I inquired about, he found not the ground to be frozen much above two foot deep. And in captain *James's* journal, page 63. the most that I find (and that too, where he gives an account of the prodigiously tall ice they had in *January*) concerning the piercing of the frost into the ground, is this, that the ground at ten foot deep was frozen. Whence by the way we may gather how much sharper cold may be presumed to have reigned in

in that island, than even in *Russia*. And as for the freezing of the water, he does in another place occasionally give us this memorable account of it, where he relates the manner of the breaking up the ice in the frozen sea, that surrounds the island we have been speaking of: 'It is first to be noted (says he, page 86.) that it doth not freeze (naturally) above six foot; the rest is by accident; such is that ice, that you may see here six fathom thick. This we had manifest proof of, by our digging the ice out of the ship, and by digging to our anchors before the ice broke up.' The rest of that account not concerning our present purpose, I forbear to annex; only taking notice, that notwithstanding our lately mentioned experiment of freezing water in a glass tube thrust into the ground, yet it seems, that at least where captain *James* wintered, the water was not much above half so thick frozen as the earth. But we have already noted the indisposition of salt water to congelation; and whether fresh water would not have been deeper frozen, may be justly doubted.

TITLE XIV.

Experiments touching the differing Mediums, through which cold may be diffused.

1. **I**N examining whether cold might be diffused through all mediums indefinitely, notwithstanding their compactness, or the closeness of their texture, we must have a care not to make our trials with mediums of too great thickness, lest we mistakingly impute that to the nature of the medium, which is indeed caused by the distance, which the medium puts betwixt the agent and the patient. For the mixtures of ice and snow, wherewith we made our experiment, will operate but at a very small distance, though the medium resist no more than the common air, as may appear by some of the experiments recorded in this treatise.

THIS premised, we may proceed to relate, that having placed a copious mixture of ice and salt in pipkins glazed within, and in white basons glazed both within and without, we observed, that the outside of both those sorts of vessels was crufted over with ice: though, however the baked earth had not been compact, nor the vitrified surface of a very close texture; the very thickness of the vessels was so great, that it seemed it would scarce have been able to freeze at a greater distance.

2. By the experiments formerly mentioned of freezing water in pewter bottles, it appears, that cold is able to operate through such metalline vessels.

3. AND this may be somewhat confirmed by one of the prittiest experiments, that is to be performed by the help of cold, namely, the making icy cups to drink in. The way we used was this; we caused to be made a cup of latten (by which I mean iron reduced into tin plates, and tinned over on both sides) of the shape and bigness I intended to have the cup of; then I caused to be made of the same matter another cup of the same

shape with the former, but every way less; so that it would go into the greater, and leave a competent interval for water betwixt its convex surface, and the concave of the other. This innermost cup was furnished with a rim or lip, by which it leaned upon the greater, and by whose help its sides and bottom were easily placed at a just and even distance from the sides and bottom of the other; but the distance between the two bottoms is made greater, than that between the sides, that the icy cup might stand the firmer, and last the longer. The interval between the two parts of this mould being filled with water, and the cavity of the internal cup being filled with a mixture of ice and salt, (partly to freeze the contiguous water, and thereby cooperate to the quicker making of the cup, and partly by its weight to keep the water from buoying up so light a cup;) the external part was surrounded with ice and salt, whose cold so powerfully penetrated to the internal metalline mould, that the water was quickly frozen, and (the parts of the mould being disjoined) appeared turned into an icy cup of the bigness and figure designed. And these cups being easily to be made, and of various shapes (and that in the midst of summer, if snow or ice be at hand) are very pleasant trifles, especially in hot weather, when they impart a very refreshing coolness to the drink poured into them; and though they last not long, especially if they be employed to drink wine, and such like spirituous drinks in, yet whilst some are melting, others may be provided, and so the loss may be easily repaired. All the difficulty we met with, was to disjoin the parts of the mould, which are wont to stick very fast to the ice they include; and we tried to obviate this, sometimes by anointing the inside of the mould with some unctuous and not offensive matter, to hinder the adhesion of the ice, and sometimes by applying some convenient heat both to the convex part of the external, and the concave part of the internal piece of the mould; which last mentioned way is quick and sure, but lessens the durableness of the cup.

[WE were lately informed, that this way of making cups of ice, is set down in *Barclay's Argenis*, and it is like enough, that ingenious man may have learned it amongst some of the virtuosi of *Italy* he conversed with: but if we, that learned it from none of them, had not been taught it by experience, we should scarce have ventured to try it upon the credit of a romance; that sort of composures being wont to be fabulous enough to pass but for poems in prose.]

4. THE learned and industrious mathematician *Erasmus Bartholinus* mentions in his newly-published discourse *de Figurâ Nivis*, an experiment, by which he tells us, that some masters of nature's secrets do easily, even in the midst of heat, reduce water into air. For they put a little snow or ice into a funnel, and thereby so refrigerate and condense the ambient air, that there will dew trickle down the sides of the funnel; by which means it has been said, that some ingenious men have hoped

to make an artificial fountain in the midst of summer. But I here mention this experiment rather, because it is not unlikely to please those, to whom it is new, and because having purposely tried it in large and thick funnels of glass, it may be pertinently enough delivered in this place, (where we are treating of the transmission or propagation of cold through close and thick mediums,) than because we expect to make of it that use, especially that oeconomical use, that has been lately intimated. For first, it will be very hard to prove, that it is the very air itself, and not rather the vapours swimming in it, that are by this means transmuted into water. And secondly, it is true indeed, that a mixture of snow and salt will condense vapours on the outside of a funnel; but either they, that hoped to make this use of the experiment, have little experience of it, and write conjecturally, or else they have made it with a success very differing from ours. For though we employed a large funnel, and suspended it by a string (artificially enough tied about it) in the free air; and though the mixture of ice and salt we put in, were sufficiently infrigidating (as will appear by and by) and far more so, than ice or snow alone would have been; yet that mixture being not able to condense the vaporous parts of the air into dew, much, if at all, longer than the mutual dissolution of the salt and snow lasted, the liquor, that was this way obtained, and dropped down at the bottom of the funnel (whose internal perforation ought to be carefully stopped, lest any of the resolved snow and salt should fall through, and spoil the other liquor) was indeed sweet like rain-water, but so very little, as well as so slowly generated, that it amounted not any thing near to that, which the snow employed, and spoiled to make it, would have afforded. So that it may be questioned, whether some cooling liquors, which can as well as this mixture condense the vapid air into water, and whose texture is not destroyed in this operation, as that of the snow is, might not be more hopefully employed to obtain water from the air; to which I shall only add this one thing, that the mixture of snow and salt did turn the vapours, that fasten themselves to the outside of the glass, first into ice, before they drop down in the form of water, in almost all our trials of this nature, as well in thick funnels, as in other, and thinner glasses.

5. THAT in hermetically sealed glasses, an included mixture of snow and salt will freeze the vapours of the air on the outside of the glass, divers of the experiments of the present treatise do manifestly evince; which argue, that even so extremely close a medium as glasses is not able to hinder the transmission of cold. And this is not superfluously added, because in vessels not hermetically sealed, it may be pretended, that it is the internal air, that communicates its coldness by some unheeded, but immediate intercourse, with the external.

AFTER this we thought it worth an experiment, to try, whether, or how, cold would be

diffused through a medium, that some would think a vacuum, and which to others would seem much less disposed to assist the diffusion of cold, than common air itself. To compass this, the expedient we bethought ourselves of, was to suspend a slender glass full of water in one of the small receivers belonging to our pneumatical engine; and when the air was very carefully pumped out, to bury the exhausted receiver in a copious and ready prepared mixture of ice and salt, to see whether, notwithstanding the withdrawing of the medium, the water suspended in a kind of vacuum, as to air or gross substances, would yet be frozen by the cold. That event of our trials, which alone I find among my notes, is registered in these terms.

6. [A SMALL pipe, sealed at one end, was, at the other, filled almost with water, and was put into a receiver, consisting of a somewhat long and slender tube of glass, sealed at one end, and inverted upon the engine plate; then the air was carefully exhausted, for the pump was plied; a while after no air appeared to come forth in any bubble out of the receiver, through the external water; nor did the water in the small pipe within disclose any number of bubbles worth taking notice of: then by the help of an almost cylindrical plate of iron, beaten ice and salt were heaped against the outside of the receiver, about the height, to which the water in the small pipe reached. And at length, though, as we all thought, much more slowly than such a congelation would else have been performed, the water was for the most part frozen in odd kind of flakes from the top to the bottom, and the ice seemed not to have any considerable number of bubbles.]

7. THERE is one experiment, I have made about the transmission of cold through indispensed mediums, which may not be unworthy to be here inserted. For I had once a mind to try, whether a cold body could operate through a medium, that was, as to touch, actually hot, and had its heat continually renewed by a fountain, as it were, of heat, that perpetually diffused through it new supplies of warm liquor; so that the cold body could not here, as in other cases, first allay the heat of the medium, and then lessen it more and more, till it had quite extinguished it. To compass this, I had soon after an opportunity of making some trials presented me: for being at the mineral springs at *Tunbridge*, to drink those wholesome waters for my health's sake, I soon accustomed myself to drink them in considerable quantities very early in the morning, when they were exceeding cold, and sometimes drinking them in bed, as well as sometimes at the spring's-head, I had the curiosity to observe, whether, in case I took them down very fast, they would not through the warm muscles and outward parts of the abdomen, diffuse a sensible coldness: and upon more trials than one, I found, that by laying my warm hands on the outside of my belly, I there felt, at least as it seemed to me, a manifest and considerable degree of coldness. And when I related this to some ingenious persons,

persons, that were better acquainted with those springs than I, they told me, that there was among those many, that then resorted to those famous springs, a knight, whose name I remember not, whose disease being judged formidable, the physicians enjoined him to drink in a morning two or three times the quantity, that afforded me the observation I was relating; and that when this knight had filled his belly with so much water, he used mightily to complain of the coldness it diffused through his abdomen, insomuch that he was fain to ply those parts long with hot napkins clapped to them, one after another; which yet, as he complained, were soon refrigerated by the excessive cold, that the water diffused to the outside of his belly; which yet nevertheless was not, that I could learn, at all prejudiced, no more than mine, by so sensible and piercing a cold.

8. IT may be doubted, whether in case water be not fluid upon the account of a congenite motion in the corpuscles it consists of, its fluidness may not proceed from the agitation of the ambient air, either immediately contiguous to the surface, or communicating its agitation to the water, by propagation of its impulse, through the vessel, that interposes betwixt them. To contribute to the clearing of this, and some other things, we devised the following experiment: We provided a glass-bubble, of about the bigness of a walnut, and the form almost of a pear, whose stem was purposely made crooked for the conveniency of suspension. This being filled with water (which is troublesome enough to be done, unless one have the knack) we hung it at one end of a thread, whose other end we past through a cork, by a perforation purposely made; into which we afterwards fastened a thread, by thrusting in a small peg to rivet it in. Then filling a glass not very broad, but yet furnished with a mouth wide enough to receive the bubble, with oil of turpentine, such as we bought it at the shops, we stopped the orifice with the newly mentioned cork; so that the sealed bubble hanging at it was covered, and every way surrounded by the oil of turpentine; which being a liquor, that (at least in some colds as we here have) will not freeze, we placed the glass in beaten ice and salt, and as it were buried it therein: and at the end of about three hours (having been diverted by some occasions from taking it sooner out) we found, as we had conjectured, that, notwithstanding that, the oil of turpentine continued perfectly fluid as before, yet the bubble totally immersed in this heating chymical oil was frozen throughout, not excepting that, which was harboured in the little neck or stalk; and when I came to lift it out of the liquor, the glass being cracked (as we supposed by the cold) the string brought up a little part of that, which was nearest to it; the rest in the form above mentioned staying behind and subsiding. And that, which was remarkable in this piece of ice, was, that when we had taken it out, it appeared cleft very deep (from the outside almost to the centre) according to a line drawn from the slenderest

part of it, almost as if one should with a knife cut a pear in two, from the stalk downwards, according to its whole length. And these two pieces were easily enough separable, and (to add that circumstance) for trial sake we left them divided in the same liquor and vessel, with some thawing ice and salt about them, for 14 or 15 hours, without finding them any thing near so much wasted or resolved into water, as most would have expected.

WHILST the above mentioned vessel was exposed to be frozen, we likewise placed by it another vessel, a glass-egg, whose ball and a little part of its stem we had filled with some of the very same parcel of oil of turpentine; and placing about the sides of the egg some ice and salt, we observed, as we expected, that the liquor was, after a little while, made by the cold to subside about half an inch: so that it is worth some philosophers considering, why, if according to the lately mentioned atomical doctrine, cold be made by the introduction of swarms of real and extended, though atomical bodies, they should pervade the oil, and contract it without freezing it, but freeze the water without contracting it, but expanding it rather.

9. [A SMALL bubble of the bigness of a very little nutmeg, filled with water, and hermetically sealed up, was by a cork and a string suspended in spirit of wine, so as to be surrounded therewith; and being exposed to the air the same night, in the stopp'd glass, was the next morning found altogether frozen, though the spirit of wine it self were not at all so: but another bubble, by the help of a string cork, and piece of lead, carefully suspended in a strong solution of sea-salt, and exposed at the same time in a like vessel with the former, when they both came to be looked upon, appeared to be no more frozen than the brine it self, which was not so at all.]

10. [A GLASS bubble of the bigness of a small nutmeg, filled with water, and hermetically sealed, being immersed by a weight of lead fastened to it, beneath the surface of a very salt brine, but yet not so as to reach the bottom of the liquor or glass, was exposed all night to freeze, in weather, that was extraordinarily cold; but neither the imprisoned water, nor the other appeared to be at all frozen. The like experiment we repeated another frosty night, but without freezing either of the liquors. But to shew the usefulness of repeating experiments about cold, if there be opportunity, and especially in such cases, where the degree or some other circumstance may much vary the event, we will add, that having exposed a bubble like that newly mentioned, and immersed in spirit of wine, we found the next morning the water in the bubble turned into ice; and having likewise exposed such a bubble immersed in very strong brine, to be frozen by a mixture of ice and salt, within about two hours after, we found the bubble broken, as we supposed, upon the expansion of the water upon its growing ice. And we also found the upper part of the bubble with the ice sticking to it, and the other part of the glass was

was cracked, with lines running from a point almost like the pole and meridian in a globe; whence we concluded the glass to have been, as it is probable, burst asunder upon the expansion of the fresh water into ice; and that the reason, why there remained but a comparatively little parcel of ice, was probably, that the salt water getting in at those crannies or chinks, dissolved as much of the new-made ice, as in a little while it could easily reach.

Besides;

II. [WE filled a glass bubble with fair water, and having hermetically sealed it, we suspended it by a string fastened to the cork in the cavity of a wide-mouthed glass well stopp'd, so that the bubble was every way at a good distance from the sides, bottom, and top of the glass. This we did to try, whether a sufficient degree of cold at that distance would be freely transmitted through the glass, without the intervention of a visible liquor; and accordingly we found the suspended bubble cracked by the ice, that filled it.]

T I T L E X V.

Experiments and observations touching ice.

I. A GREAT part of our present history being employed about delivering the phenomena of congelation, it is not to be expected, that in this section, where we treat of ice as a distinct part of our theme, we should deliver all those particulars, that have occurred to us, wherein ice is concerned. And therefore we shall restrain our selves to the mention of those, that belong to ice, considered, as it consists of intire and distinct portions of congealed water. And though we shall deliver some few experiments of our own, such as we had any opportunity to make, yet much the greater part of this section will fitly enough be taken up by collections out of travellers, and navigators, into those colder regions, that afford much considerabler, or at least much stranger observations concerning ice, than are to be met with in so temperate a climate as ours. And what we have to deliver in this section will naturally be divided into two parts, the one consisting of our own experiments, and the other containing some passages, that we have selected out of voyages, or that have been afforded us by the relations of credible travellers. And of these two sorts of observables, that, which has been first mentioned, shall be first treated of.

2. SOME, that have been in the *East-Indies*, inform us, that in some parts of those countries they were looked upon as great lyars, for affirming, that in *Europe* the fluid body of water was often without any artifice or endeavour of man turned in a few hours into a solid and compact body, such as ice. And certainly, if custom did not take away the strangeness of it, it would to us also appear very wonderful, that so great a change of texture should be so easily and inartificially produced. But how solid the body of ice is, or rather how

strong is the mutual adhesion of its parts, has not yet, that we know of, been attempted by experiments to be reduced to some kind of estimate: and indeed so many things must be taken into consideration, that it will be difficult to arrive at any more than a fair conjecture in this matter; especially, because (I think) it may justly be doubted, whether or no differing degrees of cold may not vary the degree of compactness of the ice. And my doubt will not perhaps appear groundless, if I add, that having, to satisfy my self, inquired of an intelligent person, that lived some years in *Russia*, he answered me, that he found the ice of those parts to be much harder than that of these.

3. WE had in our thoughts divers ways to estimate the cohesion of the parts of ice, whereof one was, to freeze water in a hollow metal-line cylinder, and taking out the ice, and keeping it in a perpendicular posture, cast into a scale weighed beforehand, and carefully fastened to the bottom of the ice, more and more weight, till the mere weight broke the cylinder: and this we had thoughts to try in cylinders of differing diameters and lengths, but wanted conveniencies to make the experiments; (which if they were made, as some of our trials were, in the open air, and in places exposed to some gelid wind, it would the better secure the ice from being weakened or thawed during the trials.)

4. WE therefore attempted, by another way, to investigate the strength of ice. For we took a plate of it, of an uniform, and also of a considerable thickness, and with sides cut parallel, that it might serve for a kind of lever, and placed it betwixt two wooden bars, whose distance we knew; and then laying on it a great weight, the centre of whose pressure, as near as we could estimate, was equally, or in determinate measures, distant from the wooden fulcrums, we endeavoured to try, how great a weight it would support; but in the village, where we made the trials, we could not get weights, that were conveniently shaped, and ponderous enough, to break it; and though we caused a man to stand upon it, yet neither could his weight break it; till he chanced to add an impressed force with his foot to the weight of his body. So that being unable to determine, what that additional and impressed force might amount to, almost all that we could safely conclude, either from this experiment, or some other ways of trial with scales, and other ways, that we made use of, (but for want of conveniencies unsuccessfully) was, that the force of ice to support weights is much greater than men can imagine; which seems somewhat the more strange, because it is not here in *England* so solid a body, as by this one would guess: for not only glass would readily scratch it deep enough, but even with common knives we could cut it, and that with great ease.

5. YET one not inconsiderable account I was able to give my self of the strength of ice, which I find in my notes thus delivered.

[THERE was taken a piece of ice three inches long, and three broad, and somewhat less than a quarter of an inch thick; this was laid cross-ways

crossways upon a frame, so that the two parts, on which the ice leaned, were distant three inches: then there was taken an iron, shaped like the figure of (the common arithmetical cipher, that denotes seven) 7, to whose hanging leg, if I may so call it, there was fastened at the end, which was under the middle of the ice, a scale, into which several weights were put, such as by some former trials we guessed to be almost as much as the ice would well suffer: after which, the horizontal leg of the iron was very gently laid upon the ice, as near as we could guess, in the middle of the distance, between the two sides of the frame, and consequently parallel to them both. Then the weights not proving altogether sufficient to break the ice, we let them hang a while at it, and observed, how the edge of the incumbent leg of iron (which edge was * broad) did work it self downwards into the ice; so that by our guesses, when the ice broke, as after a while it did, it had lost at one end of the incision, if I may so call it, half its thickness, and at the other, about a third part of it.

THE weights, that broke it, amounted to 17 pounds averdupois, and 117 ounces Troy.

6. THE experiment was repeated with all the former circumstances, only the piece of ice was two inches and a half broad, and a quarter of an inch thick, and the distance of the frame was three inches, as before; the weights, that broke it, were 17 pounds averdupois, and 41 ounces Troy. The horizontal arm of the iron had melted somewhat more than half through the ice when it broke, *viz.* more than $\frac{2}{3}$ of the thickness at one end, and somewhat less than half at the other.

7. WE divers times intimated in some of the first sections of our present history, that the addition of salt to ice did hasten the dissolution of it, which though it may be easily proved by some other phænomena of our experiments, yet it will not be amiss to mention here a couple of particular trials, by which we have more manifestly evinced it. And first, we divers times took a broad and flat plate of ice, less than a quarter of an inch thick, and having placed it horizontally upon a joint-stool, (a table, or any other flat piece of wood will do as well) we strewed here and there a convenient quantity of bay-salt upon it; and though we observed, that, if the surfaces of the ice and stool were not both of them flat, and congruous enough, the ice would be thawed indeed, but the other part of the experiment would not well succeed; yet when we made the trial carefully and watchfully, the plate of ice partly thawed by the salt would be so firmly frozen to the stool it leaned on, that we were fain with an iron instrument to knock it all to pieces, before we could sever it from the stool; into whose pores the ice newly generated by the experiment did pierce so deep, that, notwithstanding our knocking, many little parcels of ice would continue to stick close to the wood, whose pores they had invaded. But the circumstances, which in

this experiment made the most to our purpose; are these two; the one, that having sometimes laid the salt but on few, and somewhat distant parts of the plate, the intermediate parts would many of them remain unfrozen to the stool; whilst those, where the salt had been laid, were frozen so hard to it. And the other circumstance is, that the grosser grains of salt would so far dissolve the ice, whereto they were contiguous, as (if I may so speak) to bury themselves therein; whilst the other parts of the ice, upon which, or near which, no salt had been laid, kept their surfaces smooth and intire. We tried likewise two or three times to freeze a plate of ice to a flat piece of wood, by making use of aqua fortis, instead of common salt; but the experiment succeeded not well, though once we brought the ice to stick to the wood manifestly, but not strongly.

8. TO this we shall add the following experiment, which, when we watchfully made it, succeeded well, and I find it among my notes set down in these terms.

[SOLID fragments of ice having pretty store of salt thrown on them, upon the first falling of the salt among the ice there was produced a little crackling noise, and for a good while after there manifestly ascended out of several parts of the mixture, conveniently held betwixt a candle and the eye, a steam or smoke, like that of warm meat, though the night were rainy and warm, and though the morning had not been frosty.]

The mention here made of the crackling noise made by the ice upon the addition of salt, (which seemed to proceed from the crackling of the brittle ice, produced by the operation of the salt upon it) brings into my mind an experiment I had formerly made, whereof a greater noise of the same kind is a phænomenon, though the experiment were chiefly made for the discovery of the texture of ice: the event of the trial I find thus set down among my notes.

9. [WE took some cakes of ice, each of the thickness between $\frac{1}{4}$ and $\frac{1}{2}$ part of an inch, but not so very compact ice, as to be free from store of bubbles: some good aqua fortis dropped upon this did quickly penetrate it with a noise, that seemed to be the cracking of the ice, underneath which the sour liquor was plainly to be tasted. Oil of vitrol did the same, but much more powerfully, and without seeming to crack the ice, which it pass through; so that though but three or four drops were let fall upon the plate, it immediately shewed it self in drops exceedingly corrosive on the other side of the ice. And the like success we had with a trial made with the same liquor, upon three such plates of ice frozen one upon the top of another.]

10. HAVING proceeded as far as we were able towards the bringing the strength of ice to some kind of estimate, by such experiments as we had opportunity to make here, we thought it not amiss to seek what information

we

* The breadth was, I know not how, omitted in the note; but, as I remember, it was about an 8th part of an inch.

we could get about this matter among the descriptions, that are given us of cold regions: but I have not yet found any thing to have been taken notice of to this purpose worth transcribing, except a passage in the archbishop of *Upsal*, wherein, though the estimate of the force of ice be, as we shall by and by shew, made after a gross manner, yet since this itself is more than I have met with elsewhere, I think it worth subjoining, as our author delivers it in these terms: *Glacies* (says he) *pri-*

Olav. Ma.
Genr. Sep-
entr. Hist.
h. 1. c. 14.

mæ & mediæ hyemis aded fortis & tenax est, ut spissitudine seu densitate duorum digitorum sufferaat hominem ambulantiem, trium vero digitorum equestrem armatum; unius palmæ & dimidiæ, turmas, vel exercitus militares; trium vel quatuor palmarum integram legionem seu myriadem populorum, quemadmodum inferius de bellis byemalibus memorandum erit.

BUT though this be sufficient to afford us an illustrious testimony of the wonderful strong cohesion of the parts of ice, yet we mentioned it but as a popular way of estimate, which may better embolden travellers, than satisfy philosophers, in regard, that the author determines only the thickness of the ice, and not the distance of that part of it, that supports the weight from the shore or brink, on which, as on a hypomoclion, the remotest part of the ice does lean or rest. And if we consider the ice as a lever, and the brink or brinks, on which it is supported, as a single or double fulcrum, the distance of the weight may be of very great moment in reference to its pressure or gravitation on the ice, which may more easily support the weight of divers men placed very near the prop, than that of one man placed at a great distance from it; as will be easily granted by those, that are not strangers to the mechanicks, especially to the nature and properties of several kinds of levers. But not now to debate, whether in certain cases, the ice we speak of, may not receive some support from the subjacent water, nor whether some other circumstances may not sometimes be able to alter the case a little, our very considering the ice as a single or double lever, though it may hinder us from measuring the determinate strength of ice upon *Olaus's* observation, yet it will set forth the strength of it so much the more, since by his indefinite expressions he seems sufficiently to intimate, that when the ice has attained such a thickness, its resistance is equivalent to such a weight, without examining on what part of the ice it chances to be placed.

II. THUS far our experiments concerning ice, with the appendix subjoined out of *Olaus* to the same purpose. We will now proceed to some of the observations we have met with in seamen's journals, and elsewhere. I say to some, because to enumerate them all, would spend more time and labour than I can afford; and therefore I shall restrain myself to the mention of some few of the chiefest.

V O L. II.

I. AND in the first place for confirmation of what I delivered, at the beginning of this section, from the report of a traveller into *Russia*, touching the hardness of ice in those gelid climates, in comparison of our ice, which I have found it easy to scrape with glass, or to cut with a knife; I shall subjoin this passage of Captain *G. Weymoult*, in his voyage for the discovery of the North-west passage: 'As Purchas, Lib. 4. we were (says he) breaking off some of this ice, which was very painful for us to do, for Chap. 15. it was almost as hard as a rock, &c.'

II. Next to shew, that it was not a superfluous wariness, that made me in a former section doubt, that even the ice made of sea-water might be altogether or almost insipid; I will subjoin, that I have since met with some relations, that seem to justify what is there delivered. And in one of our Englishmen's voyages into the Northern seas, I find more than one instance to my present purpose, though I shall here set down but one, which is so full and express, that it needs no companions; our navigator speaking thus; 'About Purchas, Lib. 4. nine of the clock in the forenoon, we came by a great island of ice, and by this island cap. 13. we found some pieces of ice broken off pag. 813. from the said island; and being in great want of fresh water, we hoisted out our boats of both ships, and loaded them twice with ice, which made us very good fresh water.'

BUT all this notwithstanding, I yet retain some scruple, till those, that have better opportunity to make a more satisfactory experiment, shall ease me of it. For though by these narratives it seems more than probable, that the ice in the midst of the sea consists but of the fresh particles of water, that plentifully concur to compose the sea water; yet besides that, in case the fresh water were taken, as some of that I have found mentioned in voyages, has confessedly been, from the top of the ice, it might possibly be no more than melted snow, which, as we elsewhere take notice, does in those extreme cold regions easily freeze upon the ice it falls on, and oftentimes much increases the height of it: besides this, I say, the argument from the insipidness of the resolved ice will conclude but upon supposition, that as that ice was found in the sea, so it was also made of the sea water; which though it may have been, yet I somewhat doubt, whether it were or no, since I find some navigators of the most conversant in the cold climates to inform us, that most of those vast quantities of ice, that are to be met with about *Nova Zembla*, and the strait of *Weigats*, and that choak up some other passages, whereby men have attempted to pass into the south sea, are composed of the accumulation of numerous pieces of ice (cemented by intercepted, and then frozen, water) that are brought down from the great river *Oby*, and others; so that it may very well be supposed, that these *mountainous

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* Neither hereafter will I marvel, though the strait of *Weigats* be stopped up to the North-east, with such huge mountains of ice, since the rivers *Oby* and *Jenesie*, and very many more, whose names are not yet known, pour out such a quantity thereof, that in a manner it is incredible: for it cometh to pass in the beginning of the spring, that

tainous pieces of ice may be some of those, which, upon the shattering of ice in bays and straits, partly by the heat of the sun, and partly by the tides, may be afterwards by the winds and currents driven all up and down the seas, to parts very distant from the shore; and some of these, it may be, that our countrymen met with, and obtained their fresh water from: which I the rather incline to think, because that (as we shall have occasion to observe in another section) the main sea it self is seldom or never frozen. But my scope in all this is but to propose a scruple, not an opinion.

III. The next and principal thing concerning ice is the bigness of it, which I find, by the relations partly of some acquaintances of my own, and partly of some navigators into the North, to be sometimes, not only prodigious, but now and then scarce credible. And therefore, as I shall mention but few instances, that I have selected out of the best journals, and other writings I have met with, so I shall add a few more testimonies to keep them, by their mutual support, from being entertained with a disbelief, which their strangeness would else tempt men to.

Of the vastness of single mountains of ice, the most stupendous example, that, for aught I know, is to be met with in any language but ours, is that, which I formerly took notice of, out of the Dutch voyage to *Nova Zembla*, which was ninety-six foot high (that is, above twenty foot higher, than on a certain occasion I found the leads of *Westminster Abbey* to be.) But it is probable, that our Captain *James* met with as great, if not greater: for though in some places he mentions divers hills of ice, that were aground in 40 fathom water, and consequently were as deep under water, as that newly taken notice of out of the *Hollanders*, page 14: and though he elsewhere mentions other pieces of no less depth, and twice as high as his top-mast head, and this in *June*: yet elsewhere, and long after, relating his return home, he has this passage; page 106. 'We have sailed through much mountainous ice, far higher than our top-mast head: but this day we sailed by the highest I ever yet saw, which was incredible indeed to be related.'

But the stupendous piece (for height and depth) of single ice, that perhaps has been ever observed and measured by men, is that, which our famous English seaman Mr. *W. Baffin* (whose name is to be met with in many modern maps and globes) mentions himself to have met with upon the coast of *Greenland*, whose whole relation I shall therefore subjoin, not only because of the stupendousness of this piece of ice, but because he takes notice of an observation, which I knew not to have been made by any, and comes somewhat near the estimate we formerly made of the proportion betwixt the extant and immerged parts

of floating ice; only the following estimate makes the extant part somewhat greater than we did; which may easily proceed from other men's having, as Mr. *Baffin* here does, grounded their computation upon what occurred to them at sea, or in salt water, where the ice must sink less than in fresh water, such as my estimate supposed. Our navigator's words then are these: 'The 17th of *May* we sailed by many great islands of ice, some of which were above 200 foot high above water, as I proved by one shortly after, which I found to be 240 foot high; and if the report of some men be true, which affirms, that there is but one seventh part of ice above water, then the height of that piece of ice, which I observed, was one hundred and forty fathoms, or one thousand six hundred and eighty foot from the top to the bottom. This proportion I know doth hold in much ice; but whether it do so in all, I know not.'

Purchas,
lib. 4. cap. 17.
18. pag. 857.

Thus far of the height and depth of single pieces of ice: as for the other dimensions (the length and breadth) I remember not, that I have read of any, that had the curiosity to measure the extent of any of them, excepting Captain *James*; whose ship being once arrested between some flat and extraordinary large pieces of ice, he and his men went out to walk upon them, and he took the pains to measure some of the pieces, which he says he found to be 1000 of his paces long, page 17. And probably among so many mountains and islands of ice, there would have been found some intricate pieces, of a greater extent than even these, if men had had the curiosity to measure them.

HITHERTO we have treated of the bigness of single pieces of ice; we will now proceed to say something of the dimensions of the aggregates of many of them, among which having elected four or five as the principal I remember myself to have yet met with, I presume it will be sufficient to subjoin them only.

'ABOUT ten of the clock we met with a mighty bank of ice, being, by supposition, seven or eight leagues, or twenty-four miles long,' says that experienced English pilot *James Hall*, in his voyage of *Denmark* for the discovery of *Greenland*.

ANOTHER of our English navigators mentions, that even in *June*, 'all the sea (where in he was endeavouring to sail) as far as he could see from the top of a high hill, was covered with ice; saving that, within a quarter of a mile of the shore, it was clear round about once in a tide.' By which last clause, it seems, that this vast extent of ice was either one entire floating island, or at least a vast bank or rand (as some seamen term it) of ice.

BUT the strangest account of banks of ice, that I have yet met with in any sober author,

is,

that in places near unto the sea, the ice, through the excessive thickness, and multitude thereof, doth carry down wood before it. And without doubt this is the cause, that about the shore of the strait of *Weigats*, so great abundance of floating wood is every where seen: and whereas in that strait near unto *Nova Zembla*, it is so extreme cold, it is no marvel, if in regard of the narrowness of the strait, so huge heaps of ice are gathered and frozen together, that in the end they grow to sixty or at least to fifty fathoms thickness: says the Description of the countries of *Siberia*, *Samojed*, &c. extant in *Purchas's* third part of his *Pilgrim*. Lib. 3. Chap. 7.

is, that which is mentioned by the learned French hydrographer, *Fournier*; who relates, that in the year 1635, the French fleet sailing to *Canada*, met with several pieces of ice, as high as steeples, and particularly one, whether piece or bank of ice (for the French word *glace* may signify either) which they were troubled to coast along for above forty leagues. If this be the same story, (as one may suspect it to be, by the circumstances of the place, and fleet,) there is a great mistake in another place, where our author speaks of the vastness of the ice: but if it be another story, as some other differing circumstances argue, the French, it seems, met with ice far more stupendous, than even that already mentioned. For, (says our author) in the sea, which washes *Canada*, there is often seen in the month of *August*, to pass by, ices much bigger than ships. In the year 1635, the French fleet sailing there, coasted along, for three days and three nights, one, that was above 80 leagues long, flat in some places like vast champions, and high in other like frightful hills. The latter part of which passage may confirm what we formerly delivered in another section, concerning the unequal compagination of icy islands.

To what has been said touching the extent, and other dimensions of floating, or at least loose pieces of ice, it will be fit to add something of the extent of ice, coherent to one or both of those shores, that bound the water, whose upper part is congealed. And in the first place, we shall, out of many instances to our present purpose, that might be borrowed from the writings of *Olaus Magnus*, select this one memorable one, that shall serve for all: *Neque minori bellandi impetu (says he) Sueci ac Gothi super apexa glacie, quam in ipsa solidissima terra constringunt; imo, ut prius dictum est, ubi antea æstivo tempore acerrima commissa sunt bella navalia, eisdem in locis glacie concreta, aciebus militari modo instructis, bombardis ordinatis, habentur horrendi conflictus. Adeo solida glacies est in equestribus turmis sufferendis, ampliter vel striatè collocatis.* I premit then, what he elsewhere relates of the voyages and wars made in winter by the Northern nations. They, that have lived in those countries, relate, as things most known and familiar, (what has been confirmed to me by more than one unsuspected eye-witness) the long journeys, that are commonly taken upon the icy bridges, or rather plains, by travellers, with all their carriages, to very distant places. And that, which may bring credit to these strange relations, by shewing, that no less unlikely ones are sometimes true, is, what all *Europe* knows, that within these three years the whole Swedish army, led on by their king, marched over the sea to the island of *Zeeland*, where *Copenhagen*, the capital city of *Denmark* stands*. But it may seem much more strange, which I will therefore add, that as in the North countries frequently, so sometimes even in the warmer regions of the East, the sea itself has, by the

cold, been congealed to a prodigious breadth. *Insolitum est, (saith Bartholinus) quod refert Constantinus Manasses in Annalibus accidisse, Theophilus imperante, ut hyems sæva mare cogeret in glaciem ad profunditatem sanè immensam, humidumque illud elementum, lapidis ad duritiem, fluxione prorsus ademptâ, redigeret.* And *Michael Glycas* relates, 'That in the year 775, the winter was so sharp in the East, that along the coast, the sea (he means the Mediterranean) was frozen for 50 leagues, and the ice was compacted as into a rock, 30 cubits deep; so strange a quantity of snow likewise falling, that it was raised to the height of 30 cubits above the ice.' Which likewise agrees very well with what we formerly noted, touching the possible increase of the height of some pieces of ice by the falling of the snow upon them.

IV. It remains now, that we subjoin a few promiscuous observations concerning ice, that are not so readily deducible to the three foregoing heads.

AND we shall begin with what was taken notice of by the Dutch in their *Nova Zembla* voyage, where relating, how they fastened their ships to a great piece of ice, to shelter themselves from the stormy winds; 'There (add they) we went upon the ice, and wondered much thereat, it was such manner of ice: for on the top it was full of earth, and there was found about forty eggs; and it was not like other ice, for it was of a perfect azure colour, like to the skies, whereby there grew a great contention of words amongst our men, some saying, that it was ice, others that it was frozen land; for it lay unreasonably high above the water, it was at least eighteen fathom under the water, close to the ground, and ten fathom above the water.'

THE like blue colour in rocky pieces of ice, I remember I have somewhere found, to have been taken notice of by a modern † navigator; or whether the words of *Virgil*, concerning the frigid zone, *Cerulea glacie concreta, atque imbribus atris*, belong to this subject, I leave others to consider, nor shall I stay to examine, whether this blueness, that has been observed in ice, be always an inherent or permanent colour, or sometimes one of those, that are styled emphatical.

It is very considerable, if it be true, what is related by *Olaus Magnus*, concerning the degenerating (if I may so speak) of ice from its wonted hardness in the spring of the year. For in the same chapter, where he gives us the lately transcribed account of the strength of ice in those northern countries, after having interposed some other passages, he subjoins these words; *Liquefcente tamen glacie ad principium Aprilis, nullus ejus spissitudini, minus fortitudini, nisi in aurora, ambulando confidit, quia solis diurno aspectu tam fragilis redditur, ut quæ equestres armatos paulo ante portaverat, vix hominem nunc sufferre possit inermem.*

* — Sæpe aliàs & his annis fatalibus tam profunde congelavit (marina aqua) ut non tantum plaustra, sed integrum exercitum ad aliquot millaria Germanica secure vexerit, &c. Inquit T. Barthol. de nivis usu, pag. 43.

† In the evening we were inclosed amongst great pieces (of ice) as high as our poop, and some of the sharp blue corners of them did reach quite under us. Captain James, page 6.

Hydrographie du P. G. Fournier, liv. 9. cap. 29. comparced with the 12th chapter of the same book.

Olaus Mag. lib. 3. cap. 2. pag. 334.

Barthol. de nivis usu. cap. 6.

Glycas et Fournier, liv. 9. cap. 19.

Olaus, lib. 1. cap. 14.

THIS puts me in mind to add, that oftentimes in the writers of journeys and voyages, we meet with mention of great noises made by the breaking of ice; and in this very chapter our archbishop taking notice of the clefts, that sometime happen in champions of ice, adds, 'That when the ice chanches thus to open, especially if it be in the night, the noise of it may be heard a far off, like the loud and horrid noise of thunder, and of earthquakes.' And on this occasion may be subjoined a couple of passages extant in different places of the formerly mentioned *James Hall's* voyages: the first is thus delivered; 'When we met with a huge and high island of ice, we steering hard to board the same, and being shot a little to northwards of it, there fell from the top thereof some quantity of ice, which in the fall did make such a noise, as though it had been the report of five cannons.' But the next passage is more directly pertinent to our present subject, and is couched in these words; 'About twelve of the clock this night, it being still calm, we found our selves suddenly compassed round about with great islands of ice, which made such a hideous noise, as was most wonderful, so that by no means we could double the same to the westward: wherefore, &c.'

Of these kind of icy thunders (as some travellers call them) there are divers instances to be met with, mentioned in the several voyages of the Hollanders, and particularly in those to *Nova Zembla*: but many of those noises seem to be made by the dashing of the great pieces of ice against one another; but if it happens, when the ice (as sometimes it is said to do) seems to cleave, as it were, of its own accord, to us, that live in a temperate climate, it may be a matter of some dispute, whence these loud ruptures of ice may proceed. For *Olaus Magnus*, in the chapter above cited, does not improbably ascribe them to the warm exhalations, that in some places ascend out of the ground. And I remember, in favour of this opinion, that I once caused divers pieces of thick ice to be brought out of a cool place into a somewhat warm room, and listening, observed a noise to come from them, as if it had been produced by store of little cracks made in them; but somewhat or other prevented me from repeating the experiment, and satisfying my self about the conjecture. But having lately inquired of an intelligent Polander, that has travelled much upon these icy plains, he agreed with our author, and others, as to the frightful noises, that are produced by these cracks of ice, but affirmed, upon his own observation, (for that I particularly inquired after) that these great clefts were often made, not by thawing heat, but by excessive cold, and that he had taken notice of them in extremely sharp weather. Indeed we sometimes observe, that in very bitter frosts the frozen ground will cleave, as we elsewhere have occasion to take notice. But whether that be not a different case from this, or whether the Polonian gentleman were not mistaken, or whether both these mentioned accounts, of the cleaving of ice, may on different

conjunctures of circumstances take place, we leave to farther inquiry.

THERE is a tradition concerning ice, about the famous *Vulcano Hecla*, in *Iceland*, which, though verily believed among the superstitious vulgar of those parts, is spoken of so slightly by *Blefkenius*, who being upon that coast, had the curiosity to sail purposely thither, that I think it not worth while to take any farther notice of it. But it were too tedious to set down in this section, (which the strangeness and variety of the theme has made so prolix already) the other things, that may be mentioned without impertinency concerning ice; and therefore we shall here desist from so laborious a task, as also omit the handling of snow and hail: for though they are reducible to ice, yet I shall at least suspend the treating of them, partly because *Bartholinus* and meteorologists have saved much of my labour, and partly for the reason newly intimated: so that we shall conclude this section, as soon as we have taken notice, that there is yet somewhat relating to ice, which, being in it self considerable, and whereof hitherto no experimental account appears to have been given, what we our selves have tried about it, may challenge to be treated of apart.

T I T L E XVI.

Experiments and observations touching the duration of ice and snow, and the destroying of them by the air and several liquors.

1. IT may be an experiment, as well instructive as new, to determine, what liquor dissolves ice sooner than others; and in what proportion of quickness the solutions in the several liquors are made. For men have hitherto contented themselves to suspect in general, that there are other liquors potentially hot, wherein ice will sooner dissolve, than it will in water. But this opinion either being grounded upon no experience at all, or taken up upon the sight of what happens to pieces of ice, which no care was taken to reduce to the same bulk and figure, no more than to measure attentively how long one outlasted the other; we thought fit to try, if we could not bring this matter to experiment, and make a determination in it, though not exactly true, yet less remote from exactness, than had been yet, for aught I know, so much as attempted.

2. IN order to this, we procured some bullet moulds, and having first carefully stopped the little crevice, that is wont to remain betwixt the two halves of the mould, with a good close cement, we afterwards filled them with water, and carefully closed up the orifice of the hole, at which the water was poured in; and then setting the mould to freeze in ice and salt, we found it difficult enough to keep the water (more or less of it) from running away through some unperceived passage, before the cold could have time by congealing it to arrest it. But after a while, when we had thus made a bullet of ice, we found it a new and greater difficulty to get it whole out of the moulds, without

without warming them; for by that way we could indeed loosen the ice, but then we could not avoid thawing it too, and that most times not uniformly: wherefore we tried by greasing the inside of the moulds to keep the ice from sticking so close to them, (notwithstanding the distension the water suffered by its being frozen) but that we might pick out the bullet entire; and this succeeding well enough, we hoped by this way to obtain our end, which was to have a competent number of pieces of ice of equal bulk, and of the same figure, to be put at once to thaw in several liquors. But we could by no means procure moulds, which had any number of distinct cells of the same bigness, those long pairs of moulds, that were to be met with in shops, having their distinct cells generally made on purpose of very different bignesses, which rendered them altogether useless for our design. Wherefore we were fain, for want of an exacter way, to take a glass pipe of the most even and cylindrical that we had, and of a bore capable to admit a big man's little finger. This glass being stop't at one end, and kept open at the other, was filled to the height of about half a foot or more of fair water; and ice and salt being heaped up about it, that the cold might reach as far as the water did, it was quickly frozen. In the mean while I had caused several wide-mouthed glasses to be brought into my chamber (wherein, by reason of some indisposition, that hindered me from going abroad, I kept some fire) and having poured several liquors into these glasses, which had been placed all on a row, we suffered them to rest there a while, that the ambient air might have time to reduce them, as far as it could, to its temper, and consequently to the same temper as to heat and cold: and then, with the warmth of one hand, the included ice being loosened from the glass, as it was taken out, and a ruler divided into inches and eighths, being laid alongst it, with a knife a little warmed, the ice was soon, and yet not carelessly, divided into several small cylinders of three quarters of an inch apiece; and these cylinders thus reduced to as sensible an equality as we could, were nimbly and carefully put into the several liquors hereafter to be mentioned. And whilst we our selves watched very attentively, till each of these icy cylinders was quite, and yet but just dissolved, we caused others to keep time by the help of a pendulum, whose vibrations were each a second minute, (or both part of a common minute, whereof 60 go to make an hour;) and it was easy for those we appointed, to watch the vibrations of the pendulum, notwithstanding the quickness of its motion, because it was fitted to a little instrument purposely contrived for such nice observations, wherein a long index moving upon a divided dial-plate did very manifestly point out the number of the diadromes made by the pendulum.

3. THIS experiment was afterwards repeated twice with cylinders of ice, each of them an inch long; and though the successes of these trials were various enough, yet we shall subjoin both the salt, (as being made with more

advantage than the last) that the more light may be gathered from them, and that at least we may discover, how difficult it is to make such experiments in this matter, as that all the nice circumstances of them may safely be relied on.

I. Trial.

1. OIL of vitriol, where a cylinder of ice, of an inch long, being put into, lasted five minutes.
2. SPIRIT of wine, (in which the ice sunk) lasted 12 minutes.
3. AQUA FORTIS lasted $12\frac{1}{2}$ minutes.
4. WATER lasted 12 minutes.
5. OIL of turpentine lasted (not good) 44 minutes.
6. AIR lasted 64 minutes.

II. Trial.

1. IN oil of vitriol, where an inch of cylindrical ice lasted 3 minutes.
2. IN spirit of wine, lasted 13 minutes.
3. IN water, lasted 26 minutes.
4. IN oil of turpentine, lasted 47 minutes.
5. IN sallet oil, lasted 52 minutes.
6. IN the air, lasted 152 minutes.

4. WE likewise thought it worth trying, whether there would be any difference, and how much difference there would be in the duration of pieces of ice of the same bulk and figure, some of them made of common water, and others of frozen wine, milk, oil, urine, and other spirituous liquor; these several pieces being exposed to be thawed in the same air, as other ambient liquor.

5. WE also tried, whether motion would impart a heat to ice, by nimbly rubbing a strong piece of ice upon a plate of ice; and though this seemed to hasten the dissolution in that part of the icy plate, where the attrition had been made, yet we were unwilling to determine the matter; till further and exacter trial have been made.

6. AND this brings into my mind an experiment, that has by some been thought very strange. The occasion I remember was, that I received the last winter the honour of a visit from a nobleman of great eminency and learning, who chancing to come in, while I was making some trials with ice, would needs know what I was doing with it; but the presence of a very fair lady, in whom *Hymen* had made him happy, and of some other company of that sex, that he brought along with him, inviting me to give him the answer, that I thought would be most suited and acceptable to his company, I merrily told him, that I was trying, how to heat a cold liquor with ice; and to satisfy him, that was no impossibility, I held out an open-mouthed glass, full of a certain liquor (which for some just reasons I do not describe, but do plainly teach it in an opportuner place) and desired them to feel, whether it were not actually cold. And when they were satisfied it was so, I chose among the pieces of ice, that lay by me, that I judged by the eye to be fit for my purpose, (for every piece was

not so, for a reason I elsewhere shew,) and throwing it into this liquor, it did not only in a trice vanish in it, but the lady, I was mentioning, seeing the liquor smoke, and advancing hastily to try, whether it were really warm, found it so hot, that she was quickly fain to let it alone, and had almost burnt her tender hand, with which she had, in spite of my dissuasion, taken hold of the glass, which her lord himself could scarce endure to hold in his. But this experiment, which for the main I have repeated before competent witnesses, though it be not impertinent to the *History of Cold*, yet I shall not build much upon it; because, how strange soever many have been pleased to think it, I shall elsewhere shew, that I made use of a certain unperceivable sleight, which, in my opinion, did as well, as the nature of the liquor and the texture of the ice, contribute to the suddenness and surprizingness of the effect.

7. BUT to return to the duration of the effects of cold, I think those much mistaken, who imagine, that the effects of cold do continually depend upon the actual presence and influence of the manifest efficient, as the light of the air depends upon the sun, or fire, or other luminous body, upon whose removal it immediately ceases. For when cold agents have actually brought a disposed subject to a state of congelation, though the manifest efficient cause cease from acting, or perhaps from being, the effect may yet continue. For in most cases, if a certain texture be once produced in a body, it is agreeable to the constancy of nature, that it persevere in that state, till it be forcibly put out of it, by some agent capable to overpower it. And though we usually see ice and snow, as it were of their own accord to melt away, when the frosty constitution of the air ceases; yet the cause of that may be not barely the cessation of frosty weather, but that those easily dissoluble bodies are exposed to the free air, which being heated by the sun-beams, and perhaps by calorifick exspirations from the earth, is furnished with an actual cause, upon whose account it destroys the texture of the ice and snow. But even here above ground, if snow be well compacted into great masses, in which, by reason of the closeness of the little icicles, but little air is allowed to get between them, I have seen such masses of snow last so long, not only in thawing, but in rainy weather, as to be wondered at; and if such snow (or ice) be kept in a place where it may be fenced from the sun, and other external enemies, though the place, it is lodged in, be not any thing near cold enough to produce ice, yet it will, as some trial hath taught me, preserve ice and snow for a very long time.

Appendix to the XVIth Title.

AN eminent instance to confirm what is delivered at the close of the foregoing section, is afforded us by the conservatories, wherein snow and ice are kept all the summer long. Of these I have seen in *Italy*, and else-

where; but supposing I had the command of some Italian, and other books, wherein I should meet with the dimensions, and other circumstances, that belong to them, my finding my expectation disappointed by those books, makes me think it very well worth while to subjoin somewhat about things, that may give us opportunity of making a multitude of experiments about cold. And therefore meeting the other day (by good chance) with my ingenious friend Mr. *J. Evelyn*, his inquisitive travels, and his insight into the more polite kinds of knowledge, and particularly architecture, made me desire and expect of him that account of the Italian way of making conservatories of snow, that I had missed of in several authors; and having readily obtained my desire of him, I shall not injure so justly esteemed a style as his, to deliver his descriptions in any other words, than those ensuing ones, wherein I received it from him.

[THE snow-pits in *Italy*, &c. are sunk in the most solitary and cooled places, commonly at the foot of some mountain or elevated ground, which may best protect them from the meridional and occidental sun: 25 foot wide at the orifice, and about 50 in depth, is esteemed a competent proportion. And though this be excavated in a conical form, yet it is made flat at the bottom or point. The sides of the pit are so joiced, that boards may be nailed upon them very closely jointed. (His Majesty's at *Greenwich*, newly made on the side of the Castle-hill, is, as I remember, steened with brick, and hardly so wide at the mouth.) About a yard from the bottom is fixed a strong frame or tressel, upon which lies a kind of wooden grate; the top or cover is double thatched, with reed or straw, upon a copped frame or roof, in one of the sides whereof is a narrow door-case, hipped on like the top of a dormer, and thatched; and so it is compleat.

To conserve snow:

THEY lay clean straw upon the grate or wattle, so as to keep the snow from running through, whilst they beat it to a hard cake of an icy consistence, which is near one foot thick: upon this they make a layer of straw, and on that snow, beaten as before; and so continue a bed of straw, and a bed of snow, S. S. S. till the pit be full to the brim. Finally, they lay straw or reed (for I remember to have seen both) a competent thickness over all, and keep the door locked. This grate is contrived, that the snow melting by any accident in laying, or extraordinary season of weather, may drain away from the mass, and sink without stagnating upon it, which would accelerate the dissolution, and therefore the very bottom is but slightly steened. Those, who are most circumspect and curious, preserve a tall circle of shady trees about the pit, which may rather shade, than drip upon it.]

THUS far this learned gentleman's account of conservatories of snow. And on this occasion I might add what the Dutch in their *Nova Zembla* voyage relate, namely, that 'the three and twentieth of *June*, though it were fair 'sun-shiny

‘ sun-shiny weather, yet the heat was not so strong, as to melt the snow, to afford them water to drink; and that in spite of their being reduced to put snow in their mouths, to melt it down into their throats, they were compelled to endure great thirst.’ But because it was in so cold a climate, that this duration of the snow was observed, I shall take notice, that in the *Alps*, and other high mountains, even of warmer climates, though the snow doth partly melt towards the end of summer; yet in some places, where the reflection of the sun-beams is less considerable, the tops will even then remain covered with snow, as we among many others have in those countries observed. And for further confirmation of the doctrine delivered at the end of this 16th title, I shall subjoin a passage, which having unexpectedly met with in an unlikely place of Captain *James’s* voyage, I think not fit to leave unmentioned here; not only because it is the sole artificial observation, that I yet met with, concerning the lasting of ice, and so may recommend to us the ingenuity of an author, whose testimony we somewhat frequently make use of; but because the observation is in itself remarkable, and notwithstanding the difference of places may serve for the purpose we alledge it: our navigator’s words are these; page 101. ‘ I have in *July*, and in the beginning of *August*, taken some of the ice into the ship, and cut it square two foot, and put it into the boat, where the sun did shine on it with a very strong reflex about it. And notwithstanding the warmth of the ship (for we kept a good fire) and our breathings, and motions, it would not melt in eight or ten days.’ And it is also considerable to our present purpose, what the same author elsewhere has about the durability of the congelation of the ground not yet thawed at the beginning of *June*. ‘ For the ground (says he) pag. 65. was yet frozen; and thus much we found by experience in the burying of our men, in setting up the king’s standard towards the latter end of *June*, and by our well at our coming away in the beginning of *July*; at which time upon the land, for some other reasons, it was very hot weather.’

T I T L E XVII.

Considerations and experiments touching the Primum Frigidum.

1. **T**HE dispute, which is the *Primum Frigidum*, is very well known among naturalists; some contending for the earth, others for the water, others for the air, and some of the moderns for nitre: but all seeming to agree, that there is some body or other, that is of its own nature supremely cold, and by participation of which, all other cold bodies obtain that quality.

2. **B**UT for my part, I think, that, before men had so hotly disputed, which is the *Primum Frigidum*, they would have done well to inquire, whether there be any such thing or no, (in the sense newly expressed.) For though

I make some scruple, resolutely to contradict such several sects of philosophers, as agree in taking it for granted, yet I think it may be not irrationally questioned, and that upon two or three accounts.

3. For (first) it is disputable enough, as we shall hereafter see, whether cold be (as they speak) a positive quality, or a bare privation of heat: and till this question be determined, it will be somewhat improper to wrangle solicitously, which may be the *Primum Frigidum*. For if a body’s being cold, signify no more than its not having its sensible parts so much agitated, as those of our sensories, by which we are wont to judge of tactile qualities; there will be no cause to bring in a *Primum Frigidum*, upon whose account particular bodies must be cold: since to make this or that body so, it suffices, that the sun or the fire, or some other agent, whatever it were, that agitated more vehemently its part before, does now either cease to agitate them, or agitate them but very remissly, so that, till it be determined, whether cold be a positive quality, or but a privative; it will be needless to contend, what particular body ought to be esteemed the *Primum Frigidum* (in the sense above specified.)

4. Secondly, though it be taken for granted, not only by the schools, but by their adversaries the chymists, that heat and moisture, dryness and gravity, and I know not how many other qualities, must have each of them a *πρωτον δεικτικον*, or a principal subject to reside in, upon whose account, and by participation of which, that quality belongs to the other bodies, wherein it is to be met with; though this be so, I say, yet we have * *elise* * *In the* where fully enough manifested, that this fundamental notion, upon which much of the *Sceptical Chymist* doctrine of qualities is both by Aristotelians, and vulgar chymists, superstructed, is but an unwarrantable conceit, and therefore not sufficient for a wary naturalist to build the notice of a *Primum Frigidum* upon; there being indeed many qualities, as gravity, and figure, and motion, and colour, and sound, &c. of which no true and genuine *πρωτον δεικτικον* can (for aught I could ever yet discover) be assigned. And because heat and cold are looked upon as diametrically opposite qualities, we may consider, that it will be very hard to shew, that there is a *πρωτον δεικτικον* of heat; since stones, and metals, and plants, and animals, and (very few excepted) all consistent bodies, we are conversant with, may by motion be brought to heat; which to attribute to the participation of some portion or other of the imaginary element of fire, is not only precarious (being affirmed by many, and proved by none) but erroneous, or at least needless, as we have more at large declared in other papers. *The Dialogues about Heat and Flame.*

5. A third thing, that induces me to question, whether there be a *Primum Frigidum*, is, that among those bodies, that the chiefest sects of philosophers, whether ancient or modern, have pitched upon, there is not any, that seems clearly to deserve the title of *Primum*

Primum Frigidum. But to make this appear, we must distinctly (though as briefly as our design will permit) consider those four several bodies, which we have (at the beginning of this section) taken notice of, to stand in competition, in the opinions of philosophers, for the title of *Primum Frigidum*.

6. FIRST then, *Plutarch* and others contend, that it is the earth; but to omit other arguments, we see, that the earth is frozen not by its own cold, but by its vicinity to the air, as may be argued by this, *viz.* that the congealing cold, even in the midst of winter, affects but the surface of the earth, where it borders on the air, and seldom pierces above a few feet, or, at most, yards, beneath that part, wherein the earth is exposed, and immediately contiguous, to the air; as may appear by what we have formerly delivered concerning the small depth, to which frosts reach in the ground. And therefore if the earth be protected from the air (though by so cold a body as water) it may be kept unfrozen all the winter long; as may be gathered from that remarkable practice in the great salt-marshes of the French islands of *Xaintonge*, where, as a diligent writer of that country, very well versed in the making of the French salt, informs us, when once the season of coagulating salt by the heat of the sun is quite past, the owners are careful, by opening certain sluices, to overflow all the banks, and dams, that make and divide the salt-ponds, and serve for the workmen to pass to and fro: for (says my author in his own language) if they left those marshes (or salt-works) uncovered, the frost would make such havock amongst them, that it would be necessary to make them up again every year; but by means of the water they are preserved (or kept in repair) from year to year. Which practice I the rather mention, because the hint, it affords, as it is considerable to our present purpose, so it may on some occasions be applicable to practices useful to human society.

7. BESIDES, the earth being (according to those we reason with) the coldest, heaviest, and solidest of elements, it is not so probable, as to excuse them from need of proving it, that those excessively cold agents, that freeze the clouds into snow and hail, should be terrene exhalations carried up to the middle region of the air; especially since it must be done by agents, either hard to be guessed at, or considerably hot. And it is not easy to give a reason, why, if elementary corpuscles, steaming from the earth, have such a congealing cold, where they are disunited, and but interspersed among the particles of air; the mass of the earth it self, whence those exhalations are supposed to proceed, should not be able also to congeal water, since the terrestrial corpuscles being more thick set, and united in a clod of earth, than in an equal portion of the atmosphere, it seems, that where the frigorifick matter is more dense, the cold should be more vehement; as philosophers observe, that heat is more intense in a glowing bar of iron, than an equal portion of the flame of kindled straw.

8. BUT (not to repeat what we formerly mentioned about cold's being a privation) there is another argument against the earth's being the *Primum Frigidum*; and that is taken from the subterranean fires, which breaking forth in many places of the earth; as in *Ætna*, *Vesuvius*, *Hecla*, the *Pico of Teneriffe*, &c. seem to argue a subterranean fire; upon whose existence not only many chymists build great matters, but even divers philosophers have adopted it, as to employ it as one argument of the earth's being naturally neither hot nor cold. The mention of this subterranean fire brings into my mind some things, that I have met with amongst good, though not classick, authors, and amongst men, that have been either diggers of, or conversant in, mines, not improper to be here taken notice of. For though I do not now intend to declare my opinion about the central fire, either of the chymists or Cartesians, and though the examples newly mentioned, and such other, seem to me but very inconsiderable, in reference to the whole earth; yet it is observable to our present purpose, that there should be so much subterranean heat or warmth, at least generally to be met with. For even where there appear no manifest signs of subterranean fires, I have known those, that were wont to go to the bottom of deep mines, complain, that a very little exercise would put them into a great sweat; and a learned and experienced French doctor, that hath written in his own language, of stones and jewels, affirms, that in such mines the subterranean vapours and exhalations, are visibly so abundant, and likewise so hot, that the mine-men are constrained (which a person I spoke with affirmed to me, touching himself) to work in their shirts, by reason of the great heat they there felt. And though I would have been glad to know, whether those deep places would have appeared as hot, when judged of by a sealed weather-glass, as they did to the mine-mens sensories, because of some little doubt I harboured, whether much of that copious sweating, and seeming heat, might not proceed from the thickness of the dampish air, and its unfitnes for respiration; yet, because a virtuoso, that had a lead-mine of his own, in which he wrought himself for curiosity, answered me, that he was not wont to find any difficulty of breathing in the place, where he was so apt to sweat; and since I find not, that others have complained of having their respiration incommodated in such places, unless by accidental damps, my scruple was much abated; and the rather, because the author lately mentioned expressly affirms, *ibid.* that the sudorifick heat (if I may so speak) is to be found in the bowels of the earth, as well in summer as in winter, which prevents the ascribing of it to *Antiperistasis*. And in other places than mines it is generally observed, that wells and springs freeze not, if the place whence the water is drawn be very deep; but, as we have observed elsewhere, that it oft comes up smoking, and, as it were, reeking; which argues, that at the least the earth, wherein it was harboured, or through which it passed, was,

De Claves
au second
Livre des
pierres &
pierreries,
cap. 2.

Monsieur de
Claves,
liv. 11.
cap. 8.

was, if not warm, free from such a degree of cold, as might be expected in the earth, if it were the *Primum Frigidum*. Nor can it be reasonably pretended, that the subterranean heat comes from the beams of the sun, since learned men have observed, that those heat not the earth above six or seven foot deep even in Southern countries; and though we should allow them to pierce three times as far, yet that would not be considerable to the depth of the mines above-mentioned; and if the lower part of the earth were of its own nature cold, and received the heat it discloses only from the sun and stars, the deeper men dig, the lesser of heat and steams they would meet with; whereas the above-cited French mineralist affirms, that the lower they go, the more vapours, exhalations, and heat they find.

9. BUT because this learned man delivers this circumstance in a dogmatical, rather than an historical way, I will add somewhat out of a relation (whence I have * elsewhere taken other particulars) made by a French physician likewise, that had the curiosity to descend himself into the deep mines of *Hungary*; some of which, that he went down into, may be collected by his narrative, to have three or four hundred fathom, that is, eighteen or twenty-four hundred foot of perpendicular depth. This author then relates, that after he had descended about 80, or 100 fathoms, he came into a very warm region of the earth, which lasted to the bottom of the mine, and is so hot both winter and summer, that the labourers are wont to work in it without their clothes, and he was scarce able to indure the heat of it, although the external air were very hot, the weather being very fair, and the month *July* †. He adds, that he having demanded of the overseer of the mine, whence this heat came, he was answered to that and several other questions, that it came from the lower parts of the earth; that wherever they dig the ground, after they are come to such a depth (which he elsewhere mentions to be about 80 or 100 fathom) they feel no more any cold, but a perpetual heat, how deep soever they dig, (‡ yet without observing, that after they are once got into that warm region, they find the heat sensibly increase, the nearer they approach to the centre of the earth, unless by accident they happen to dig through veins of hotter minerals.) And these answers (subjoins my author) I received not in one mine alone, or from a single overseer, but in all the mines, and from all the masters of them; so that if these were not mistaken, we may safely conclude, that as far as experience can inform us, the body of the earth in its lowermost parts,

V O L. II.

where it is presumed to be coldest, is every where, and that considerably, hot. I said if, *if these mine-men were not mistaken*, because having been in the bottom of some mines myself, though I find it acknowledged, that it is still warm in the bottom of deep ones; yet I confess, I somewhat suspect, by what I have observed, that this degree of heat, which our French physician found in the Hungarian mines, might be rather in great part from the peculiar nature of those places, or of the minerals generated there, than barely (as he and those, that informed him, suppose) from the greatness of their depth beneath the surface of the earth: for I know several mixtures, besides those that are common, of bodies neither of them actually hot, which will produce a considerable degree of heat. And very credible eye-witnesses affirm, that in some parts of *England* they dig up a good store of a vitriolate nature, which, by the bare addition of common water, will grow hot, almost to ignition. So that the Hungarian mines being deep, as appears by our author's narrative, being not destitute of water enough to make a subterranean spring in the mine itself, besides what water may plentifully ascend in the forms of vapours, and moisten the ore, it may be suspected, that either the water, or some appropriated mineral spirit or juice (of which the bowels of the earth may contain divers, that we know nothing of) may produce, together with the mineral, a warm steam, which, for want of sufficient vent in those narrow, and close places, may heat them considerably. Which conjecture may be countenanced by these three circumstances, that I took notice of in our author's narrative; one, that the smoke, that copiously ascended out of the mine by the perpendicular groove, was not barely hot, but consisted of stinking exhalations, which were so saline, and fretting, as oftentimes to corrode and spoil both the wooden ladders or stairs, and the iron instruments of the diggers. The other, that the overseers themselves of the mines told *Morinus* (as we lately saw) that they in some places met with veins of hot minerals, which made it hotter than the bare vicinity of those places to the centre of the earth would have done. And lastly ||, as our author was descending into the golden mine at *Cremnitz*, he found in one place, the heat to increase as he descended more and more, (which seems not to agree with a passage we lately mentioned out of him) and to exceed any he had met with in any other mine; and afterwards the overseer bringing him into a room, that abounded with smaragdine vitriol, (the

K k k k

mineral

* In the discourses about *Antiperistasis*, the following passages are taken out of a small narrative, consisting of about two sheets of paper of *Jo. Baptista Morinus*, published in the year 1619, and entitled, *Relatio de Locis Subterraneis*, annexed to a discourse (too much built on Astrological and Aristotelian grounds) of the threelfold region, that he conceives to be as well in the earth as in the air.

† Unde calor ille procederet petii à præfetto. Respondit, ex partibus inferioribus, inferius enim perpetuo calet. Quod responsum magis adhuc miratus, quæsi an res ita sese haberet in fodinis omnibus. Respondit ita se habere in omnibus, saltem profundis, ut post profundum terræ frigide tractum, in locum calidum descendatur. Et quod, ubicunque terra foditur post similem profunditatem, nullum amplius sentitur frigus, sed semper calor, quantumcunque profundè foditur.

‡ Percussatus sum, an quo magis acceditur ad terræ centrum, calor ille major perciperetur. Respondit, id nunquam fuisse animadvertitum, nisi interdum dum fodiendo occurrerent venæ calidorum mineralium.

— Hæc responsa non in unica fodinâ, sed ab unico præfetto accipi; sed, &c.

|| Cum descendendo calorem illam magis ac magis augeri sentirem; hujus rationem petii à præfetto, quod in nullâ adhuc odinâ similem caloris intensiorem perciperem. Respondit, mineram vitrioli paulo inferius existere, quæ calorem multiplicaret.

mineral, whence this heat proceeded) though the room were spacious, he found there, besides a sharp spirit very offensive to his throat, so troublesome a heat, that he was ready to faint away with sweating, and very much wondered how the diggers were able to work there. And elsewhere the author himself notes, that such hot mines of vitriol, or sulphur, may be found even in the first region of the earth, (as he calls that, which is somewhat near the surface, which he thinks fit to name the *cold region*) and within a large sphere of activity make it perpetually hot. But this, as I was intimating, I mention but as a suspicion, or a conjecture; and notwithstanding that the degree of heat may be much increased in these mines, by the concurrence of accidental causes, in case the conjecture be admitted; yet the frequency of a sensible degree of heat in very deep places does very little favour their opinion, that will allow the earth to have no other heat but what it receives from the sun-beams, or by the manifest fire of burning hills, as *Ætna* and *Vesuvius*. And if it should be objected, that this subterranean heat is adventitious to the earth, which is supremely cold of its own nature; *Gassendus* might reply, that it is as likely, that the coldness of it near the superficies may be adventitious too, and that it appears at least as manifestly, that the one proceeds from the contiguous air, as it does, that the other proceeds from some included fire. And if I misremember not, he hath this consideration, that it is somewhat strange, that nature should have intended the earth for its *Summum Frigidum*, and yet that a greater part (and for aught we know the greatest) should be constantly kept warm, either by the sun, as under the torrid zone, or by the subterranean fires. But the objection mentioned against *Gassendus* opposes but one of the arguments we have alledged against the earth's being the *Primum Frigidum*, and would leave the others in their force, though it did more convincingly answer that, against which it is framed, than it seems to do.

10. AND if the patrons of the earth's coldness, to evade the arguments I have alledged, should pretend, that when they affirm the earth to be the *Primum Frigidum*, they mean not the elementary earth, but some body that is mingled with it; I shall desire to know, which it is they mean, of the many other bodies, that make up the terrestrial globe, that we may examine what right it has to that title. And in the mean time I shall conclude against them, that the earth it self has none, since they grant a colder body than it, and such a one as the earth must be beholden to, for the greatest degrees of coldness it chanceth to possess.

11. BUT though, I presume, enough has been said to make it appear unlikely, that the earth should be the *Primum Frigidum*, yet I must in this dissent from the learned *Gassendus*, that he thinks the earth, not only not to be the *Pri-*

mum Frigidum, but not to be naturally cold any more than hot. For the insensible parts of the earth, like those of other firm bodies, being heavy, and perhaps gross, and either having no constant motion at all, or at least a far more remiss agitation, than that of our sensories; it seems to follow, that the earth must seem cold to us, unless it be, by the communicated heat, or motion of some extrinseck agent, put into a degree of agitation, that belongs not to its nature. And for the like reason I think it not improbable, that pure earth should in its own nature be colder, than either pure water, or pure air; since the earth being a consistent body, its component particles are at rest among themselves, or at least moved with an almost infinite slowness; whereas water and air being fluids, their component particles must be in a restless and various motion, and consequently be less remote from heat, which is a state, wherein the various agitation of the minute particles is more vehement.

12. AND if those, that plead for the earth, had declared, that they meant not the pure or elementary earth, but that part of the terrestrial globe, that is distinct from the sea, and other waters, that make it up, and would have earth in that sense not to be the *Primum Frigidum*, but only the *Summum Frigidum*, perhaps they might have a better plea for their opinion, than they can urge for theirs; who contend for the water or the air; especially, if, to countenance their opinion, this memorable observation be added, which I have met with among those navigators, that have had the greatest experience of the frigid zone; for the Dutch, that sailed thrice to *Nova Zembla*, and once wintered there, * affirm in their first voyage, that the highest degrees of cold are not to be met with in the main sea, where yet men are most exposed to the operations of the air, and of the water, but either upon the land or near it. That accurate geometrician and hydrographer *Fournier* tell us, that in 1595, the Hollanders being intercepted by icy shoals in the strait of *Weigats*, and meeting with certain *Muscovites*, demanded of them, whether those seas were always frozen; and were answered, that neither the northern sea, nor that of *Tartary* did ever freeze; and that it was only that strait, with the sea contiguous to the shores of some bays and gulphs, that were frozen. And our judicious author not only adds, that in effect all those, that sail into those parts, relate, that all those lumps of ice are such as have been loosened, and sever'd from the islands, and the rivers of the *Samojeds* and *Tartars*, but adventures to affirm in general terms, that it is certain, the main seas never freeze, and that it is but the confines, and shores of some of them, that are frozen.

13. THAT the water is the *Primum Frigidum*, the opinion of *Aristotle* has made it to be that of the schools, and of the generality

* It was not the sea, nor the nearness unto the pole, but the ice about the land, that lett and hindred us (as I said before; for that as soon as we made from the land, and put more into the sea, although it was much farther northward, presently we felt more warmth, and in that opinion our pilot *William Barents* died, who notwithstanding the fearful and intolerable cold that he endured, yet he was not discouraged, but offered to lay wagers with divers of us, that by God's help he would bring that pretended voyage to an end, if he held his course north-east from the north cape. *Gerat de Veer in Puchas*; p. 474.

of philosophers. But I can as little acquiesce in this opinion, as in the former, not finding it agreeable to what experience teaches us.

14. For not to mention, that it would be very difficult to prove, that divers very cold bodies, as gold, and silver, and crystal, and several other fusible stones have in them any water at all, to which their coldness may with any degree of probability be ascribed; nor to urge the arguments, that some modern contenders for the supreme coldness of the air are wont to employ; not (I say) to insist on such things, I shall content my self to make use of this obvious *φαιδόμενον* of cold, that in rivers, ponds, and other receptacles of water, the congelation begins at the top, where the liquor is exposed to the immediate contact of the air; which sufficiently argues, that the air is colder than the water, since it is able not only sensibly to refrigerate it, but to deprive it of its fluidity, and congeal it into ice: whereas if the water it self were the *Primum Frigidum*, either it ought to be, at least as to the major part of it, always congealed, or we may justly demand a reason, why, when it does freeze, the glaciation should not begin in the middle, or at the bottom, as soon as at the top, if not sooner. And our arguments against the precedency of the water in point of coldness may be strengthened by this, that frosts are wont to be hardest, when the air is very clear, and free from aqueous vapours; whereas in rainy weather, wherein such vapours most abound, the cold is wont to be far more remiss. To which we may add, what we lately delivered from the observation of navigators, that even in the frigid zone the main sea, where yet the water is in the greatest mass, and so most likely, as well as advantaged to disclose its nature, never freezes, though the straits, and bays, and gulphs be frozen over; which argues, that the greatest degrees of cold are rather to be assigned to the air, or to the earth, than to the water, which by the practice formerly mentioned of the masters of the French salt-marshes appears to be (when it is of a considerable depth) fitter to preserve bodies from congelation, than to congeal them. Which instance I the rather repeat, because it seems to argue, that the water is not so much as disposed to receive any very intense degree of cold at a remote distance from the air. For though navigators tell us of exceeding thick pieces of ice, yet, as we have already elsewhere noted, we are not bound to believe, that the congealing cold has pierced any thing near so much as that thickness amounts to, from the superficies of the sea directly downwards: for though it were no great matter, if it did, in comparison of that depth of the sea, which, though the water be naturally cold, the sharpest air is unable to congeal; yet we have elsewhere proved, that those thick masses of ice are not solid and intire pieces, but rather heaps of many flakes, and other fragments of ice, which running upon one another, or sliding under one another, are by the congelation of the intercepted water (and perchance half thawed snow) as it were, cemented together into mishapen unwieldy

masses: which conjecture agrees very well with that observation of the ingenious captain *James*, which he delivers in these words:

‘ It seldom rains after the middle of *September*, but snows; and that snow will not melt on the lands, nor sands: at low water, when it snows (which it doth very often) the sands are all covered over with it, which the half-tide carries officiously (twice in twenty-four hours) into the great bay, which is the common rendezvous of it. Every low water, are the sands left clear, to gather more to the increase of it. Thus doth it daily gather in this manner till the latter end of *October*, and by that time hath it brought the sea to that coldness, that as it snows, the snow will lie upon the water in flakes, without changing its colour, but with the wind is wrought together, and as the winter goes forward, it begins to freeze on the surface of it, two or three inches, or more in one night; which being carried with the half tide, meets with some obstacle (as it soon doth) and then it crumples, and so runs upon it self, that in few hours it will be five or six foot thick; the half-tide still flowing, carries it so fast away, that by *December* it is grown to an infinite multiplication of ice.’ Thus far this navigator; to which I shall add another passage out of one of his countrymen, (Mr. *Hudson*, famous for the northern discoveries, that bear his name) by which, added to what has been elsewhere delivered to the same purpose, we may be invited to believe, that the vast hills and islands of ice, that are to be met with about the straits of *Weigats*, and elsewhere, are not generated of the sea it self. ‘ It’s no marvel (says he, *Purchas*, lib. 3. cap. 15. p. 579.) that there is so much ice in the sea towards the pole, so many founts and rivers being in the lands of *Nova Zembla*, and *Newland* to ingender it, besides the coasts of *Pecora*, *Russia*, and *Greenland*, with *Lappia*, as by proof I find by my travel in those parts.

15. But for all this, I think not fit, as does the ingenious *Gassendus*, and some others, to make the water indifferent, as to heat and cold. For, as I formerly noted concerning the earth, so I must now represent touching the water, that, setting aside the heat of the sun, which is but adventitious, where it does operate, and which leaves many vast portions of that element, which it does not constantly reach, the insensible parts of water are much less agitated, than those of our sensories temperately disposed, and consequently may in regard of us be judged cold. For though water being a liquor, I readily allow it a various motion of its component corpuscles, (that being requisite to make a body fluid,) yet such an agitation, which is sufficient for fluidity, may be, and often is, far more remiss, than that of the spirits, blood, and other liquors of so hot a sanguineous animal as man; as we see, that urine, though after it has been long omitted, it continues a fluid body, yet its parts are far less agitated, than they were, when it came hot, and reeking out of the bladder.

16. AND upon this occasion, I shall add, what by inquiry I have learned, that (except the

the parts somewhat near the superficies of the water, which the heat of the sun, or the warmth of the neighbouring lower region of the air may give some warmth to) the whole body of the sea is very cold: for being very well acquainted with one, that for some time got a livelihood by going down into the bottom of the sea, to fetch up what could be recovered out of shipwrack't vessels, I purposely inquired of him, what cold he felt under water; and he more than once told me, that though near the top of the water the cold were very moderate, yet when he was necessitated to descend a great depth, he found it so great, that he could not very long support it. And particularly he told me, that having occasion to descend about twelve or fourteen fathom deep (which is nothing in comparison of the depth of many seas) to fasten ropes to the ordnance of a great ship, that was some years since cast away, near the coast of one of the northern countries; though he was not incommoded in point of respiration, and though he felt no other inconveniencies, that might dissuade his tarrying longer, yet the cold was so great, and troublesome, that he was not able to endure it above two or three hours, but was constrained to remount to a milder, as well as higher region. I wished several times he had had with him a weather-glass (for ordinary thermometers would on that occasion have been unserviceable) to prevent some little doubt, that might be made, whether the intense cold he felt might not be only and chiefly in reference to his body, which might be so altered, and disposed by this new briny ambient, as to make such a disturbance in the course or texture of his blood, as that, which makes aguish persons so cold at the beginning of the fit, though the temperature of the ambient body continue the same. But this is not the only person, that found the sea exceeding cold; for I remember *Beguinus* relates from the mouth of a Marseilian knight, that was overseer of the coral-fishing in the kingdom of *Tunis*, that having upon that coast let down a young man, to feel whether coral were hard or soft, as it grew in the water, when this man was come about eight fathom, near the bottom of the sea, he felt it exceeding cold. To which we shall add the testimony of a sober traveller *Josephus Acofta*, who tells us, 'That it is a thing remarkable, that in depth of the ocean, the water cannot be made hot by the violence of the sun, as in rivers: finally (he subjoins) even as salt-petre (though it be of the nature of salt) hath the property to cool water, even so we see by experience, that in some parts and havens, the salt water doth refresh; the which we have observed in that of *Callao*, where they put the water or wine, which they drink, into the sea in flaggons to be refreshed: whereby we may undoubtedly find, that the ocean hath this property, to temper and moderate the excessive heat.' For this cause we feel greater heat at land than at sea, *cæteris paribus*, and commonly countries lying near the sea are cooler than those that are farther off. By all

Beguinus
in *Tyrocinio*
Chymico,
lib. 2. c. 1.

Josephus
Acofta lib.
2. cap. 11.

these testimonies, it seems to appear, that both in very cold regions, and very hot, the deep parts of the sea seem to be very cold, the sunbeams being not able to penetrate the sea to any great depth: for I remember, that having enquired of the diver I lately mentioned, whether he could discern the light of the sun at any great distance from the surface of the water, he answered me, that he could not; but as he went down deeper and deeper, so he found it darker and darker, and that to a degree, that would scarce have been expected in so diaphanous a body as water is.

17. BUT this submarine cold (if I may so call it) though it be great and considerable, is not so intense, as to intitle water to be the *Primum Frigidum*; since as cold as our divers found it at the bottom of the sea, they did not find it cold enough to freeze the water, as the air often does at the top.

18. THE next opinion, we are to consider, is that of the Stoicks of old, and adopted by the generality of modern philosophers, that are not Peripateticks, who assert the air to be the *Primum Frigidum*: but being ere long more particularly to treat of the temperature of the air, we will reserve till then to examine, whether it be cold of its own nature or not; but in the mean time, we shall here take leave to question, whether it ought to be esteemed the *Primum Frigidum*. For not to mention, that *Aristotle*, and the schools, with many other learned men, think the air so far from being the coldest of the elements, that they reckon it among the hot ones, because I confess their opinion is not mine, not to represent the heat of the air in the torrid zone, nor that by the generality of philosophers, the upper region of the air, which is believed to make incomparably the greatest part of it, is always hot, and the lower region is so too, in comparison of the middle, though the coldness even of this is not perhaps unquestionable; not to urge any of these things, I say, I shall in this place mention only two observations.

19. THE one is that, which I lately recited, touching the great coldness of the water in the deeper parts of the sea; for it is not easy to shew, how this great cold proceeds from that of the air, whose operation seems not (as may be judged by that little way that frosts pierce into the moist earth) to reach very far beneath the surface of the water, (insomuch that captain *James*, who had very good opportunity to try, allows not, in case the ice be not made by accumulation, that the frost pierces above two yards perpendicularly downwards from the surface of the water, even in the coldest habitable regions.) And this will seem the more rational, if we consider, that in case the coldness of the sea proceeded constantly from the air, as such, the cold would be greater near the surface, where it is contiguous to the air, than in the parts remoter from it; and yet the contrary may appear by the passages lately recited.

20. BUT if it be objected, that this at best can prove no more, than that the air is not the *Primum Frigidum*; notwithstanding which,

it may be the *Summum Frigidum*. For answer, I must proceed to my second argument, which will perhaps evince, that it is not that neither; for by the same way of arguing, by which those, I am now dealing with, endeavour to prove the air to be the coldest body in the world, I shall endeavour to prove, that it is not so: for their grand, and (as far as I remember) their only considerable argument is drawn from experience, which shews, that water begins to freeze at the top, where it is exposed to the air. But to this vulgar experiment I oppose that of mine, which I have often mentioned already to other purposes, that by an application of salt and snow, I can make water, that would else freeze at the top, begin to freeze at the bottom, or at any side I please, and that much sooner than the common air, even in a sharp frosty night, would be able to congeal it: and when in exceeding cold weather the ambient nocturnal air had reduced a parcel of air, purposely included in a convenient glass, to as great a degree of condensation as it could; I have more than once, by the external application of other things, been able to condense it much farther: which argues, that it is not the air as such, but some adventitious frigorifick corpuscles (taking that term, as I do in this treatise, in a large sense) that may sometimes be mingled with it, which produce the notablest degrees of cold, or upon whose account the air produces them. And if these be duly applied, water will be congealed, whether air comes to touch the surface of it or no; nay, though bodies, which the air can never penetrate, nor congeal any of their parts, be interposed, as may appear by the experiments formerly mentioned of freezing water included in glass bubbles, and suspended in oil of turpentine, and other uncongealed liquors; and it is worth taking notice of by them, that conclude the air's being the *Primum Frigidum*, from the water's beginning to freeze at the top, where it is contiguous to the air, that it is there also, where the ice begins to thaw.

21. BESIDES the three opinions we have hitherto examined, there is a fourth, that justly deserves to be seriously considered; for the learned and ingenious *Gassendus* is supposed, though I doubt how truly, to be the author of it; and though, according to his custom, he speaks warily, and not so confidently of it, yet in his last writings he much countenances it; yet some eminently learned men, as well of our own, as of other nations, have resolutely enough embraced it. According then to these, the congelation of liquors, and the cold we meet with in the air, water, and other bodies, proceeds from the admixture of nitrous exhalations, or corpuscles introduced into them: and as I have a great respect for divers of these men's persons, so I like very well, in their opinion, that they do not ascribe the supreme degree of frigifactive virtue to the air itself, but to some adventitious thing, that is mingled with it: but whereas they pitched upon nitre, as the grand universal efficient of cold, I confess I cannot yet fully acquiesce in that tenet. For though I am not averse

from allowing salt-petre to be one of those bodies, that are endued with a refrigerating power, and to be copiously enough dispersed through several portions of the earth; yet, for aught I know, there may be not only divers other causes of cold, but divers other bodies qualified to be efficient of cold, as well as salt-petre.

22. AND first, if cold be not a positive quality, but the absence of heat, the removing of calorifick agents will in many cases suffice to produce cold; without the introduction of any nitrous particles into the body to be refrigerated. But because it is disputable, whether cold be a positive quality or no, we will urge this argument no further, till the controversy be decided; and till then, as it will remain not improbable, we propose it as no other, but proceed to the next.

23. IN the second place, I see not as yet any proof, that the great cold, we have formerly mentioned to be met with in the depths of that vast body, the sea, especially when it is greater elsewhere than nearer the top, where the air may better communicate its coldness to it, must be the effect of nitrous atoms, which must certainly swarm in prodigious multitudes, to be able to refrigerate every drop and single particle of so stupendously vast a body as the ocean. Besides that I remember not to have found or known it observed, that nitre, especially in vast quantities, reaches near so deep in the earth, as those parts of the sea, that are found exceeding cold. And as the halituous part of nitre is more disposed to fly up into the air, than drive down into the sea; so we find no great documents of its having its grosser and sensible parts abounding in the sea-water, since the evaporations of that leaves not behind it salt-petre, but common salt. But these, though no light considerations, are not those, that most weigh with me.

24. FOR, in the next place, I am not satisfied with the experiences I find alledged to prove, that it is by nitre, that the air and the neighbouring parts of the earth, and water (not to repeat the objections I lately borrowed from the sea) receive their highest degrees of cold. For when *Gassendus* and others tell us, that it is nitre resolved into exhalations, that makes the gelid wind, which refrigerates all things it touches, and penetrating into the water, congeals it; this, I say, to me will seem precarious, until *Gassendus* (or some other for him) tells us, what experiments they are (which he seems in one place to intimate) that this new doctrine depends on: for I confess, that for my part, I, who have perhaps had more opportunity to resolve nitre, have seen no great feats, that the steams of it have done, more than those of other saline bodies, in the production of cold; and the spirit of nitre, which is a liquor consisting of the volatile parts of that resolved salt, not only does not (that I have observed) appear to the touch to have considerably, if at all, a greater actual cold, than that of divers other liquors, but seems to have a potential heat. For whether or no the exhalations of nitre be able to congeal water into ice, I have formerly

observed, that the spirit of nitre or aqua fortis will dissolve ice into water, very near, if not altogether as soon as the spirit of wine it self; which inflammable liquor is generally acknowledged to be in a high degree potentially hot. If *Gassendus* did not mean such steams of salt-petre as these, which I have been speaking of, it had not been amiss to have signified, what other kind of corpuscles of resolved nitre he meant, without leaving his reader to divine it: and if we may judge of other experiments, which we lately took notice, * that *Gassendus* seems to intimate by that, which he sets down a little after, compared with that he had mentioned a little before; I am not likely much to be convinced by them, but shall rather be tempted to suspect, that learned man might be imposed upon by others to write that, as matter of fact, which he never had tried, and yet own not the having it by report. For whereas he seems to say, that dissolved nitre mingling itself with water, freezes it, and that in summer; yet I must freely profess, that although some other learned moderns teach the same thing (but without any man's avouching it, that I know, upon his own experience) I, who am no stranger to nitrous experiments, have never been able to produce, or so fortunate, as to see any such effect: and it is somewhat strange to me, that chymists, who make such frequent solutions of nitre, and oftentimes with less water than is sufficient to dissolve it all, so that by consequence the proportion of the nitre to the water must have run through almost all the possible measures of proportion, should never so much as by chance (as I can hear) have observed any such matter. And that, which makes me thus interpret *Gassendus* his meaning, (though in one of the two passages, wherein he sets down this experiment, he mentions also snow, or ice, to be added to the nitre) is, that in the first of those two passages, he ascribes the congelation to nitre alone, without speaking of either ice or snow; and in the other place, not only his words seem to import, † that notwithstanding the addition of the other ingredients, the corpuscles of the nitre expiring out of the mixture, and penetrating into the water, are they, that make it freeze; but the exigence of his discourse seems to require such an interpretation: for to say, it is the corpuscles of the nitre, that were harboured in the ice or snow, that freeze the water they invade, is no better than to beg the question. For besides that he ought to prove, that there are multitudes of the corpuscles of nitre lodged in snow and ice; besides this, I say, since these two bodies are said to be water, before they were congealed, to grant what his explication supposes about ice and snow, is to grant in effect, that nitre alone (without ice or snow) can turn water into ice, which is the thing, that experience

warranted us lately to deny. And if this be all, that is meant by the experiment, the mixing of nitre with the ice, or the snow, will signify very little, to evince what should be proved. For, if instead of nitre you take sea-salt, or the spirit of salt, nay, the inflammable part of wine, the experiment will succeed; and yet I think *Gassendus* would not have the corpuscles of these bodies to be frigorifick, like those of nitre; which yet they may be proved to be by the same argument, which is employed to shew, that the corpuscles of the nitre, which is added as a distinct ingredient to the ice, or to the snow, are the efficient of the congelation.

25. HAVING thus examined *Gassendus* his experiments, we will now, as our next and last argument touching this subject, subjoin our own, as far as we can find any of them among our notes; some of which follow in these words,

26. [As cold as they think salt-petre to be, who teach its spirituous parts to be the grand and catholick efficient of cold, yet we found, that it would dissolve ice readily enough, as well as sea-salt, &c. are wont to do, as we collected from this, that roch'd petre mingled with ice would freeze the vapours wandering in the air to the outside of the single phial, wherein we made the experiment, which the ice alone would not have done; and having placed some grosser beaten nitre (of the same parcel) in little heaps here and there upon plates of ice, we manifestly found them to sink into the ice, which argued their dissolving it; and having put some of it upon a thick and smooth piece of ice, we found, that it had pierced a hole quite through it, whilst the surrounding part of the ice remained of a good thickness.]

27. [WE took a large single phial, almost full of water, and put it into as much roch'd petre, as by keeping it a good while by the fire's side, we could dissolve in it; of which one mark was, that there remained a pretty deal of salt intire at the bottom of the liquor: this being exposed to the air, during an extremely sharp night, and a good part of the day, the solution was frozen so hard to the very top of the liquor, that having broken the glass, we could hardly break the included mass. But at the bottom there appeared some liquor, with crystals of nitre well figured, that seemed to have shot in it, and argued the water to be sufficiently impregnated with the salt.]

28. [As for the spirituous parts of nitre, so far forth as their temper, as to heat or cold, can be judged by distillation, and by weather-glasses, they are not actually more cold than some other liquors, and appear rather to be potentially hot, than cold; at least, they seem indisposed to turn water into ice, since we have tried, that the spirit of nitre will readily enough turn ice into water.]

29. THESE

* *Gassendi Phys. Lib. 6. Sect. 1. pag. 399. De qualitibus rerum—ac addi quidem fortassis potest, præcipua frigoris semina, si quæ constant, potissimum ex frigorificis atomis abire in halinitrum corporaque ipsis affinia, quando experimur non exsolvi halinitrum, quin et penetrando in aquam, ipsam congelet, et universa a se contacta refrigeret, et abscondo in halitum creet gelidum seu frigidum ventum, sed res pendet ex variis, quæ non possunt hoc loco commemorari, experimentis.*

† b. pag. 400. *Quomodo possint corpuscula nitri in aquam insusi illam præter modum adeo frigidam reddere, imò et per æstatem etiam congelare, dum nitrum nivæ glaciæque detritæ commistum lagenæ circumponitur, ipseque præter corpus lagenæ penetrant in aquam contentam.*

29. THESE three foregoing notes shew, that salt-petre is no such wonderfully cold body, but that there are others colder, as being able to freeze water, which nitre could not congeal. Nay, they manifest, that nitre, which is said to be the efficient of ice, does thaw and dissolve it, and so seems, at least in reference to it, to be rather hot than cold.

30. I shall add now one note more, to shew it does not always make water so much as equally cold with the common air; the experiment I find thus recorded.

31. [WE took a sealed weather-glass, and by a little pulley fastned to a frame, suspended it in a solution of roch'd-petre, as strong as we could make it, without heat; as appeared by a pretty quantity of nitre, that had continued some days undissolved in the vessel, which was a beer-glass, with a flat bottom. After the ball of the weather-glass had been suspended in this liquor, to try, whether the ambient air were not at this time colder than the liquor, (it being a cloudy and windy day, and betwixt the hours of 11, and 12.) though both the weather-glass and it had stood some days in the place; I lifted up the glass out of the water by the string it hung by, that I might not touch it with my warm hands, and found the liquor in the glass to descend by degrees, about two divisions (which were eighths of an inch;) and then by the string lifting up the weather-glass, and putting again the solution of nitre under it, the included liquor was impelled up again two divisions, and sometimes two divisions and a half: for to satisfy my self the more fully, I repeated the experiment several times, and observed, that the included liquor usually ascended the first division so fast, that the eye could perceive its progress, and that the ascent upon the immersion in the dissolved nitre was discernibly quicker than the descent, upon the removal of the weather-glass into the open air, though the space both of the one and of the other were about, either two divisions, or two divisions and a half.]

32. If it be here demanded, what then I think of the frigidative virtue of nitre, I must answer, that I have not yet fully satisfied my self concerning it: but thus much I am not willing to deny, that among divers other bodies, that upon several occasions exhale from the terrestrial globe, those corpuscles, that are of a nitrous nature, may be for the most part well qualified to refrigerate the air. And I am not indisposed to think, that there may be store of little saline bodies of kin to nitre, that (especially at certain times) rove in great multitudes to and fro, in some parts of the atmosphere; but that this aerial salt, which some moderns call volatile nitre, should be true and perfect salt-petre, is more than I am sure of, and that this salt alone should be the *Summum Frigidum*, is more than as yet I am convinced of; especially, since, for aught I know, there may be in the bowels of the earth, (whence I have seen many concretes digged out, whose very names and outsidings are for the most part unknown, even to chymists themselves) divers other bo-

dies besides salt-petre, whose steams may have a power of refrigerating the air, as great in proportion to their quantity, as those of salt-petre. And since common salt in artificial glaciations is found to cooperate as powerfully as salt-petre it self; and since it is undeniably a body, of which there is a vast quantity in the terrestrial globe, and which by reason of the sea, where it abounds, is exceedingly diffused; I see no great reason, why we may not as well esteem that kind of salt among the catholick efficiencies of cold, and the rather, because that the smallest corpuscles our eye discerns of sea-salt, are wont to be, (though not exactly) of a cubical figure: which is that figure, *Philoponus* informs us, the great *Democritus* of old (justly admired by *Gassendus*) assigned to the atoms of cold; whereas, according to *Gassendus* himself, the corpuscles of nitre, at least as far as sense has informed us, are not the most conveniently shaped to produce cold, since he labours to shew, that the figure of frigorifick atoms is to be tetrahedral or pyramidal: whereas the crystals, or grains, great or small, into which good salt-petre shoots, are wont to be prismatical, having their base sexangular. But to return to what I was saying concerning the congealing of water with ice, I shall subjoin, that the same experiment countenances my conjecturing, that oftentimes it may not be emanations of one salt, or other body, but a peculiar and lucky conjunction of those of two or more sorts of them, that produces the intense degree of cold; as we see, that ice and snow themselves have their coldness advanced (as to its effects) by the mixture either of sea-salt or nitre, or spirit of wine, or any other appropriated additaments. Nay, I may elsewhere have occasion to shew, that actual cold may be manifestly promoted, if not generated, by the addition of a body, that is not actually cold. But to all this I must add, that I doubt, whether any of those saline or terrestrial exhalations, either single or conjoined, be the adequate causes of cold; since, for aught I know, there may be other ways of producing it besides the introduction of frigorifick, whether atoms or corpuscles, of which we may have occasion to take some notice hereafter. In the mean time, having discoursed thus long against the admitting a *Primum Frigidum*, I think it not amiss to take notice once more, that my design in playing the sceptick on this subject, is not so much to reject other men's probable opinions of a *Primum Frigidum*, as absolutely false, as it is to give an account, why I look upon them, as doubtful.

T I T L E XVIII.

Experiments and observations touching the coldness and temperature of the air.

1. I HAVE shewn in the former section, that the air is not the *Primum Frigidum*; but yet I cannot readily yield my assent to the opinion of the learned *Gassendus*, and some others, (who have written before and since him) that the air is of itself indifferent; that is, neither cold, nor hot, but as it happens to be made

made either the one or the other by external agents. For if we take cold in the obvious and received acceptation of the word, that is, for a quality relative to the senses of a man, whose organs are in a good or middle temper, in reference to cold and heat; I am hitherto inclinable to think, that we may rather attribute coldness to the air, than either heat, or a perfect neutrality as to heat and cold. For to make a body cold as to sense, it seems to be sufficient, that its minute corpuscles do less agitate the small parts of our organs of feeling, than they are wont to be agitated by the blood, or other fluid parts of the body; and consequently, if supposing the air devoid of those calorifick and frigorifick atoms, to which the learned men, I was naming, ascribe its heat and cold, it would constitute a fluid, which either by reason of the minuteness of its parts, or their want of a sufficiently vehement motion, would less affect the sensory of feeling, than the internal liquors and spirits of the body are wont to do, and so it would appear actually cold. Nor is it necessary, that all liquors, much less all fluids, should be as much agitated as the blood and vital humours of a human body, as we see (to omit what in the last section is mentioned about newly emitted urine, and to skip other obvious instances) in those fishes and other animals, whose blood and analogous juices are always, and that in the state, which passes for their natural state, actually cold to our touch. And I see no sufficient reason, why we should not conceive the air even in its natural state, (at least as far forth as it can be said to have a natural state) to be one of the number of cold fluids. For as to the main, if not only, argument of *Gassendus*, and others, namely, that as we see the air to be easily heated by the action of the sun, or the fire, so we see it as easily refrigerated by ice, and snow, and northerly winds, and other efficientes of cold, and that heat and cold reign in it by turns in summer and in winter; this only proves, what I readily grant, that the air is easily susceptible at several times of both these contrary qualities; but it does not shew, that one is not more connatural to it than the other; as we see, that the water may be easily deprived of its fluidity by the circumposition of snow and salt, and reduced to be fluid again by the sun, or the fire; and yet, according to them, as well as to others, fluidity, not firmness, is the natural quality of water. But this is not that, which I lay most weight upon; for I considered, that it is manifest, and acknowledged by these learned men themselves, that the heat of the air is adventitious to it, and communicated by the beams of the sun, or of the fire, or by some other agents naturally productive of heat, as well in other bodies as the air. And it is also evident, that upon the bare absence, (for aught else, that appears) of the sun, or extinction of the fire, or removal of the other causes of heat, the air will, as it were, of its own accord, be reduced to coldness. Whereas, that there are swarms of frigorific atoms diffused through the air, from which all its coldness proceeds, is but an hy-

pothesis of their own, far from being manifest in itself, and not hitherto, that I know of, proved by any fit experiment, or cogent reason. And though in some cases I am not adverse to the admitting such corpuscles, as may in a sense be styled frigorific, yet I see not, why we should have recourse to them in cases, where such a bare cessation, or lessening of former motion, as may easily be ascribed to manifest causes, may serve the turn, as to a *sensible*, (for I now consider not the causes of the *intenser*) coldness in the air, without taking them in. And the opinion, I incline to, has at least this advantage, that the air seems to be as rightfully termed cold, as iron, marble, mercury, crystal, salt-petre, and such other bodies, which men unanimously look upon as such; there being none of these, to which the argument employed against the coldness of the air, is not applicable, save that the air being a fluid of a looser and finer texture, does sooner receive and lose the impressions of heat and cold. And yet if a block of marble, for instance, or an iron bullet, were removed into one of those empty spaces, that *Gassendus*, and some others, supposed to be beyond the bounds of this world, I see not, why it should not be rather cold, than either warm, or in a state of perfect neutrality; since when the corpuscles of heat and those of cold had extricated themselves, and were flown away into the neighbouring vacuum, the component particles of the stone or metal, whose implicated texture would hinder their diffultion, remaining much less agitated than our organs of feeling are by the warm blood and spirits, that vivify them, must, if applied to those sensories, appear cold.

2. I SHALL not, upon this subject, spend any farther discourse, since perhaps the dispute either may be, or at least may easily be made verbal; for in case those I argue with, should so explain their opinion, as not to deny, that in its own nature the air, left to itself, may be reputed cold in reference to the sensories of men, who are warm animals; but say, that nevertheless, comparing it indefinitely to other than human bodies here below, it is so easily susceptible of both the contrary qualities, that neither of them seems predominant in it, and that when it is considerably either cold or hot, it is made so by adventitious agents; I shall not much contend with them, especially if it can clearly be made out, that there are great quantities of such cold spirits, as *Cabeus* and *Gassendus* supposed to be universally productive of cold (more or less) in all bodies, where they get admission: but of these cold spirits more perhaps elsewhere; our principal business in this section being to deliver experiments and observations; and because we shall mention but few of the former sort, we will dispatch them first.

[3. *November* the 20th, 1662. we took a weather-glass, filled to a convenient height, with well-rectified spirit of wine, and hermetically sealed: this we inclosed in a glass receiver of a cylindrical form, of about two inches diameter, and about a foot and a half high, and

and having cemented on the receiver, we let it alone for some hours, that it might be perfectly cool. Then drawing out the air, and watching it narrowly, we observed, that the liquor in the weather-glass descended a little, though but a very little, upon the first exsuction of the air, and a little, though it seemed somewhat less, upon the second; but afterwards we did not find it sensibly to descend. This subsidence of the liquor, in all amounting to about the length of a barley-corn, we attributed to the stretching of the glass by the spring of the included air, when the ambient was withdrawn; and accordingly, upon our allowing a regrefs to the excluded air, we saw the spirit in the thermometer rise about half a barley-corn's length to the place, whence it began to subside. Afterwards we sucked out, and let in the air of the receiver, as before, with like success, as to the descent and remounting of the liquor.

4. *N. B.* WE tried with a very hot handkerchief applied to a convenient place to the outside of the receiver, whether the included weather-glass would receive impressions from it, the air, that was wont to be intermediate, being removed; but we did not find the liquor in the weather-glass sensibly to swell, either by this way, or by casting upon it the concentrated beams of a candle trajected through a double convex-glass. But when the air was re-admitted into the cavity of the receiver, then the same handkerchief, heated afresh, and applied, made the spirit of wine sensibly, though but little more, to ascend; of which, yet it seemed something difficult, by reason of the nicety of the experiment, to estimate with any thing of certainty the cause.] So that upon the whole matter, till the experiment be repeated in air of differing tempers, to verify, whether it was the withdrawing of the wonted pressure, or the recess of the substance of the air, that made the liquor included in the thermoscope subside, and till the experiment be repeated with the further observation of other circumstances, (which reiteration of the trial we intended, but were by intervening accidents hindered) the recited experiments will not afford much more than good hints towards the discovery of the temperature of the air.

I HAVE elsewhere * taken notice, that air, included in vessels sufficiently strong and well closed was not sensibly or at least considerably condensed by cold; but when the air was not so included, as not to be in some part or other exposed to the pressure of the outward air or atmosphere, it would then by a degree of cold, capable to freeze water, be manifestly reduced into a less room. But how much this contraction or condensation of the air may amount to, I did not there subjoin, nor has the measuring of it been, that I know of, attempted by any man. Wherefore we thought fit to endeavour something in this kind, of which we shall annex a brief account, whereby it will appear upon the whole matter, that in the climate we live in, the cold does not so considerably condense the air, as most men seem to have hitherto imagined.

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6. AND first, it will not be amiss to intimate, that among other ways we tried to measure the shrinking of the air by sealing it up in glasses furnished with long and very slender stems, that by breaking off the tips of those glasses immersed under water, when by the cold air of a frosty night, or the circumposition of snow and salt, the included air was highly refrigerated, the water might (by the pressure of the atmosphere upon it) be impelled into the cylindrical cavity of the broken glass, and by its greater or lesser ascent therein shew, how much the internal air had been made to shrink upon the account of the cold. But this way, for reasons too long to be here deduced, we found troublesome and difficult to practise with any thing of certainty. Nor did we ever, that I remember, by this way, bring the refrigerated air to lose above a 30th part of its former dimensions.

7. WE would have tried also to measure the condensation of the air by the ascent of water into the stem of a bolt-head, so invented, that the orifice of the stem might be under the surface of the water, and the bolt-head kept erected. But this way we disapproved, because it was likely (and indeed we found it so by experience) that the external air would first freeze the uppermost part of the water contained in the stem, and thereby hinder its ascent, and perhaps occasion the bursting of the lower part of the said stem.

8. WHEREFORE, though for want of a sufficient quantity of some liquor, that would neither freeze like water, and aqueous bodies, nor congeal like common oil, and the like unctuous juices, we found it for a while somewhat difficult to practise the experiment; yet bethinking ourselves of the indisposition, that brine has to congelation, we made so strong a brine with common salt, that with it (and, as I remember, with oil of turpentine also, of which we chanced to have some quantity by us) we made divers trials, of which I had two among our collections, which we shall here subjoin; whereof the one informs us, that an egg being inverted into salt water, the cold of a frosty night made the air shrink in the pipe near five inches; and the other (which is the accuratest I meet with among my collections) gives me this account, that *January* the 29th, the air extended into 2057 spaces, was by the cold of the sharp and frosty night contracted into 1965 spaces; so that in extraordinarily cold weather, the most we could make the air lose of its former dimensions by the additional cold of the atmosphere, was a twenty-second part, and a little more than a third. And this was the greatest condensation of the air, that we remember ourselves to have observed, though we were so careful, as after we had placed marks, where the incongealable liquor reached into the pipe, that when the internal air was exposed abroad to the cold, we caused servants to watch, and from time to time to take notice (by placing marks) of the various ascents of the liquor, especially early in the morning, lest we should omit taking notice of the greatest

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* In the third preliminary discourse.

contraction of the air; which omission (by reason that the coldness of the ambient air does oftentimes begin to be remitted before we can feel it to be so) is not easily avoided without watchfulness.

9. BUT having thus observed the condensation of included air by the natural and unassisted cold of the external air, we thought fit to prosecute the trial somewhat further; and in regard we conceived the cold of a mixture of snow and salt to be far more intense, than that of the meer ambient air alone, we endeavoured to measure, as near as we could, how much the one exceeded the other. And though we found, that by prosecuting the lately mentioned trial in the glass-egg, by the application of ice and salt to the elliptical part of the vessel, the liquor rise by our estimate near four inches more (than those five, which it had risen already, upon the account of the refrigeration of the included air by the bare cold of the external;) yet by prosecuting the other experiment (made the 29th of January) at the same time, when we were making it, we did somewhat more accurately determine the matter. For by applying ice and salt to the outside of the vessel, we found, that the included air was contracted from 1965 spaces, to which the cold of the ambient air had reduced it, into 1860 spaces; so that the composition of ice and salt did as much, nay somewhat more, condense it, after the meer cold of the external air had contracted it as far as it could, than the bare, though intense, cold of the ambient air could condense it at first; and the greatest degree of adventitious cold we were able to give, by the help of nature and art, did not make the air exposed to it lose a full tenth part of its former dimensions. On which occasion it may not be unworthy observation, that there is no greater disparity betwixt the proportion, in which the cold was able to condense the air, and that, wherein the cold was able to expand water.

10. This is all that at present I think fit to say, concerning the interest, that winds may have in the temperature of the air. And therefore I will now proceed to those other particulars, wherewith I not long since said, that I intended to close up this section; and I might on this occasion subjoin many things, but partly haste, and partly other considerations will confine me to those, that relate to the effects of cold upon the air in a more general way.

11. AND first, we will observe, that cold may hinder, in an almost incredible measure, the warming operation of the sun upon the air, not only in the hottest part of the day (for that may sometimes happen, even in our climate) but at several times of the day, even in the heat of summer.

12. I remember I once accidentally met with an intelligent and sober gentleman, who had several times failed upon the frigid zone, and though an intervening accident separated us so suddenly, that I had not opportunity to obtain from him the resolution of above two or three questions; yet this I learn-

ed of him belonging our present purpose, that by the help of a journal he kept, he called to mind, that upon the coast of *Greenland* he had observed it to snow all midsummer night; which affirmation of so credible a person imbaldens me to add some other relations, which I should else have scrupled at.

13. Mr. *Logan*, an English merchant, that wintered at *Pecora*, one of the northern towns of *Muscovy*, relates, that being there at a great salmon-fishing, there happened about the close of *August* (which in many countries is wont to be the hottest time of all the year) so strong a frost, which lasted till the fourth day, *Purchas*, lib. 4. pag. 542. 'That the *Ozera* was frozen over, and the ice driving in the river to and again, broke all the nets; so they got no salmon, no not so much as for their own victuals.'

14. CAPTAIN *G. Weymouth* mentions, that in *July*, though he was not near the latitude of *Nova Zembla*, much less of *Greenland*, yet sailing in a thick fog, when by reason of the darkness it occasioned, *Purchas*, pag. 811. 'he thought good to take in some of his sails; when his men came to hand them, they found their sails, ropes, and tacklings so hard frozen, that it did (says he) seem very strange unto us, being in the chiefest time of Summer.'

15. IN the fifth voyage of the English to *Cherry Island*, which lies betwixt 74 and 75 degrees of latitude, they observed, that the wind being at North-east upon the 24th of *July*, 'it froze so hard, that the ice did hang on their clothes.' And in the seventh voyage (which was made three years after,) to the same island, they mention, *Purchas*, pag. 564. that on the 14th of *July*, 'the wind being northerly, they had both snow and frost.'

16. The next thing, that we shall take notice of, is the degree of cold, which the efficient causes of that quality, whatever they be, are able to produce in the air; but of this we must not here treat indefinitely, the strange effects of cold upon other bodies being most of them produced by the intervention of the cold first diffused in the air, and those are treated of in a distinct section: wherefore we shall now give two or three instances of the sudden operations of the cold harboured in the air.

THE formerly mentioned English ambassador into *Russia*, Dr. *Fletcher*, gives us two instances very memorable to our present purpose: *Purchas*, pag. 415: 'When you pass (says he) out of a warm room into a cold, you will sensibly feel your breath to wax stark, and even stifling with the cold, as you draw it in and out.' So powerfully and nimbly does the intensely refrigerated air work upon the organs of respiration.

[AND whereas a very credible person, now chief physician to the *Russian* emperor, being asked by me concerning the truth of what is reported sometimes to happen at *Moscow*, and is reputed the eminentest proof, that is readily observable of the extreme coldness of the air, assured me, that he himself saw the water thrown up into the air fall down actually congealed

into ice; Dr. *Fletcher* confirms this report.] For our ambassador also says, *Purchas*, pag. 414. 'That the sharpness of the air you may judge of by this, for that water dropped down, or cast up into the air, congealed into ice, before it come to ground.' And I remember, that inquiring about the probability of such relations, he answered me, that being at the famous siege of *Smolensko* in *Russia*, he observed it to be so extremely cold in the fields, that his spittle would freeze in falling betwixt his mouth and the ground; and that if he spit against a tree, or a piece of wood, it would not flick, but fall to the foot of it.

17. AMONG the phænomena of cold, relating to the air, I endeavoured to observe, whether, upon the change of the weather from warm or mild to cold and frosty, there would appear any difference of the weight of the atmosphere by its being plentifully furnished with a new stock of such frigorifick corpuscles, as several of the modern philosophers ascribe its coldness to: but though I several times observed by comparing a good barometer (and sometimes also unsealed weather-glasses, furnished one with a tinted liquor, and the other with quicksilver) with a good sealed weather-glass, furnished with pure spirit of wine, that, upon the coming in of clear and frosty weather, the atmosphere would very early appear sensibly heavier than before, and continue so, as long as the cold and clear weather lasted; yet by reason of some considerations and trials, that bred some scruples in me, I refer the matter to more frequent and lasting observations, than I yet have been able to make; in which it will concern those, that have a mind to prosecute such trials, not only to consider, whether or no the increased gravity of the atmosphere may not proceed from some other cause, than the coming of frigorifick atoms into the air; but to have a special care, that their baroscopes be more carefully freed from the air, that is wont to lurk in quicksilver it self, as well as other liquors, than those, in the making of the Torricellian experiment, tubes usually are, lest that air getting up into the deserted part of the tube, do, by its expansion and contraction, obtain an unsuspected interest in the rising and falling of the subjacent mercurial cylinder, and so impose upon them.

18. ANOTHER effect, that the cold, especially in northern countries, has oftentimes upon the atmosphere, is, the making the air more or less clear than usually it is. For in the northern voyages, the seamen frequently complain of thick and lasting fogs, whose causes I shall not now consider, but some help to guess at them may be given by what we are about to add; namely, that it frequently happens, on the contrary, that when the cold is very intense, the air grows much clearer than at other times, probably because the cold by condensing precipitates the vapours, that thicken the air, and by freezing the surface of the earth, keeps in the steams, that would else arise to thicken the air. Not to dispute, whether it may not also somewhat repress the vapours, that would be afforded by the water it self,

since some of our navigators observe, that even when it was not cold enough to freeze the surface of the sea, it would so far chill and infrigidate it, that the snow would lie on it without melting.

19. I remember a *Swedish* extraordinary ambassador, and a very knowing person, whom I had the honour to be particularly acquainted with, would say, when he saw a frosty day accompanied with great clearness, that it then looked like a *Swedish* winter; where, when once the frosty weather is settled, the sky is wont for a very long time to be very serene and pleasant; and here in *England* we usually observe the sharpest frosty nights to be the clearest. But to confirm our observation by a very remarkable instance, I shall borrow it from a navigator very curious of celestial observations; which circumstance I mention to bring the greater credit to the following observation of Captain *James*, which in his journal, pag. 52. is thus delivered: 'The thirtieth and one and thirtieth of *January*, there appeared in the beginning of the night more stars in the firmament, than ever I had before seen by two thirds. I could see the cloud in *Cancer* full of small stars.'

20. To determine what effect the coldness of the air may have upon the refractions of the luminaries and other stars, I look upon as a work of no small difficulty, and that would require much consideration as well as time: wherefore I shall only add two or three narratives, supplied me by navigators, without adding at present any thing to the matters of fact.

21. The first is that famous observation of the *Dutch* in *Nova Zembla*, who take great pains to evince by several circumstances, some of them highly probable, that they were not mistaken in their account of time; according to which, they concluded, that they saw the sun, whom they had lost sight of eleven weeks before, about fourteen days sooner than he ought to have appeared to them: which difference has been, for aught I know to the contrary, by all that have taken notice of it, ascribed to the strangely great refraction in that gelid and northern air.

22. AND as for that other extremely cold country, where Captain *James* wintered, it appears by his journal, that he there made divers celestial, and other observations, which gave him opportunity to take notice of the refraction; and he seems to complain, that he found it very great, though among the particulars he takes notice of, there are some, that seem not very strange, nor are there any, that are near so wonderful, as that newly mentioned of the *Hollanders* in *Nova Zembla*; however in regard of the extreme coldness of the winter air in *Charleton Island*, it may be worth while to take notice of the following passages out of his journal, since they may at least help us to conjecture, what is not to be expected in reference to refractions from the coldness of the air as such, page 61. 'The 21st of *January* (says he) I observed the latitude with what exactness I could (it being very clear sun-shiny weather) which

‘ which I found to be 52 deg. 52 min. This difference is by reason, that here is a great refraction.’ Which last clause is very obscure, unless it refers, as one may guess it does, to what he had elsewhere said, that on his first coming to the island, pag. 46. ‘ he took the latitude with two quadrants, and found it to be just 52 degrees,’ without any minutes. Elsewhere, pag 64. ‘ my observations (says he) by these glasses I compared to the stars coming to the meridian.’ By this means we found the sun to rise twenty minutes before it should, and in the evening to remain above the horizon twenty minutes (or thereabouts) longer than it should. And this by reason of the refraction.

AND in another place, *March* the 15th. ‘ This evening (says he) pag. 66. the moon rose in a very long oval alongst the horizon.’

I shall add one passage more out of our author, concerning refractions, not only because it may bear testimony to some relations of the like kind, that I have mentioned in another treatise; but because it is concluded with an observation, that (if there be nothing of mistake in it) is odd enough. ‘ I had often (says he) pag. 69. observed the difference betwixt clear weather and misty refractious weather in this manner. From a little hill, which was near adjoining to our house, in the clearest weather, when the sun shone, with all the purity of air, that I could conceive, we could not see a little island, which bare off us south south-east some four leagues off; but if the weather were misty (as aforesaid) then we could often see it from the lowest place.’

23. HITHERTO I have treated of the temperature of air in general; and though the past discourse have been prolix enough, yet possibly I may have no fewer things to say, if I would at present fall upon the consideration of the three regions, into which the air is wont to be distinguished. For I confess I am not altogether without scruples, both as to the number, and as to the limits, and as to the qualities assigned to these aerial regions. But (as I have partly declared in another tract) though I had time to enter upon so intricate a disquisition, yet till I have an opportunity to consult some other papers, I know not, whether what I have noted, touching these difficulties, may not more properly belong to another treatise, than this of cold.

24. HAVING thus dispatched the few experiments I can meet with among my papers; concerning the coldness of the air, I now proceed to subjoin some observations, that have occurred to me in the writings or verbal relations of navigators and travellers about that subject. But in regard, that the greatest part of the phenomena of cold, which nature of her own accord presents us with, seem to be produced, either mediately or immediately by the air, we intend not here to treat of the coldness of the air in the largest sense, but only to take notice of some of the choicer instances, that seem to belong to our present argument. And these we shall annex, either as promiscuous observations at the close of this section, or as

illustrations or proofs of the three following observations.

2. THE first I shall propose in these terms; ‘ That the greater or lesser coldness of the air, in several climates and countries, is nothing near so regularly proportionate to their respective distances from the pole, or their vicinity to the equator, as men are wont to presume.’

THIS puts me in mind of what I have formerly, either heard from a skilful man, or observed my self about the difference betwixt places of the same latitude in the northern and southern hemisphere; namely, that of places equally distant, the one from the northern, the other from the southern pole, the latter are generally much colder than the former. And, as I remember, I long since noted some things to this purpose; but being not at present able to recover them, I shall propose this only, as that, which may deserve an inquiry, being not yet satisfied, but that in the examples I had taken notice of, some accidental and concurrent causes may have occasioned the greater coldness observed in the places seated on the other side of the line; as, on this side of it, the like causes may much vary the coldness of differing places of equal latitudes, as we are now going to shew by the following testimonies.

1. How excessive a cold reigns at *Moscow* and thereabouts in the winter time, when many men lose their noses or their toes, and some their lives by the extremity of the cold; we have several times occasion to take notice of in this treatise. And yet at *Edinburgh*, which I find some of our modern navigators to place more northerly by above a degree; there, I say, and in the neighbouring places, the air is known to be temperate enough, and the cold very tolerable: and it is affirmed, that the snow very rarely lies any long time on the ground after it is fallen.

2. In the voyage made for discoveries northward by Mr. *Pool*, in the year 1610, I find this passage, pag. 702. ‘ I was certified, that all the ponds and lakes were unfrozen, they being fresh water; which putteth me in hope of a mild summer here, after so sharp a beginning, as I have had; and my opinion is such (and I assure my self it is so) that a passage may be as soon attained this way by the pole, as any unknown way whatsoever, by reason the sun doth give a great heat in this climate; and the ice (near the 79th degree) I mean that, that freezeth here, is nothing so huge as I have seen in 73 degrees.’

To this agrees the testimony of the *Hollanders* in their first voyage to *Nova Zembla*, in which the writer of it, *Gerat de Veer*, speaks thus, pag. 473, 474. ‘ We have assuredly found, that the only and most hinderance to our voyage was the ice, that we found about *Nova Zembla*, under 73, 74, 75 and 76 degrees, and not so much upon the sea, between both the lands; whereby it appeareth, that not the nearness of the north pole, but the ice, that cometh in and out from the Tartarian sea

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* A sceptical disquisition of Antiperistasis.

‘ about *Nova Zembla*, caused us to feel the greatest cold. Therefore in regard, that the nearness of the pole was not the cause of the great cold that we felt, &c.’ And a little after, — ‘ It is true (says he) that in the country lying under 80 degrees (which we esteem to be *Greenland*,) there is both leaves and grass, to be seen, wherein such beasts, as feed of leaves and grass, as harts, hinds, and such like beasts, live; whereas to the contrary in *Nova Zembla* there groweth neither leaves nor grass, and there are no beasts there, but such as eat flesh, as bears and foxes, &c. although *Nova Zembla* lieth 4, 5, and 6 degrees more southerly from the pole, than the other land aforesaid.’

AND to this purpose I remember what is related by the learned *Josephus Acosta*, concerning the heats and colds in the torrid zone, and elsewhere: *Acosta, lib. 2. cap. 9. pag. 101.* ‘ When I passed (says he) to the *Indies*, I will tell what chanced unto me: having read what poets and philosophers write of the burning zone, I persuaded my self, that coming to the equinoctial, I should not endure the violent heat: but it fell out otherwise, for when I passed, which was when the sun was there for zenith, being entered into *Aries*, in the month of *March* I felt so great a cold, as I was forced to go into the sun to warm me. What could I else do then but laugh at *Aristotle’s* meteors and his philosophy, seeing that in that place, and at that season, whenas all should be scorched with heat, according to his rules, I and all my companions were a-cold? In truth there is no region in the world more pleasant and temperate than under the equinoctial, although it be not in all parts of an equal temperature, but have great diversities. The burning zone in some parts is very temperate, as in *Quito*, and on the plains of *Peru*; in some parts very cold, as at *Potosi*; and in some very hot, as in *Ethiopia*, *Brasil* and the *Moluccoes*.’ And within two chapters after, he discourses more largely of some of these particulars. And again chapter the 12th, ‘ You may continually (says he) *pag. 109.* see upon the tops of these mountains snow, hail, and frozen waters; and the cold so bitter, as the grass is all withered, so as the men and beasts, which pass that way, are benumbed with cold. This, as I have said, is in the burning zone, and it happens most commonly, when they have the sun for zenith.’

THESE testimonies of a learned man, that writes upon his own knowledge, I thought worth producing, to make it probable, that as in several countries the heat does not always answer to the nearness of places to the line; so in northern regions the cold may not always be proportionate to their vicinity to the pole. In Mr. *Hudson’s* second voyage, written by himself, he mentions, that above 71 degrees, though they were much pestered with ice, about the end of *June*, ‘ that day (when this happened) *Purchas, pag. 578.* was calm, clear, and hot weather; adding of the next

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‘ day also, that it was calm, hot, and fair weather.’ And *Acosta* tells us, ‘ that we see these differences, not only on the land, but also on the sea: there are some seas, where they feel great heat, as the report of that of *Mazambigus*, and *Ormus* in the East, and of the sea of *Panama* in the West. There are other seas in the same degree of height very cold, as that of *Peru*, in the which we were a-cold, when we first sailed it, which was in *March*, when the sun was directly over us. In truth, on this continent, where the land and sea are of one sort, we cannot imagine any other cause of this so great a difference, but the quality of the wind, that doth refresh them.’

But to multiply no more instances, we shall conclude with this one, that *Charleton Island*, where Captain *James* wintered (and of which we so often have occasion to make mention in our history) though it seems by the effects to be a colder region, than even the country about *Moscow*, and perhaps as cold as *Nova Zembla* it self; yet Captain *James*, who had several times occasion to take the latitude of it, (see *James’s* voyage, *pag. 61*, and *81*, and elsewhere) assigns it the same elevation, and consequently the same distance from the pole, with *Cambridge*, whose latitude he reckons to be 51 degrees besides minutes, and whose air is very well known to be very temperate. And it is remarkable, that though this place, whose latitude is short of 52 degrees, was found uninhabitable by reason of the cold, (*Purchas, pag. 569.*) yet not only in Mr. *Hudson’s* voyage, the writers admonish the readers to take notice, ‘ That although they ran along near the shore, they found no great cold, which made them think, that if they had been on shore, the place is temperate.’ *Josephus Acosta, lib. 2. pag. 111, 112.* And yet in this place they reckon themselves to have reached the 78th degree of latitude: and our recenter navigations inform us, that several parts of *Greenland*, to which this newly-mentioned coast belonged, are well enough inhabited: and one of our English navigators assures us, that the true height of *Pustozera* in *Russia* is no less than 68 degrees and a half, if not more, and yet that is a town not only well inhabited, but of great trade. But in *Hudson’s* voyage I find what is more strange, that under the 81st degree of latitude, beyond which they discovered land very far off, but (beyond which none is thought to have actually sailed towards the pole) ‘ they found it during the whole day clear weather, with little wind, and reasonably warm.’ *Purchas, pag. 571.* And beyond 80 degrees, they not only found a stream or two of fresh water, but found it hot on the shore, and drank water to cool their thirst, which they also commended.’

II. THE next observable I am to propose about the coldness of the air, is this; ‘ That the degrees both of heat and cold in the air may be much greater in the same climate, and the same place, at several seasons

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of the year, or even at several times of the same day, than most men would believe.'

For the proof of this proposition, we shall subjoin two sorts of testimonies, of travellers, and navigators; the former shewing, that in countries, where it is very cold in winter, it may nevertheless be hot in summer; and the latter manifesting, that even on the same day, as well as in the same place, the heat and cold, that succeeded one another, may be one of them sensible, though the other were extreme, or may perhaps be both of them considerable.

To make this good, we shall produce the following testimonies.

1. Dr. *Giles Fletcher*, English ambassador to the *Muscovian* emperor, in his treatise of *Russia*, and the adjoining regions, has this memorable passage to our present purpose: 'The whole country (says he, pag. 414.) differeth very much from itself, by reason of the year; so that a man would marvel to see the great alteration and difference betwixt the winters and summers in *Russia*. The whole country in the winter lieth under snow, which falleth continually, and is sometime of a yard or two thick, but greater towards the north; the rivers and other waters are all frozen up, a yard or more thick, how swift or broad soever they be; and this continueth commonly for five months, to wit, from the beginning of *November*, till towards the end of *March*; what time the snow beginneth to melt, so that it would breed a frost in a man to look abroad at that time, and see the winter's face of that country.' And a little after he adds, *Purchas*, 415. 'And yet in the summer time you shall see such a new hue and face of a country, the woods (which for the most part are all of fir and birch) so fresh, and so sweet; the pastures and meadows so green, and well grown (and that upon the sudden) such variety of flowers, such noise of birds (especially of nightingales, that seem to be more loud, and of a more variable note, than in other countries) that a man shall not lightly travel in a more pleasant country.' And some lines after, 'As the winter exceedeth in cold, so the summer inclineth to over-much heat, especially in the months of *June*, *July* and *August*, being much warmer than the summer air in England.'

Voyage de Moscovie & de Perse, livre 3. p. m. 117, 118, 119. ALMOST like things have been much more recently affirmed by the learned *Olearius*, secretary to the Duke of *Holstein's* embassy into *Russia*, and now *Bibliothecarius* to the present Prince of *Holstein*. And an acquaintance of mine, who, after having lived in *Italy*, passed a summer in *Russia*, assured me, that he scarce in *Italy* did ever eat better melons, than some, which he had eaten at *Moscow*, of a strange bigness; which bears witness to that almost incredible relation of *Olearius*, who (after having much praised their goodness at *Moscow*) affirms, that he there met with melons of 40 pound weight, of which he there teaches the culture. (pag. 119.)

AT the royal city of *China*, *Pequin*, which scarce exceeding the 42d degree of latitude,

one would expect, that as the summer is very warm, so the winter should be very mild, as it is observed to be in divers places of *Spain*, *Italy* and *Greece*, that have the same, or a more northern latitude: and yet the learned Jesuit *Martinus*, who lived many years in *China*, assures us, that usually for four whole months together all the rivers are so hard frozen, that not only all ships are closed, and kept immovable by the ice, but that also horses, waggons, and even the heaviest carriages do securely pass over the ice. Concerning which he adds this strange circumstance, that it is usually made in one day, though to its dissolution it require many.

Prosper Alpinus, in his learned treatise *de medicina Aegyptiorum*, lib. 1. cap. 6. tells us, that at *Grand Cairo*, where he practised physic, though that famous metropolis of *Aegypt* be distant six degrees from the tropick of *Cancer*, yet the air, which in summer is almost insupportably hot, in winter is sometimes very considerably cold; adding, that there is not any sort of diseases, that proceed (as he is pleased to speak) from distillations from the head, to which the people are not there subject. To these instances we shall annex but two more, but those remarkable ones.

THE first is mentioned by *Purchas*, as communicated to him by an eye-witness, in these words: 'This I thought good at our parting to advertise thee, that Mr. *Hebey* hath affirmed to me, touching the diversity of weather in *Greenland*, that one day it hath been so cold (the wind blowing out of some quarter) that they could scarce handle the frozen sails; another day so hot, that the pitch melted of the ship, so that hardly they could keep their cloths from pollution: yea, he hath seen at midnight tobacco lighted or fired by the sun-beams with a glass.' The other example, I am to produce, is no less remarkable; namely, that in the often mentioned *Charleton Island*, where that winter was as sharp, perhaps, as any known place of the habitable world, Captain *James* his journal gives us this account of the weather: 'In *June* the sixteenth (says he, pag. 81.) was wondrous hot, with some thunder and lightning, so that our men did go into the ponds ashore to swim, and cool themselves; yet was the water very cold still. Here had lately appeared divers sorts of flies, as butterflies, butcher's-flies, horse-flies, and such an infinite abundance of blood-thirsty muskitoes, that we were more tormented with them, than ever we were with the cold weather. These (I think) lie dead in the old rotten wood all the winter, and in summer they revive again. Here be likewise infinite companies of ants, and frogs in the ponds upon the land.'

THUS we see, what difference there may be in the same place betwixt the temperature of the air in the winter and summer. We shall now add, what may appear more strange, that there may be very great disparities in the heat and coldness of the air, not only in the same place, but within the compass of the same day.

THE lately mentioned *Alpinus* affords me an example to this purpose in *Ægypt* it self, where one would expect a much more uniform heat. *Hyeme* (says he, pag. 9.) *nocturnus aer admodum frigidus observatur, qui oborto sole paulo post parum incalescit, in meridieque plurimum; adveniente vere nocte rursus in frigidum permutatur, ita, at aer ille valde inæqualis sit dicendus, ab ipsiusque illa inæqualitate plurimi morbi originem ducunt atque generatur, qui eo tempore per urbem vagantur.*

THE learned *Olearius* relating how he travelled with the ambassadors, whose secretary he was, over a branch of mount *Taurus*, takes notice, that it being after the middle of *June*, the air of that hot region of *Persia* obliged them only to travel by night, and yet the nocturnal cold was so great, that they were all benumbed with it, insomuch, that they were hardly able to alight from their horses; adding, that the sudden change from an extreme cold to the excessive heat, they were again exposed to the next day, cast no less than 15 of their company into strong burning fevers at once. (Which brought into my mind the complaint of good *Jacob*, who, though he lived in an eastern country, when he had said, *that in the day the drought consumed him, adds and the frost by night.*)

AND the same curious traveller mentions, that in another country in *Persia*, called *Faclu*, notwithstanding the heat of the region (at the end of *March*, at which time they passed that way) they saw and felt in one night, which they were forced to pass without their tents, both lightning, and thunders, and winds, and rain, and snow, and ice.

WE will conclude with a remarkable instance, afforded us by the journal of the English, that wintered at *Charleton Island*. 'The season here in this climate (says the often quoted author of the voyage) is most unnatural; for in the day-time it will be extreme hot, yea, not endurable in the sun; which is, by reason, that it is a sandy country. In the night again, it will freeze an inch thick in the ponds, and in the tubs about, and in our house, and all this towards the latter end of *June*.'

III. THE third observable I intended to take notice of about the coldness of the air, may be comprized in this proposition, 'That in many places the temperature of the air, as to cold and heat, seems not to depend so much upon the elevation of the pole, as upon the nature and circumstances of the winds, that blow there.'

IT would require a very long discourse to treat in this place of winds in general, and much more to examine the several causes of winds, that are assigned by several authors; and therefore when I have once given this intimation, that divers of these opinions may be more easily reconciled, than the maintainers of them

seem to have thought, to the truth, if not to one another; the causes, that may produce wind, being so various, that many of those proposed may each of them in some cases be true, though none of them in all cases be sufficient: having hinted this, I say, it may suffice, on this occasion, to subjoin three or four observations, to prove and illustrate the matter of fact delivered in the proposition.

AND first, it is a known observation in these parts of the world, that northerly and northerly winds do at all times of the year bring cold along with them, and commonly, if it be winter, frost. And here in *England* I have sometimes wondered at the power of the winds, to bring not only sudden frosts, but sudden thaws, when the frost was expected to be settled and durable; which yet seems to hold commonly, but not without exception. For during one of the considerablest fits of frost and snow, that I have taken notice of in *England*, I remember, that I observed (not without some wonder) that the wind was many days * southerly; unless it may be said, that this southerly wind was but the return of a stream of northerly wind, which had blown for many days before, and might by some obstacles, and agents, not here to be inquired after, be made to wheel about, or recoil hither, before it had lost the greatest portion of the refrigerating corpuscles it consisted of before.

THE formerly mentioned *Prosper Alpinus* attributes strange things to the northerly wind, that blows in *Ægypt*, as to the cooling and refreshing the air, in spite of the violent heats, that would otherwise be intolerable. And many in † *Ægypt* ascribe to the *Ætesian* winds that almost miraculous ceasing of the plague at *Grand Cairo*, of which we elsewhere speak. (*Ibid. lib. i. cap. 6.*) *Dominatur autem aer* (says he) *summè calidus, ipsius cæli, ut dictum est, ratione, quod hæc civitas à Tropico Cancræ tantum 6. gradibus distet. Quâ brevi intercapedine dum sol ad illum accedit Tropicum, & illorum Zenith sit propinquior, aer ille valde incalescit, & nisi Ætesia venti tunc à septentrione spirarent, vehementissimus, & qui vix à nostris perferri possit, caloris æstus sentiretur.*

Advenæ nostri iis provenientibus ad subterranea loca confugiunt, in quibus morantur, quousque ille ventorum ardor residerit atque cessaverit. Conjunxit hæc incommoda Deus optimus cum aliis quibusdam bonis, nam ubi calidissimi illi venti conticuere, statim à septentrione flare alii incipiunt, qui subitaneum inflammatis atque laxatis corporibus solatium præstant. Si enim illi diu perseveraverint, nemo in eâ regione vivere possit. *Ibid. lib. i. cap. 7. pag. 11.*

WHENCE winds should have this power to change the constitution of the air, and especially to bring cold along with them, is not so easy to be determined. Indeed the other qualities, and even the heat, that is observable in winds, may for the most part be probably

* The weather was snowy and foggy, freezing our rigging, and making every thing so slippery, that a man can scarce stand. And all this with the wind southerly, says Captain *James*, (page 104.) in his journal, the 26th of August.

† *Ab his ventis aërem alteratum, esse causam, cur pestis illa dissolvatur, multi illorum affirmant. Quod etiam non videtur penitus à veritate alienum, quando id multis etiam rationibus nobis persuaderi possit, inprimisque, &c. Prosper. Alpin. lib. 1. De medicina Ægypt. cap. 18.*

bably enough derived from the qualities of the places, by which they pass. Of this we have already given an example or two in the passages lately mentioned. And it may be further confirmed by what *Acosta* says, that he himself saw in some part of the *Indies*, (namely, *Josephus Acosta*, lib. 3. cap. 9.) ‘ That the iron gates were so rusted and consumed by a peculiar wind, that pressing the metal between your fingers, it would be dissolved and crumbled, as if it had been hay or parched straw.’ And this learned traveller, who seems to have taken peculiar notice of the winds, affords us, in divers places of his book, several examples to confirm what we were saying, (though he take not the nature of the regions, along which the wind blows, to be alone in all cases a sufficient cause of their qualities) of which yet we shall now mention but these two memorable passages. *Lib. 3. cap. 2. pag. 120.* ‘ In a small distance (says he) you shall see in one wind many diversities. For example, the *Solanus* or Eastern wind is commonly hot and troublesome in *Spain*; and in *Murcia*, it is the coldest and healthfullest that is, for that it passeth by the orchards, and that large chamber, which we see very fresh. In *Cartagena*, which is not far from thence, the same wind is troublesome and unwholesome. The Meridional, (which they of the ocean call South, and those of the Mediterranean sea, *Mezzo Giorno*) commonly is rainy, and boisterous, and in the same city, whereof I speak, it is wholesome and pleasant.’ And in this description of *Peru*, lib. 3. cap. 3. speaking of the South and South-west, he affirms, that this wind yet in this region is marvellous pleasing:

BUT though, as we were saying, many other qualities of winds may be deduced from the nature and condition of the places, by which they pass; and though the heat also, which *Prosper Alpinus* (as we lately took notice) attributes to the southerly winds, that blow in *Egypt*, may be probably ascribed to the heated exhalations and vapours they bring from the southern and parched regions they blow over; yet whence the great coldness of northerly and easterly winds should come, may be scrupled at by many of the modern philosophers, who, with divers Cartesians, will not admit, that there are any corpuscles of cold.

AND possibly I could, about these matters, propose some other difficulties, not so easy to be resolved. But not being now to discuss the hypothesis about cold, I think it will be more proper in this place, instead of entering upon disputes and speculations, to subjoin an experiment, that I made, to give some light about this matter.

CONSIDERING then, that I had not met with any trial of the nature of that I am about to mention, and that such a trial might possibly prove lucrative, I caused a pretty large pair of ordinary bellows to be kept a good while in the room, where the experiment was to be made, that it might receive the temperature of the air in that chamber: then placing upon a board one of those flat-bottomed weather-

glasses, that I elsewhere described to contain a moveable drop of pendulous water, blowing at several times with intermissions upon the bubble or lower end of the weather-glass, though the wind blown against my hand were, as to sense, very manifestly cold, yet it did not cool the air included in the bubble, but rather a little warmed it, as appeared by a small, but sensible, ascension of the pendulous drop each time, that, after some interposed rest, the lower part of the glass was blown upon, which seemed to proceed from some small alteration towards warmth, that the air received by its stay (though short) in the bellows, as seemed deducible from hence, that if by closely covering the clack, the matter were so ordered, that the air, that should come into the bellows, must come in all at the nose: if this nose being held very near the bubble of the weather-glass, the air were, by opening the bellows, suddenly drawn in, that stream or air of wind coming from a part of the window, where the air was a little cooler than that, which was wont to come out of the bellows, would not, as the other, make the pendulous drop rise, but rather the contrary.

THIS done, we proceeded to shew by experiment, that though a wind were nothing but a stream of air, yet in its passage it might acquire a considerable coldness distinct from that, which it has by virtue of its motion; though upon the score of that, we see, that air moved by a fan, or (as in our newly-mentioned trial) by a pair of bellows, might, to our touch, feel cold; nor did we forbear to expect a good event of our trial, upon the doubt, that may be raised, whether there be frigorifick corpuscles or no. For whatever become of that question, I thought I might expect, that whether or no ice emit corpuscles, that are universally frigorifick, yet the air being, either by them, or upon what account soever, highly refrigerated, the corpuscles, that compose this cold air, being most of them driven on before it by the wind, that meets them in its way, will, in a sense, prove frigorifick, in regard of a less cold body, which they shall happen to be blown upon; and accordingly, having provided a ridge-tile inverted, and half filled the cavity, which looked upwards, with a mixture of ice and salt; and having likewise put the iron pipe of the bellows upon that mixture, and then covered it with more of the same, that so the pipe being surrounded, as far as conveniently it could be, with ice and salt, the air contained in it might thereby be highly refrigerated; I found, that blowing wind out of the bellows upon my hand, that wind felt much more cold than that, which had been before blown upon my hand out of the same bellows, before the frigatefactive mixture was applied to it. But for fear my sense of feeling should deceive me, I caused a weather-glass, made after the common manner, but with a more slender pipe, to be so placed, that the nose of the bellows (which, together with the tile and ice, was upheld with a frame) lay in a level with the bubble of the thermometer; and then blowing the refrigerated air of the bellows upon the globular

bular part of the glass, I saw the water in the cylindrical part and shank manifestly ascend, as it was wont to do upon the refrigeration of the included air: and as this ascension of the liquor continued, during three or four blasts of the bellows, so, upon the cessation of the artificial wind, the water subsided by degrees again, till by fresh blasts it was made to ascend. Lastly, having repeated this experiment, we thought fit to try, how much the air, refrigerated immediately by the frigorifick mixture, would produce a colder wind than the former; and accordingly drawing back the nose of the bellows, that the air, that should be blown out, might pass along the cavity left in the frigorifick mixture by the iron pipe (of the bellows) which we had withdrawn, the wind was manifestly more cold than before, and had a greater operation on the weather-glass, it was blown upon.

THIS experiment, if carried on, and prosecuted, may possibly prove more luciferous; but I will not take upon me here to determine, whether all cold winds must necessarily be made so by frigorifick corpuscles properly so called; since I have sometimes suspected, that some winds may be cold, only by consisting of, or driving before them those higher parts of the air, that, by reason of the languid reflection of the sun-beams, in that upper, (or perhaps arctick) region of the air, are for the most part very cold. For it may be observed, that rains oftentimes very much and suddenly refrigerate the lower air, when no wind, but what the clouds and rain make, accompanies them, as if they brought down store of cold air with them from that upper region; which *Acofta*, and one I conversed with, that visited far higher mountains than the *Alps*, affirm to be in some places (for I am not satisfied, that it is so every where) exceeding cold, both in hot climates, and in hot seasons of the year. And I observe that the *Hollanders* do, in more places than one or two, mention the northerly and north-easterly winds, to be those, that brought them the prodigious colds they met with, though in *Nova Zembla*, where they were exposed to them, be so northwards, that it lies within 16 or 17 degrees of the pole itself. This being a bare suspicion, it may suffice to have touched it. But I shall subjoin two or three instances on the occasion of our proposition, concerning the influence of the winds upon the air, and to shew more particularly, that even cold winds receive not always their qualities so much from the quarter, whence they blow, as from the regions, over which they blow: I shall therefore begin with what is delivered by *Mr. Wood*, in his *New England's Prospect*, part I. chap. 2. 'Whereas in *England* (says he) most of the cold winds and weathers come from the sea, and those situations are counted most unwholesome, that are near the sea-coast; in that country it is not so, but otherwise.' And having added, as his reason, that the 'north-east wind, coming from the sea, produces warm weather, melting the snow, and thawing the ground;' he subjoins, 'only the North-west

'wind coming over the land, is the cause of extreme cold weather, being always accompanied with deep snows, and bitter frosts, &c.' To which passages we shall add only one out of *Captain James*, as being considerable to our present purpose. *Captain James's* voyage, page 52, 53. 'The winds (says he) since we came hither, have been very variable and unconstant; and till within this fortnight, the southerly wind was coldest. The reason I conceive to be, for that it did blow from the main land, which was all covered with snow, and for that the North winds came out of the great bay, which hitherto was open.'

T I T L E X I X.

Of the strange effects of Cold.

I. **T**O enumerate and prosecute all the several effects of cold, being the chief work of the whole book, it is not to be expected, that they should be particularly treated of in this one section of it, wherein I shall therefore confine myself to mention only those effects of cold, that are not familiar, but seem to have in them something of wonderful; nor must I take notice of all them neither, lest I should be guilty of useless repetitions, but only of them, which either are not at all, or are but incidentally or transiently delivered in the foregoing sections. Nor is it to be expected, that I should pawn my credit for the truth of every one of the relations I am about to subjoin. For if they had not something of extraordinary; and, consequently, that may beget some diffidence in wary men, they would not be proper for the title of this section; and most of them, that they may be fit to be placed here, must be the effects of such extreme degrees of cold, that I cannot, in this temperate climate of ours, examine the truth of them by my own trials: so that all I can do, is to make choice of such relations, as are almost all of them delivered by the relators, as upon their own knowledge. And even this may perchance not only gratify and excite the curiosity of some, who are pleased with no things so much, as with those, that have somewhat in them of prodigy; and (which is more considerable) their narratives may afford the ingenious such strange phenomena, that the explication of them may serve both to exercise their wits, and try their hypothesis.

2. IT seems not necessary, in the marshaling these observations; to be scrupulous about method; but yet to avoid confusion, we shall first mention the effects of cold, as to those four great bodies of that part of the sublunary world we live in; that are commonly reputed elements; and thence we will proceed to take notice of the effects of cold upon some other inanimate bodies, and, for an instance of its operation on living creatures, upon men.

3. OF the power of cold, either to straighten the sphere of activity of fire, or to hinder its wonted effects, the chief examples I have met with are recorded, partly by the *Dutch* in *Nova Zembla*, and partly by *Captain James*, when he wintered

Purchas,
lib. 3. cap.
5. sect. 2.
pag. 495.

wintered in *Charleton Island*. These Hollanders in one place speak thus; ‘The twentieth it was fair and still weather, the wind easterly, then we washed our sheets, but it was so cold, that when we had washed and rung them, they presently froze so stiff, that although we laid them by a great fire, the side that laid next the fire thawed, but the other side was hard frozen, &c.’ Elsewhere thus: ‘We were in great fear, that if the extremity of the cold grew to be more and more, we should all die there with cold; for what fire soever we made, it would not warm us.’ And because it were tedious to transcribe all, that their journals afford us to our present purpose, we will conclude with this passage: ‘Hereby we were so fast shut up into the house, as if we had been prisoners; and it was so extreme cold, that the fire almost cast no heat, for as we put our face to the fire, we burnt our hose before we could feel the heat, so that we had work enough to do to patch our hose; and, which is more, if we had not sooner smelt than felt them, we should have burnt them ere we had known it.’ Though Captain *James* wintered in a country many degrees remoter from the pole, than *Nova Zembla*, yet in one place he gives us this account of the cold’s power to restrain or oppose the action of fire: (Captain *James* p. 65.) ‘The cook’s tubs, wherein he did water his meat, standing about a yard from the fire, and which he did all day ply with melted snow water, yet in the night season, while he slept but one watch, would they be firm frozen to the very bottom. And therefore was he fain to water his meat in a brass kettle, close adjoining to the fire; and I have many times both seen and felt, by putting my hand into it, that side, which was next the fire, was very warm, and the other an inch frozen. I leave the rest to our cook, who will almost speak miracles of the cold.’

Thus far our English navigator, whose relation, compared with those of the Hollanders, makes me not so much wonder, as I once did, that men should relate to *Marcus Polus*, that there is a certain plain in *Tartary*, situated between some of the highest mountains in the world, ‘where, if fire be kindled, it is not so bright, nor so effectual to boil any thing, as in other places.’ (*Purchas*, lib. 1. cap. 4. pag. 74.) For so *Purchas* renders that passage; whence occasion has been taken to impute to *Marcus Polus*, a writer not always half so fabulous, as many think him, that he affirmed, that there was a country in *Tartary*, where fire could not be kindled.

4. AND as for the other newly mentioned relations of seamen and travellers, though to us, that live in *England*, they cannot but seem very strange; yet I am kept from rejecting them as utterly incredible, by considering, that ice and snow having before their congelation been water, must in probability owe their coldness to that which reigned in the air: so that if in any place nature has, either so plentifully stocked the air itself with frigorifick exspirations, or other corpuscles (if we will admit any such) or have

upon any other account rendered it as cold, as it can make ice and snow to be, even here amongst us; I know not, why the northerness of the climate, and perhaps some saline exspirations from the earth and sea, may not there diffuse through the air a cold superior to that, which by small quantities of ice (or snow) and salt can at a small distance be produced here. And this cold is so intense, that by pouring some water on a joint-stool, and placing on it a silver tankard, or other convenient vessel, we may, as experience has assured me, with beaten ice (or snow) and salt, and a little water (which is added to hasten the solution of the other) nimbly stirred together in the pot, make the mixture freeze the external water quite through the tankard; and they may be by this way so hard frozen together, as that by lifting up the pot, you may lift up the joint-stool too, and that (which is the circumstance, for which I mention this) just by the fire, which in this case is unable to hinder so difficult an operation of the cold.

5. Thus much of the effects of cold, in reference to fire. What the same quality may perform upon air, we shall say but little of in this place, because we treat of those phenomena, partly in the foregoing section of the coldness of the air, and partly in other places. Only we shall not here pretermite a testimony of the learned *Olearius*, who, as an eye-witness, confirms what we elsewhere deliver of the high degree of cold, to which the air may be brought. For he tells us, ‘That in *Moscovy* he experimentally found that, which others left recorded in their writings, that one’s spittle would be congealed before it reached the ground, and that water would freeze as it was dropping down.’ (*Olear.* lib. 3. p. m. 117.)

6. OF the effects of cold upon water, we shall not need to say much in this place, since the two notablest of them being the power cold has to congeal water suddenly, and the force it has to turn vast quantities of it into solid ice; of the former I have newly given, out of *Olearius*, an example as eminent as almost any, that is to be met with; and of the latter also I have given several instances, in the section, that treats of ice: yet two or three notable instances, which we do not elsewhere mention, it will not be improper to deliver in this place.

7. THE first declares, that notwithstanding the warmth of the inside of a man’s mouth, his spittle may be frozen even there. ‘The 27th of *September* (they are the words of *Gerat de Veer*) it blew hard north-east, and it froze so hard, that as we put a nail into our mouths (as when men work carpenter’s work, they use to do) there would ice hang thereon, when we took it out again, and made the blood follow.’ (*Purchas*, pag. 461.) The like relation (if I misremember not) I have met with in a modern English navigator; and it is very little, if at all more strange, than what is affirmed by Queen *Elizabeth*’s ambassador to the *Russian* emperor: ‘In the extremity of winter (says Doctor *Fletcher*, speaking

ing of *Muscovia*) if you hold a pewter dish or pot in your hand, or any other metal, except in some chamber, where their warm stoves be, your fingers will stick fast to it, and draw off the skin at the parting.'

8. THE other instance, I intend to mention, is this, that though *Macrobius*, and other learned men both ancient and modern, will not allow salt water to be congealable; yet the *Dutch* at *Nova Zembla* relate even in the midst of *September* (and as the marginal note says, in a night) 'it froze two inches thick in the salt water.' (*Purchas*, pag. 491.)

9. As to the effects of violent colds upon the earth, what they would prove upon pure elementary earth (if any such there be) I can but conjecture; but as for that impure or mingled earth, which we commonly read on; the effects of extreme cold upon that may be very notable. For *Olearius* relates, 'that in the year 1634, the cold was so bitter at *Moscow*, that in the great market-place he saw the ground opened by it so, that there was made a cleft of many yards long, and a foot broad.' [And the present great duke of *Muscovy*'s physician being asked by me concerning the truth of such relations, answered me, that he himself had in those parts seen the ground reduced by the cold, to gape so wide, that a child's head might well have been put into the cleft.]

10. IT is somewhat strange, that the violent heat of summer, and the extreme cold of winter should both of them be able to produce in the ground the like effects: but whether to make these gaping chinks, that we have been speaking of, the surface of the ground exposed to the air, being first frozen, is afterwards broken by the expansive force of the moist earth underneath, to which the cold at length pierces, and congealing it, makes it swell, and heave, and so burst or cleave the hard and frozen crust of the ground, which cannot sufficiently yield to it; whether this (I say) may produce the clefts we were speaking of, or whether they must be derived from some other cause, not having yet made the experiments I thought upon, to clear the matter one way or other, I do not as yet pretend to determine, but will rather subjoin the second observation, I purposed to mention, of a strange operation of cold upon the ground; and it is afforded us by the *Dutch*, in their often quoted third voyage to *Nova Zembla*; in one place of which they tell us, 'That when they had built them a wooden house, and were going to shut themselves up in it for the winter, they made a great fire, without the house, therewith to thaw the ground, that they might so lay it, viz. the wood, about the house, that it might be the closer; but it was all lost labour, for the earth was so hard, and frozen so deep into the ground, that they could not thaw it, and it would have cost them too much wood, and therefore they were forced to leave off that labour.'

11. AFTER what we have said about the strange effects of cold, in reference to fire, air, water, and earth, we will now proceed to

take notice of its effects upon confessedly compounded bodies, whether inanimate or living: but of the former sort of mixed bodies (I mean those, that have not life) it will not be necessary to say much in this section, in regard that we have in many other places, upon several occasions, had opportunities to mention already most of the particulars, that belong to that head. For we elsewhere take notice, that violent colds would freeze beer, ale, vinegar, oil, common wine, and even sack, and *Alicant* themselves. We have likewise noted, that the cold may have a notable operation upon wood, bricks, stone, vessels of glass, earth, and even pewter, and iron themselves; to which *Bartolinus*, out of *Janus Munck's* voyage to *Greenland*, allows us to add vessels of brass (though these are not immediately broken by the cold, but by the included liquors, which it dilates;) and divers strange effects of cold upon inanimate bodies, which it were here troublesome to recapitulate, may be met with dispersed in several places of the present history. Wherefore having only intimated in general, that, though many plants are preserved by a moderate cold, yet it has been observed, that most garden-plants are destroyed by excessive degrees of it, we will pass on to consider the effects of cold upon animals: of the many observations, that we have met with among travellers, concerning this subject, we shall, to avoid prolixity, deliver only the considerablest, and those, that we find attested by very credible writers.

12. Captain *James*, speaking of the last of the three differences he makes of cold (namely, that, which he and his company felt in the woods) gives this account of it; (Captain *James's* voyage, p. 64.) 'As for the last, it would be so extreme, that it was not endurable; no clothes were proof against it, no motion could resist it. It would moreover so freeze the hair of our eye-lids, that we could not see; and I verily believe, that it would have stifled a man in a very few hours.'

13. *Olearius* giving an account of the air of *Muscovy*, and especially the capital city of it, 'The cold (says he, *Livre* 3. p. m. 117.) is there so violent, that no furs can hinder it, but sometimes men's noses and ears, feet and hands will be frozen, and all fall off.' He adds, that in the year 1634, when he was there, 'they could not go 50 paces without being benumbed with cold, and in danger of losing some of their limbs.' And yet to add that remarkable observation upon the by, the same author, near the same place, speaking of *Moscow*, and the neighbouring provinces distinguished from the rest of that vast empire, says, (*Livre* 3. 116.) 'that the air is good and healthy, so that there one scarce ever hears of the plague, or any other epidemical diseases.' And he adds, that for that reason, when in the year 1654, 'the plague made havock in that great city, the thing was very surprizing, nothing like it having been seen there in the memory of man.'

14. OUR already divers times mentioned, English ambaffador Dr. *Fletcher*, fpeaking of the cold, that fometimes happens in *Ruffia*, witneffeth thus much of it: ‘Divers (fays he, *Purchas, lib. 3. pag. 415.*) not only that travel abroad, but in the very markets and ftreets of their towns, are mortally pinched, and killed withal; fo that you fhall fee many drop down in the ftreets, many travellers brought into the towns, fitting dead and ftiff in their fleds. Divers lofe their nofes, the tips of their ears, and the balls of their cheeks, their toes, feet, &c. Many times when the winter is very hard and extreme, the bears and wolves iffue by troops out of the woods, driven by hunger, and enter the villages, tearing and ravening all they can find, fo that the inhabitants are fain to flee for the fafeguard of their lives.’

15. To defcend now to obfervations, that do fomewhat more punctually fet forth the more particular phaenomena of cold, in reference to men’s bodies, take the following obfervation: ‘The 15th of *March* fome of their men, that had been abroad to kill deer, returned fo difabled with cold, which did rife up in blifters under the foles of their feet, and upon their legs, to the bignefs of walnuts, that they could not recover their former eftate (which was not very well) in a fortnight after.’ This may be confirmed by that paffage of the *Hollanders*, where fpeaking of their preparing fpringes to take foxes, they add, (*Purchas, pag. 497.*) that ‘they did it with no fmall trouble; for that if they ftayed long without doors, there arofe blifters upon their faces and ears. We did daily find by experience (fays Captain *James, page 64.*) that the cold in the woods would freeze our faces, or any part of our flefh, that was bare; but it was not fo mortifying, &c.’

16. THE *Dutch*, fpeaking of the pains they were fain to take to dig away the fnow, that covered the houfe, and choaked up their doors, adds, (*page 497.*) that in that laborious work, ‘they were forced to ufe great fpeed, for they could not long endure without the houfe, becaufe of the extreme cold, although they wore foxes fkins about their heads, and double apparel upon their backs.’

17. THE lately mentioned Captain *James* relates, that in *Charleton* Ifland he was fain to cut the hair of his head fhort, and fhave away all the hair of his face, becaufe the icicles, that would be faftned to it, made it, (as he fpeaks, *page 56.*) become intolerable.

18. AND he elfewhere relates, that once he and his companions, having been for a little while parted into two companies, ‘had their faces, hair, and clothes fo frozen over, that they could not know each other by their habits, nor (which is a confiderable circumftance, for whofe fake chiefly I mention this paffage) ‘by their voices.’

19. AND the fame author gives this account of the death of the gunner of his fhip, whom he calls a ftrong-hearted man, and who died before the end of *November*. ‘He had (fays our author) a clofe boarded cabin in the gun-room, which

‘was very clofe indeed, and as many clothes on him as was convenient, (for we wanted no clothes) and a pan with coals of fire continually in his cabin; for all which warmth, his plaifter would freeze at his wound, and his bottle of fack at his head.’

20. ‘THE 11th of *December* (fays *Gerat de Purchas, Veer*) it was fair weather, and a clear air, *lib. 3. cap. pag. 496.* but very cold, which he that felt not would not believe; for our fhoes froze as hard as horns upon our feet, and within they were white, fo that we could not wear our fhoes, but were forced to make great pattens, the upper part being fheeps-fkins, which we put on over three or four pair of focks, and fo went in them to keep our feet warm; yea, and the clothes upon our backs were white over with froft.’

21. WHICH may be fomewhat confirmed by this paffage of Captain *James*: ‘The clothes on our beds would be covered with hoar froft, which in this little habitacle was not far from the fire.’ We might add to all thefe this other paffage of the often-mentioned *Gerat de Veer*: ‘The 26th of *December*, it was foul weather, the wind north-weft, and it was fo cold, that we could not warm us, although we ufed all the means we could with great fires, good ftore of clothes, and with hot ftones and billets laid upon our feet, and upon our bodies, as we lay in our cabins; but notwithstanding all this, in the morning our cabins were frozen, &c.’ But we fhall not infift on fuch paffages as this laft recited, becaufe that of the force of cold to repress and withftand the fire we have already delivered as remarkable things, as will be eafily met with, in approved writers, in the former part of this prefent fection. *Purchas, page 49.*

22. I HAVE myfelf met with a knowing and very credible perfon, that related to me of the cold of *Ruffia*, where he travelled, little lefs ftrange things, than thofe I have mentioned out of books; and if I did not want the hiftorian’s name, I fhould make fmall difficulty to add, that fince I made a good progrefs in this prefent fection, a very learned traveller (though not into cold countries) related to me, upon the occafion of what I was treating, what he affirmed to have met with in an approved hiftory of the ftrange operation of the inclemency of the air upon multitudes of men at once; namely, that about the year (if he rightly remember it) 1498, an army of the *Turks* making an incurfion into *Poland*, upon their return was furprifed with fuch an extremity of cold and of fnow, that though it were but (if he miftake not) in *November*, forty thoufand of them (the whole army confifting of feventy thoufand) perifted through the extremity upon the place.

23. AMONGST the many relations I have met with of the fatal effects of cold in the northern countries, I took notice, not without a little wonder, as well as trouble, that I could not find, that any of the relators had the curiofity to fee, what change was made in the internal parts of the bodies fo deftroyed, which yet were an inquiry very proper to have been made.

made ; but at length the other day an ingenious person having shewed me a book newly published in French, containing the description of a Polonian province he calls *Ukrain*, as I was skimming it over, with hopes to find some observations about cold, I lighted on a relation, which, though not such as I desired, is more than I have any where else found ; and I take the more notice of it, because that though the very name of this province is scarce hitherto known to us in *England*, yet having a while after, by good chance, met with an intelligent Polonian lord, and having enquired of him, whether he had ever been in that country, he both told me, that he had been quartered there, and by his answers and relations did countenance divers particulars of it, mentioned by this French officer (named *Monsieur de Beauplan*) who lived long there. This author then, after having taken notice, that this fertile province, though but situated in the same height of the pole with *Normandy*, is oftentimes subject to excessive colds, (which circumstance I mention as a further confirmation of something of the same nature delivered in the former section) gives an account of two differing effects of this cold upon the bodies of men ; the one being a peculiar kind of sickness, the other death.

24. THE first, which I remember not to have elsewhere met with, is, that sometimes, when the natural heat proves strong enough to protect the toes, and cheeks, and ears, and other parts, that are either more remote from the heart, or more tender, from a sudden mortification ; yet unless nature be assisted, either by good precautions, or remedies, she cannot hinder the cold from producing in these parts cancers, as painful as those, which are caused by a scalding and malignant humour ; and which let me see (says my author) when I was in those countries, that cold was not less cutting nor powerful to destroy things, than the fire to consume them. He adds, that the beginning of these cancerous sores is so small, that what produces the pain scarce equals the bigness of a pea, and yet in few days, nay sometimes in few hours, it spreads so, as to destroy the whole part it invades ; which he confirms by the example of two persons of his acquaintance, who in a trice lost by congelation the badges of their sex.

25. AS to those, that are killed with cold, our author informs us, that they perished by two differing kinds of death. For some being not sufficiently fortified against the cold by their own internal heat, not competently armed against it by furs, inunctions, and other external means, after having had their hands and feet first seized by the cold, till they grow past feeling it there, the rest of their bodies are so invaded, that they are taken with a (kind of lethargick) drowsiness, that gives them extreme propensity to sleep ; which if indulged to, they can no more awake out of, but die insensibly. And from this kind of death our author adds, that he was several times snatched by his servants, who were more accustomed to the cold, and seasonably forced him to awake

out of those drowsinesses, which they knew to be most dangerous. And that sometimes the death by cold is indolent enough, the relations of some intelligent acquaintance of mine, who have been in exceeding cold countries, do confirm.

26. BUT the other way, whereby cold destroys men, is that, which is the most remarkable in our author, and though less sudden is more cruel. For he tells us, that sometimes the cold seizes men's bodies in the reins, and all about the waist (and especially horsemen underneath the armour of the back and breast) and straightens, as he speaks, those parts so forcibly, that it freezes all the parts of the belly, especially the guts ; so that though they have keen appetites, they cannot digest, or so much as retain the lightest and easiest aliments, without excepting broths themselves, but presently reject them by vomit, with unspeakable gripings and pains, and so continually complaining of their condition, and sometimes crying out, as if somebody were tearing out their bowels, they end their miserable lives, being often brought, by the violence of their torments, to the brink of madness and despair, before they come to that of the grave. And our author having seen some of these departed wretches opened, says, that they found the greatest part of their guts black, burnt up, and as it were glewed together ; whence he thinks it probable, that, as their bowels came to be spoiled and gangrenated, they were forced to those complaints and exclamations ; and we may add, that probably upon the same cause depended those continual vomits of what they eat or drank, the gangrene of the guts hindring the descent of excrements downwards, as it often falls out in the true *Iliaca Passio*, and the peristaltick, or the usual motion of the parts being inverted, as it also frequently happens in the same disease. There is no doubt but anatomists and physicians will think this account very imperfect, but yet I think myself beholden to the author for it, because it is not the best, but the only, that I have hitherto yet met with of this matter ; though I could wish it had been much more full and particular, and that he had also opened those animals, and especially their brains, that he mentions to have been killed suddenly, and without pain, by cold. For such informations (whose want, as far as our climate will permit, I have had thoughts of supplying upon experiments of other animals) would perhaps satisfy me one way or other about a conjecture I have had, and been able to countenance by several trials upon vegetables and dead animals, about the cause of mortifications produced by excessive cold.

27. WHAT effects a violent cold may have upon the bodies of other animals than men, I scarce find at all taken notice by the writers I have met with, and what I remember upon that subject amounts to but few particulars : the French author lately quoted takes notice in general, that the cold in *Ukrain*, as the Polanders call it, is sometimes so great, as to be scarce supportable by horses, and some other tame beasts.

28. THIS same author also mentions a certain four footed-animal called *boback*, which is said to be peculiar to those parts, and hides himself under ground in the winter: and having inquired of the lately mentioned Polish nobleman concerning this beast, he told me, that being in that province he had one presented him as a rarity, upon an occasion proper enough to be mentioned here. For some of the *Poles* chancing to dig (for some purpose that I remember not) in a certain retired place, were surprized to find under ground an animal not familiar to them; and though this creature was so frozen and stiff, that they thought it to be stark dead, yet when they came to flea it for its skin, being awakened by pain, it recovered life again, and was brought as a rarity to the commander, from whom I have the relation.

29. THAT some other animals may be frozen till they are stiff, and yet recover, I shall (ere long) have occasion to observe at the close of the 21st section. And therefore I shall now add but this, that whereas it is a tradition among travellers into northern climates, that both birds and wild beasts are in icy and snowy countries ordinarily turned white, if not at all times, yet at least in the winter by the coldness of those gelid climates; I dare neither admit the position, as a thing that is true universally, nor reject it as a thing that is never so. For not now to enquire, whether whiteness proceeds from the coldness of the country, or from some settled seminary impression, or from the imagination of the females affected by the vivid whiteness of the snow, that almost all the year long is the constant object of their sight; I find by the voyages I have perused, that navigators often mention their meeting with store of white bears and foxes in *Nova Zembla*, and other very northern regions, as also their meeting sometimes with herds of white deer. And in the *Alps*, always covered with snow, good authors mention their having met with white partridges; to which purpose I remember, that when I was in *Savoy*, and the neighbouring countries, which have mountains almost perpetually capp'd with snow, I heard them often talk of a certain white kind of pheasants to be met with in the upper parts of the mountains, which for the excellency of their taste were accounted very great delicacies. But on the other side, the same navigators treating even of the coldest climates, seem to distinguish the white bears from others of those parts*; and as for a herd of white deer, their colour may proceed from seminal impressions, since here in *England* I have seen several deer of that colour; and though *Greenland* be by some degrees nearer to the pole than *Nova Zembla*, yet I have seen a live deer brought thence somewhat differently shaped from ours, whose skin was not white, but rather a kind of dun: and to add that upon the by, I took notice, that provident nature, to arm them against the cold, had afforded him a coat, that might have passed for a fur.

30. Yet these two things seem remarkable in favour of the efficacy of cold; the one, that in several cold countries, as particularly *Greenland*, and *Livonia*, even modern describers of them affirm †, that hares will grow white in winter, and return to their native colour in summer; and the other, that though *Charleston Island* differ not one degree in latitude from *London*, yet (as the cold is there prodigious, so) I remember, that Captain *James* somewhere takes notice of his having seen there, both divers foxes, that were pied black and white, and white partridges, though he could not catch them. (*Pag.* 46, and *pag.* 89.) But of the whiteness of animals I elsewhere treat among other subjects, that belong to the history of colours. And having already been more prolix than I intended in setting down the observations of others, I think it now time for me to resume the mention of my own experiments, divers of which, though made before others, that have been already mentioned, X or XII sections off, I thought fit to reserve for this place, both for other reasons, and because this place seems proper for experiments, that have a nearer tendency to the hinting or the examining the more general hypothesis about cold.

T I T L E XX.

Experiments touching the weight of bodies frozen and unfrozen.

1. SINCE divers of those ingenious men, that have of late revived and embraced the doctrine of the old Atomists, teach us, that water is turned into ice by the introduction of frigorifick corpuscles, which *Democritus* of old is said to have believed to be cubical (and to which other philosophers of late have assigned other shapes indeed, but yet determinate ones) we thought fit, not so much for our own satisfaction, as for that of others, to try, whether or no a liquor by its increase of weight, when frozen, would betray any substantial accession of the corpuscles of cold, which, according to the Epicurean principles, may, by reason of their smallness, pass in freely, and in vast multitudes, at the pores of other bodies, and even of glass; and which, by reason of the same smallness, must be supposed exceedingly numerous to be able to arrest the motions of such multitudes of minute corpuscles, as must go to the making up of any considerable quantity of water.

2. AND first we made a trial with eggs, of which our notes give us the following account.

3. [WE took a good pair of scales and placing them upon a frame (purposely made for such experiments, as required, that the things to be weighed should remain long in the ballance) we put into one of these a couple of eggs, and having counterpoised them with brass weights, we suffered them to continue all night in a turret (built as it had been made for an observatory) that the breaking of the eggs, or any such other accidents might not hinder the

* And it is from very northern countries, that we usually receive very dark coloured furs, and the skins as well of black foxes as of white ones.

† *Lepores coloris & pellis mutatione anni tempestates sequuntur, ac hiberno tempore albis pilis vestiti, aestivis meisibus eisdem cinereis habent.* *Livoniae nova descriptio*, pag. 303.

the success of our endeavours, (which were to try, whether the corpuscles of cold, which divers philosophers suppose to be the efficient of congelation, would make them any whit heavier :) but we were somewhat surprized, when the next morning, after a very sharp night, going up to the turret, we found (the scales and frame being in good plight) the eggs to be grown lighter by near four grains.]

Thus far the note.

4. But though we afterwards repeated the experiment once or twice (if not oftener) yet having been, by intervening avocations, diverted from registering the circumstances of the events, I dare not now trust my memory for any more, than that some of the circumstances seemed odd enough, but uncertain, and that I desisted from prosecuting the experiment, chiefly for this reason, that an increase of weight in exposed eggs was scarcely to be hoped for, because it seemed probable, that part of the more subtile and spirituous corpuscles contained in the egg do continually, by little and little, get away through the pores of the skin and shell; that seeming to be the reason, why eggs long kept have usually within the shell a manifest, and sometimes very considerable cavity unfilled with either yolk or white; which cavity seems to have been left by the recess of the subtile parts we have been mentioning: so that although the frigorifick atoms should by their ingress add some, not altogether insensible, weight to the egg, yet that would not, unless perhaps in the very nick of time, when the congelation is first actually made, be taken notice of, by reason of the greater decrement of weight, that proceeds from the avolation of the more subtile parts of the egg it self.

5. AND to satisfy ourselves about this matter, we took four hen eggs, and counterpoised them carefully in a good pair of scales, which were suspended at a frame, that the balance might be kept unstirred in a quiet room, wherein we had placed it; and suffering it to continue there for a pretty while, we observed, that though it were winter, and though the room, wherein it stood, were destitute of a chimney, yet that scale, wherein the eggs lay, did almost grow manifestly lighter; so that it was requisite, from time to time, to take a grain out of the opposite scale, to reduce the balance to an æquilibrium. And by this means we found the eggs, after some time, to have lost eight grains of their former weight: but how much more they would have lost, if we had continued the experiment, the need we had of the scales kept us from discovering.

6. UPON this occasion I will add, that I used some endeavours to satisfy my self about this inquiry, viz. whether eggs being once actually frozen (for those mentioned in the former note, might lose their weight before they were so) and kept in a pair of good scales fastened to a frame in some quiet place, well fenced from the sun, would by the cold of the air, in freezing weather, be kept for any considerable time, without a sensible diminution of weight: but an unexpected thaw

hindered us from seeing the success of what we designed of this nature, both as to eggs, and also some other bodies: for if the experiment were very carefully tried upon a competent variety of them, it might possibly assist us to guess, especially in camphire, and some other easily exhalable bodies, what interest cold may have in suppressing or diminishing the expiration of their effluvia.

7. BUT to return to the weight of bodies frozen and unfrozen, we attempted to discover somewhat about it by several ways, according as the differing accommodations, we were furnished with, permitted. And of these trials I will mention four or five, as well of the less, as of the more accurate, as my memory or notes supply me with them.

8. ONE of the less accurate ways we always employed to try, whether ice, in which, according to the Atomists, great store of these corpuscles must be wedged, would not, upon their expulsion or recess, leave the water lighter than was the ice, was that, which follows; wherein, to hasten the experiment, we mingled a little salt. And though we foresaw, there would be a difficulty from the adhesion of the vapours of the external air to the outside of the glass we were to employ, we thought that inconvenience might be remedied by well wiping off the frost, or dew, from the outside of the glass, till it were clean and dry: the event of the trial we find succinctly set down among our notes as follows. [A single phial sealed up with ice and salt, being wiped dry, and weighed, was found to weigh four ounces four drachms and a half: when it was quite thawed, it was found to weigh somewhat more than a grain less than its former counterpoise.]

BUT more accurate and satisfactory trials about this matter, I find thus set down in one of my papers:

9. [WE took a phial more thin than those, that are commonly used, that, of the aggregate of that and the liquor, the glass might make so much the lesser part. This phial was furnished with a somewhat long-neck, which at the flame of the lamp was drawn by degrees slenderer and slenderer, that being very narrow at the top, it might the more readily and conveniently be sealed, notwithstanding the waters being in it: then we almost filled it with that liquor, I say almost, because a competent space ought to be left unfilled, to allow the water, swelled by glaciation, room to expand it self. This phial, with the liquor in it, was placed in a mixture of snow and salt after our usual manner; and when the glass appeared almost full of ice, it was taken out, and nimbly closed with *Hermes's* seal. Presently after, this was weighed in a pair of very good scales, and the phial together with the contained liquor, amounted to ℥v. 58. gr. β. which yet was not all ice, because these things could not be done so nimbly, but that some of the ice began to thaw, before we were able to dispatch them quite. The phial thus sealed being removed, and suffered for two or three hours to thaw, when the ice was vanished, we weighed again the sealed glass in the same scales,

scales, and found, that it weighed, as before; at least, if there were any difference, it seemed to weigh a little more.] But this increment, that amounted not quite to $\frac{1}{2}$ a grain, might easily be attributed to some difference in the weights and grains themselves, wherein it is not easy to find a perfect exactness, or to some little unheeded moisture, that might adhere to some part of the phial.]

10. AND because it may be wished, that as the experiment shews the weight of ice dissolved into water, to be the same with that of the solid ice; so we had tried, whether the weight of water congealed into ice would be the same with that of the former fluid water, we will subjoin what immediately follows in the same paper, in these words.

11. [WE took a sealed phial, very thin, that it might be lighter, but not so large as the other, by about a third, as amounting in the lately mentioned scales but to $\text{ziii. 3ij. gr. 4i.}$ when we had sealed it up with the water in it. This phial we placed, as we had done the other, in a mixture of snow and salt, freezing it warily, lest being sealed it should break; then we removed it into the same scales, to try, whether it had got any weight by the supposed subingression of the atoms of cold, which many learned men take to be the efficient of congelation; but it either weighed just as before, or if there were any difference, it seemed to have lost $\frac{1}{2}$ of a grain. Being suffered to thaw, and put into the same scales again, it weighed just as much as it did when frozen, though the weights were numerically the same, and about $\frac{1}{2}$ would sway the scales, or at least be sensible upon them. But note, that I was careful this last time to wipe the outside of the glass with a linen cloth, because I have observed, according to what I elsewhere deliver, that, in case ice be any thing hastily thawed, it may produce a dew on the outside of the glass, as I suspected that even the warm air might in some measure do in this: and if it had not been for this suspicion, some adhering dew, that I was thereby enabled to detect and wipe off, before I took the phial into the scales, might easily have imposed upon us.

12. THESE trials I presume may give some satisfaction about the enquiry, for the resolving whereof I thought fit to make them.

13. BUT I was also desirous to see, whether any difference, as to weight, would be produced by freezing and thawing (if I may use those expressions in this case) iron, stone, wood, or the like solid and permanent bodies, which I intended to have exactly weighed before and after their being exposed to the air, and also after the frost was gone, (and all this against counterpoises not exposed to so great a cold) would discover any sensible alteration, as to weight, that might safely be ascribed to the cold. And though avocations, and the negligence of one, that we employed, kept us from bringing the matter to such an issue as was desired, yet the trials seemed not altogether irrational, since we have formerly made it probable (and have since met with fresh instances to confirm it) that even stones, and metals,

may resent some change of texture by the operations of some degrees of cold. And indeed induced by such considerations of that kind, as seemed the least doubtful, I remember I sometime made several experiments of the weight of some metals, and stones, both before and after they had been much exposed to a more vehement cold, than would have sufficed to turn water into ice; and also after they had been, if I may so speak, thawed in a warm air. But the paper, in which we registered the events of these trials, having been mislaid, I dare not charge my memory with the particulars. Only, if I mistake not, one or two of the stones seemed to have increased in weight, after having been buried in our frigorifick mixture, which I was apt to impute to some particles of the ice resolved into water by the salt, that was mingled with it, and (being perhaps made more piercing by the saline particles associated with them) imbibed into the pores of the stone. For I remember, that having procured an experiment, that I then wanted conveniency to try myself, to be made by an ingenious person, upon a stone hard enough to bear a good polish, I was by him informed, that the stone, by having been kept a while in water, did, though it were afterwards wiped dry, discover a manifest increase of weight: and in confirmation of my conjecture, I shall add, that from a sort of stones, that are of a texture close enough to be usually polished, I did, as I expected, obtain, by distillation, (and that without a naked fire) a considerable quantity of an almost insipid liquor, which I suspected to be in good part but water soaked into the stone, for reasons, that it is not worth while here to discourse of; the cause of my mentioning these particulars being, that (I hope) they may make those, that shall hereafter try such experiments, cautious how they draw inferences from them, and may invite them to expose the bodies, they would make trial of, rather to the cold of the free air in very sharp weather, (for want of which, we ourselves could not do what we advise) than to artificial glaciations at least, unless they be so ordered, that nothing that is moist come to touch those bodies to be wrought upon.

14. BUT such trials as these newly mentioned, and others of the like kind, we must leave to be prosecuted by those, that are furnished with accurate scales, and leisure; for want of the latter of which, and sometimes too of the former, we were fain to give over the pursuit of them: which troubled us the less, because those made with the sealed phials were diligently made; and as for divers others, we made them, as we were saying, more to be able to gratify others, than to satisfy ourselves; because though in case there should unquestionably appear some sensible increase or decrement of weight, upon that, which the Atomists would call the *accession* or *expiration* of frigorifick corpuscles, it would afford a plausible argument in favour of the Epicurean doctrine, about the generation of ice: yet if no such change of weight should be found upon the freezing or the thawing of the water, or any other body, I doubt whether it may, on the contrary,

contrary, be safely concluded, that the Atomists theory of cold is false. For possibly they may pretend, that the atoms of cold may not have either gravity or levity, or any more than the steams of electrical bodies, or the effluvia of the load-stone. Nay, though we should admit the frigorifick corpuscles not to be altogether devoid of gravity, it may yet be said, that when they invade the body they freeze, they expel thence some other pre-existent atoms, that may also have some little weight; and that the frigorifick corpuscles, that fly, or are driven away, may be succeeded by some such, when bodies come to be thawed. But of this no more at present.

Appendix to the XXth Title.

THE experiments, we recorded in the foregoing section, may perchance in this regard prove more useful than I was aware of, that they may keep men from being misled by the contrary accounts, that I find to have been given of the weight of ice, and water, by no obscure writers. For, to spare one of the famousst of the ancients, *Helmont*, in the treatise he calls *Gas Aquæ*, where he gives an account of the congelation of water; which I confess to be unintelligible enough to me, and where he is pleased to ascribe to I know not what extenuation of part of the sulphur he supposes to be in water, that levity of ice, which the bubbles, it contains, afford us an intelligible and ready account of, delivers very positively this experiment. *Imple* (says he, *Num. 35.*) *lagenam vitream & magnam frustis glaciæ, collum verò claudatur sigillo Hermetis, id est, per vitri ibidem liquationem: ponatur hæc tum lagena in bilance, adjecto pondere in oppositum, & videbis, quod propemodum octava sui parte aqua post resolutam glaciem erit ponderosior seipsa glaciæ. Quod cum millesies ex eadem aqua fieri possit, &c.* Thus far *Helmont*, who in case he take *lagena vitrea* in the ordinary acception of the word, would have made us some amends for this erroneous account, if he had taught us the way, how he could seal such a broad vessel, as a glass flaggon, hermetically. But what has been delivered in the foregoing section, will sufficiently shew, what is to be thought of this experiment of *Helmont*. And for further confirmation, we have several times weighed ice frozen, and reduced to water, without finding any cause to doubt, but that *Helmont* was mistaken. And particularly upon the last trial I made of this kind, having filled a wide-mouthed glass with solid fragments of ice, together with it, amounting to a pound (of which the glass alone weighed somewhat above five ounces) I whelmed over the mouth of it another flat bottomed glass, that if any vapours should ascend, they might be condensed into drops, as in the like case I had formerly observed them to do. And this ice being thawed in a warm room, as no drops were seen to stick to the inside of the inverted glass, so the other glass being again put into the same scales, appeared almost exactly of

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the same weight as formerly; whereas the ice alone, that had been dissolved, amounting to much above eight ounces, according to *Helmont's* proportion, the weights should have been augmented by a whole ounce at least: and I make little doubt, but that if the experiment had been tried in greater quantities of ice, the event would have been very little, if at all different. But I purposely chose, in the statical experiments about cold, to make my trials in no greater quantities of matter than I have done, because it is very difficult to get scales strong enough to weigh, without being injured, much greater weights, and yet be accurate enough to discover truly such small differences, as are fit to be taken notice of in such experiments. But to return to *Helmont*; Notwithstanding all that we have said against what he delivers about the weight of ice, yet because I take this inquisitive chymist to have been, in spite of all his extravagancies, a benefactor to experimental learning, I am willing to suggest on his behalf, that possibly much of the additional weight he ascribes to the resolved ice, may have proceeded from that which would not have been taken notice of by an ordinary experimenter. For (as I not long since intimated) I have (sometimes purposely, and sometimes by chance) by thawing ice in closed vessels somewhat hastily, produced a copious dew on the outside of the vessels; which dew, as being made by the condensed vapours of the ambient air, ought to be wiped off, before the vessel be put into the scales to weigh the melted ice: and it is possible also, that *Helmont* may have erred in the manner of weighing his *Lagena*, whatever he mean by it; it being usual even for learned men, that are not versed in statics, to mistake in experiments, which require, that things be skilfully and nicely weighed. How far this excuse may be applied to a late * commentator upon *Aristotle's* meteors, who says, he tried, that water frozen is heavier than unfrozen; being a stranger to that author's writings, I shall not consider: only whereas *Helmont* and he seem to agree very little in their affirmations, it will be perhaps more difficult to accord them, than to determine, by the help of our formerly registered experiments, what may be thought of both their relations.

YET I shall add on this occasion, that if I had not devised the abovementioned way of freezing water by art in hermetically sealed glasses, I should have found it difficult to reduce, what is affirmed by *Manelphus*, which I then dreamt not of, to an accurate experiment: for though I had employed a sealed glass, (which I have not heard, that he or any other has yet made use of to that purpose) yet if I had in that vessel exposed the water to be frozen the common way, it is odds (though it be not absolutely certain) that the water beginning, as it is wont, to congeal at the top, the expansion of the subsequently freezing water would break the glass, and so spoil the experiment. And for the same reason I have sometimes in vain attempted to examine the weight of water

Q q q q

frozen,

* — *Hinc gelidam congelatamque aquam graviolem esse non congelata expertus est Jo. Manelphus. Com. in 4. Meteor. Aristor. inquit Tho. Bartholinus de Nivis usu, cap. 12.*

frozen by nature, according to her wonted method in open phials. And if, instead of glaffes, you make use of strong earthen vessels, there is danger, that something may be imbibed, or adhere to the porous vessel, and increase the weight; and by some such way, or by some mistake in weighing, it is very probable *Manelpbus* may have been deceived: which I am the more inclined to think, if we suppose him a sincere writer, not only because of some things I have taken notice of, about congelations made in earthen vessels, but because, when I have, instead of an earthen, made use of a metalline pottinger, (both which sorts of vessels have in common this convenience, that their ponderousness makes them less fit for accurate scales) there appeared cause to suspect, either that our author did not use metalline vessels, or, which I rather suspect, that he wanted skill or diligence in weighing. For as I find no intimation of his having employed any peculiar or artificial sort of vessels, so, if he used such as we have newly been speaking of, and had weighed them carefully, I cannot but think, that instead of finding the ice heavier than the water it was made of, he would have rather found it lighter. For I remember, that having once exposed all night a pottinger, almost full of common water, to an exceeding sharp air, and having caused it the next morning to be brought me, when the liquor was thoroughly frozen, I found it to have lost about 50 grains (if I misremember not) of its former weight. And though this event were consonant enough to my conjectures, yet for greater certainty I repeated the experiments another frosty night with this new caution; that the pottinger and water, together with the counterpoise, were kept suspended in the scales, to be sure, that no effusion of any part of the water in carrying it abroad to the open air should be made without being taken notice of: but the next morning (somewhat late) the vessel, with the contained water now congealed, appeared to have lost about 60 grains; and with the like success the trial was reiterated once more, and that in weather so sharp, that I am not apt to think, the water exposed by *Manelpbus* began to freeze sooner than ours. But the event was not unexpected; for besides that I considered, that in these kind of experiments, part of the water, notwithstanding the exceeding coldness of the air, must in all likelihood fly away before the surface of it began to be congealed, I judge it not improbable, that not only the fluid part, but even that, which was already congealed, might continually lose some of its corpuscles, and by their recess lose also somewhat of its weight. And lest these conjectures should seem too unlikely, it will not be amiss to add in favour of the first of them, that having purposely provided a large pewter box, with a cover to screw on it, and having fill'd it almost full of water, (I say almost, because if the vessel had been quite full, the congealing cold might have burst it) and carefully weighed the aggregate of both (which amounted to zv. zii. gr. 11. whereof the vessel weighed zii. zvj. and gr. 8.) we exposed the

water after the top of the pot was screwed on, to hinder the avolation of it, to the freezing air all night, and the next morning found it frozen from the top to the bottom, though not uniformly and perfectly, but found not one grain difference betwixt its present and its former weight. And as for the second conjecture newly proposed, though it may seem somewhat strange, yet it is confirmable by this experiment, that having placed divers lumps of solid ice in a pottinger, which together with them weigh'd a pound, consisting of 16 $\frac{3}{4}$, and having exposed these things in the same scales, wherein they were weighed, to the free air, on a very frosty night, we found the ice to have lost the next morning 24 grains of its weight; and the weather continuing so cold, that it froze hard all day long in the shade, I gave order to have it kept out of the sun in the same scales, during all that time, and a good part of the following night, and then weighing it the second time, found, that the whole decrement of weight did now amount to five grains above two drachms, though the weight of the ice, without the pottinger were but about seven ounces: and when we had kept about 13 ounces of ice, in a very frosty night, exposed to the cold air, it had lost, as early as the next morning, a good deal above two drachms of its former weight. But these statical observations have perhaps already but too much swelled this Appendix.

TITLE XXI.

Promiscuous experiments and observations concerning cold.

I Hope it will not be imagined, that I have such narrow thoughts of the subject I treat of, Cold, as to believe, that I have comprized under those few titles, prefixed to the Sections of this historical treatise, all the particulars, that I knew to belong to so comprehensive a theme; as would readily appear, if I thought it convenient to insert here the scheme of articles of inquiry, that I drew up to direct myself, what inquiries and experiments to make. But though there were divers of those heads, to which I could say so little, that I judged it improper to assign them distinct titles, because, as to some of them, I had not time and opportunity to make those trials, which, if I had not wanted those requisites, might have been made, even here in *England*; and because also, as to more of them, I conceived my self unable to produce, in this temperate climate, so strong and durable a cold, as seem'd necessary to make the trials, that might be referred to them, succeed so far, as to satisfy my doubts, either affirmatively, or negatively: Though I say, these and some other considerations kept me from increasing the number of the titles, among which I have distributed the experiments and observations, that make up the foregoing part of this treatise, yet since divers particulars have occurred to me, which though they seem not properly reducible to the foregoing titles, do yet belong to the subject and design of this treatise, I think

think it fit to annex them in this place, and without any other order than that, wherein they shall happen to occur to me, throw them into this one section; together with some loose experiments, and divers relations, that I have met with among navigators and authors, that have travelled into the northern climates, touching cold, not forbearing to insert promiscuously among them some few *paralipomena*, which, if they had seasonably come to my hands, or into my mind, might have had a more proper place among the foregoing sections, or have composed a title by themselves. Wherefore though the observations will not be altogether unaccompanied with experiments, yet for the reasons above intimated, much the greater part of what is to be delivered under this title, will consist of collections out of voyages, in which the strange things mentioned being such, as we cannot examine by our own trials, I can equitably be thought answerable for the truth of nothing but the citations.

2. I REMEMBER I tried, at several times, divers experiments, to discover, whether or no congelation would by constriction of the pores of bodies, or vitiating their texture, or arresting the motion of their parts, hinder them from emitting those effluvia, that we call odours; but the register of these observations, being unhappily lost in one of my late removes, I dare add but these few, wherein I have no cause to distrust my memory.

3. I DID, in the months of *December* and *January*, at several times gather differing sorts of flowers in frosty weather; but in most, when they were freshly gathered, and hastily smelt to, I could scarce perceive any sensible smell; whether it were, that the causes above hinted hindered the expiration of the odoriferous steams, or that the cold had some undiscerned influence upon the organ of smelling, which made the sense more dull, or that the same cold kept the alimantal juice of the flowers from rising in such plenty, and abounding so much with spirituous parts, as was usual at the more friendly season of the year: and this seem'd the more likely to be one reason of the phenomenon, because most of the flowers were flaggy, and as it were, ready to wither; and because also a primrose, that was vigorous and fresh in its kind, had an odour, that was manifestly (and it will easily be believed, that it was not strongly) sweet, and genuine.

4. I TOOK also, about an ounce, by guess, of rose-water, and putting it into a small phial, after I had smelt to it, it was exposed to freeze in the open air; and when it began to have ice in it, I then smelt to it again, but found not the perfume considerably, if so much as manifestly abated: and lastly, having suffered it to continue in the air, that was then very sharp, 'till it was quite frozen, and discovered no liquor, when the phial was turned upside down, the ice notwithstanding was not destitute of a graceful and genuine scent, though

it seem'd somewhat faint; but after the ice was reduced to water again, the fragrancy appeared considerable. But on this occasion it will not be improper to subjoin this caution, that care must be had, in trials of this nature, to make one's estimate betimes; for if a man should stay too long about it, there is danger, that the warmth of ones breath and face may relax the pores, or thaw the surface of the ice, that is held near his nose, and both free and excite the corpuscles of smell, that are imprisoned there, that so instead of ice, he may smell a liquor. The reasonableness of which advertisement may be justified by an experiment, that I am about to annex. For being pretty well confirmed by the casual and unwilling observations of one of my friends, curious in making sweet water, that even liquors more easy to be spoilt than rose-water would not have their fragrancy destroyed, though perhaps impaired, nor so much as their odours for the time quite imprisoned and suppressed by congelation; and this appearing congruous to what I formerly noted of the effluvia, that may, by the decrement of weight, be gathered to issue from ice itself, I thought it worth while to try, whether stinking liquors would not be more altered by congelation, than odoriferous ones. And accordingly having procured some rain-water, that had been kept in a tub, 'till it stunk so strongly, that I could hardly endure it near my nose, I caused a pottinger full of it to be exposed all night to a very sharp air; and examining it the next morning, when it was all turned into ice, neither I, nor some others, to whom it was offered, could perceive any stink at all in it. And having in another place, but with as stinking water, repeated the experiment, when the pottinger was the next morning brought to my bed's side, I found it to smell abominably; whereupon guessing, that this difference proceeded from some thaw made by the warmth of the room in the superficial parts of the ice, I found it to be so indeed, partly by the help of the light, which discovered a little liquor upon the ice, and partly by exposing the vessel with that liquor in it to the cold air again, by whose operations an ice was produced, that was perfectly inodorous; and I remember, that one of these parcels of ice being thawed, seem'd to be less stinking than before * it had been frozen; and if I had not been diverted, I should have tried, whether this ice, that did not omit odours, would emit, like other ice, effluvia, discoverable by the scales: for whether the ice would lose of its weight, which seem'd the more probable, or would not, the event may afford a not inconsiderable hint.

5. IT is a thing not only remarkable, but scarce credible, that though the cold has such strange and tragical effects at *Moscow*, and elsewhere in cold countries, as we have formerly mentioned, especially a little after the beginning of the 18th and somewhere in the 19th section; yet this happens to the *Russians* and

Livonians

* If it had not been for the negligence or mistake of one, that I ordered in my absence, to freeze and thaw the same water, divers times one after another, I might have added the success of that experiment, which I was sorry to miss of, because it might possibly have afforded an useful hint about a way to correct stinking waters, in some climates or season.

Livonians themselves, who, not only by living in such a country, must be accustomed to bitter colds, but who, to harden themselves to the cold, have used themselves, and thereby brought themselves to be able to pass to a great degree of cold, from no less a degree of heat, without any visible prejudice to their healths. For I remember, that having inquired of a virtuoso of unquestionable credit, whether the report of our merchants, concerning this strange custom of the Muscovites and Livonians, were certainly true, he assured me, that it was so, at least as to the Livonians, among whom, being in their country, he had known it practised. And the same was affirmed to me by an ingenious person, a doctor of divinity, that had occasion some years since to make a journey to *Moscow*. And the tradition is abundantly confirmed by *Olearius*, whose testimony we shall subjoin, because this seems one of the eminentest, and least credible instances, that we have yet met with of the strange power, that custom may have, even upon the bodies of men. 'It is a wonderful thing says he, to see how far those bodies (speaking of the Ruffians, that are accustomed and hardened to the cold) can endure heat, and how when it makes them ready to faint, they go out of their stoves stark naked, both men and women, and cast themselves into cold water, or cause it to be poured upon their bodies, and even in winter wallow in the snow.' To which passage our author adds, from his own observation, particular examples of the truth of what he delivers.

Olearius,
livre 3.
pag. 168.

6. I HAD several years since, the curiosity to try, whether there were any truth in that tradition, which is confidently affirmed, (and experience by some is pretended for it) that the beams of the moon are cold; but though I were not able to find any such matter, either by the united beams of the moon, or by the same beams concentrated by such burning-glasses as I then had; yet having some years after furnished my self with a large and extraordinary good metalline concave, I resolved to try, whether those beams were not only devoid of cold, but also somewhat warmish, since they are the sun-beams, though reflected from the moon. And we see, that his beams, though reflected from glasses not shaped for burning, may yet produce some not insensible degree of warmth. But notwithstanding my care to make my trials in clear weather, when the moon was about the full, and, if I misremember not, with a weather-glass, I could not perceive by any concentration of the lunar beams, no not upon a black object, that her light did produce any sensible degree, either of cold or heat; but perhaps others, with very large glasses, may be more successful in their trials.

7. ON this occasion I shall add, that meeting the other day in a bookseller's shop with the works of the learned physician *Sanctorius* (whom I look upon as an inquisitive man, considering when and where he lived) a picture drew my eyes to take off an experiment, whereby he thinks to evince the light of the moon to be considerably hot; which he says, he tried

by a burning-glass, through which the moon's light being cast upon the ball of a common weather-glass, the water was thereby depressed a good way, as appeared to many of his disciples, amidst whom the observation was made. But though this may invite me, when opportunity shall serve, to repeat my trials, yet I must till then suspend my assent to his conclusion. For my burning-glass was much better, than by the narrative his seems to have been; and my trials were perhaps at least as carefully and impartially made, as his experiment, in which this may probably have imposed upon him; that performing the experiment, a company of his scholars, whilst they stood round about his thermoscope, and stooped (as in likelihood their curiosity made them to do) to see by so dim a light the event of the experiment, the unheeded warmth of their breath and bodies might, unawares to *Sanctorius*, somewhat affect the air included in the weather-glass, and by rarifying it, cause that depression of the water, which he ascribed to the moon-beams. But because this is a conjecture, I intend, if God permit, to repeat the experiment, when I shall have opportunity to do it with a more tender weather-glass, than I had by me, when I made my former observations.

To the XIth TITLE.

BY the unsuccessfulness of the former attempts made with an iron instrument, I was invited, especially being at another place, where I was unfurnished with such hollow iron balls, as are mentioned *numb. 10.* to substitute the following experiment. I caused a skilful smith to take a pistol-barrel, guessed to be of about two foot in length, and of a proportionable bore; and when he had, by riveting in a piece of iron, exactly stopped the touch-hole, I caused him to fit to the nose of the barrel a screw, to go as close as well he could make it: and then having filled it to the very top with water, I caused the screw to be thrust in (which could not be done without the effusion of some of the water) as forcibly as the party I employed was able to do it, that the water, dilated by congelation, might not either drive out the screw, or get between it and the top of the barrel. And having then suspended this barrel in a perpendicular posture in the free air, in a very cold night, which then unexpectedly happened, and gave me the opportunity of making the trial, I found the next morning, that the intumescent water had thrust out a great part of the screw, notwithstanding, that, to fill up intervals, I had oiled it before; and was got out betwixt the remaining part of it, and the barrel, as appeared by some ice, that was got out, and stuck round about the screw. Wherefore, the bitter cold continuing one day longer, I did the next night cause the intervals, that might be left betwixt the male and female screws, to be filled up with melted bees wax, which I presumed would keep the screw from being turned by the water: and having in other points proceeded as formerly, I found the next morning that

that the screw held, as I desired, and the preceding night having been exceeding bitter, the cold had so forcibly congealed, and expanded the water, that it burst the iron barrel somewhat near the top, and made a considerable and oblique crack in it, about which a pretty quantity of ice appeared to stick; besides that, there were three or four other flaws, at some of which smaller quantities of water appeared to have got out. At the same time, that I bespoke this iron barrel of the smith, I ordered him to get me a brass one filled up after the same manner, to make the experiment the more satisfactory. But though he could not procure it, yet the success was not unwelcome, because it was manifest, that there were cracks in the iron in one place conspicuous, and in others easily discoverable, by blowing into the barrel, and putting on the outside of the suspected parts, either spittle or some fit liquor, whose agitation plainly disclosed the egress of the wind; and there appeared small cause to doubt, but that these cracks were produced by the operation of the cold; since not only the smith was a skilful man in his trade, and one, that I used to employ about instruments, and also the barrel had been sometimes kept many hours filled with water, without appearing other than very staunch: but, which is the considerablest circumstance the night before, the frost, as I lately noted, was not able to make the water break out at any of these clefts, though it were able to force it self a way out at the screw, in spite of all the care we had taken to make it go close. I have only this circumstance to add about this matter, that when by thawing one part of the ice, some pieces of the rest were got out of the barrel, all I took notice of appeared to be full enough of bubbles, but yet such as seemed lesser than ordinary, whether they were so by chance, or were determined to be so, by the resistance or compression, which the freezing water found upon its endeavouring to expand its self in the barrel.

Appendix to the XVIIth Title.

LONG since the writing of the foregoing section, meeting with a passage in *Bartholinus*, where he vouches *Cabeus* for the experiment of congealing water (without limiting it to any season of the year) by putting salt-petre into it, and shaking it strongly, I was thereby confirmed, that I was not mistaken, in supposing, that *Gassendus* (mentioned in the former section) did not exclude that corporal and visible nitre out of the number of the grand efficient of congelation. For *Cabeus* having published his comment upon *Aristotle's* meteors (whence this experiment is taken by *Bartholinus*) before *Gassendus* published this book, it is probable, that he as well as others borrowed the experiment from him; and *Cabeus*, as *Bartholinus* quotes him, prescribes the putting the salt-petre itself into water, which being a while put into a brisk motion, will, after some agitation, not only refrigerate that water, but bring it to a true and proper congelation.

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WHEREFORE suspecting, that this relation, wherein *Bartholinus* says, he will believe him without an oath, may have given rise to the opinions and affirmations of those ingenious writers, that have since ascribed such wonderful coldness to nitre, and finding in *Bartholinus*, that *Cabeus's* proportion betwixt the nitre and the water, was that of 35 to 100, that is, almost as one to three, I thought it very well worth while to make trial of an experiment, which seemed to me little less unlikely than considerable.

I Took then a pound of good salt-petre, and near three pound of common water (to observe the more narrowly *Cabeus's* proportion) these being put into a large new pipkin, were kept constantly and nimbly stirred about, sometimes by me, sometimes by one or other of the domesticks relieving one another, when they were weary; but though the mixture was with a kind of broad glass spattle kept in a brisk motion, that for the most part was after the manner of a whirl-pool, and sometimes a more confused agitation, and though we kept it thus stirring for almost an hour and a half, till we saw no likelihood of effecting any thing by trying our selves any further, yet not only we could not perceive that any atom of true ice was produced; whereas, according to our authors, we might have expected a true and perfect congelation of all, or the greatest part of the water, but we did not find, that there was so much as any freezing of the vapours on the outside of the vessel; and for this reason we thought fit about the same time, to try the experiments by another kind of agitation, and mixing two ounces of salt-petre with about six of water, in a conveniently sized phial, we did several of us successively vehemently shake the phial to and fro, till we were almost tired; but neither this way was there produced the least ice within the glass, or the least congelation of the vapours of the air on the outside of it. It is true, that when so great a proportion of salt-petre began to be dissolved in the pipkin, the water had a sensible increase of coldness, which afterwards seemed to diminish, when once the nitre was dissolved; but not to mention, that (if I much mistake not) we have observed the water to be refrigerated, when, upon the dissolution of common salt, multitudes of actually cold and solid corpuscles came to be every way dispersed through it; this coldness produced by the nitre was very far short of the degree requisite to congelation: for to satisfy myself, that my sense did not mis-inform me, I took a good sealed weather-glass of about ten or twelve inches long, and immersing it into the cold mixture of nitre and water, I observed the tinted spirit of wine in the stem to descend not inconsiderably; and when I perceived that degree of cold to have wrought its effect, I removed the thermoscope into a phial filled with common water; about which I had caused to be placed a mixture of beaten ice and salt, to refrigerate the contained water, in which the ball of the instrument being placed, the spirit of wine hastily descended two or three inches

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below

below that place, at which it stood, when it was removed out of the nitrous solution: and, for further satisfaction, removing the thermometer once again into that solution, the spirit of wine in the stem was hastily impelled up, as if the bubble had been put into warm water. And, once more, the weather-glass being removed into the formerly mentioned refrigerated water, the tinted liquor began to fall down hastily again, and, within a while, subsided almost into the bubble; whereupon, to avoid injuring the instrument, we thought fit to take it out. So that, upon the whole matter, if the learned *Cabeus* were not deluded by mistaking some crystals of nitre (which I have observed easily to shoot again in water, that has been glutted with it) for true and proper ice, I cannot but wonder at his assertion, and must take the liberty to think my self warranted, by so many harmonious trials, as I have found unfavourable to the supposed supremacy of cold in salt-petre, to retain my former opinion about it, till more successful experiments withdraw me from it.

It is a received tradition, among the watermen and many others, that the rivers, if not ponds also, are frozen first at the bottom, and begin to thaw there. But though I find this opinion to be in request, not only among English watermen, but among the French too, yet I think it may be very warrantably questioned: for it is evident, in waters we expose to freeze in large vessels, that the congelations begin at the surface, where the liquor is contiguous to the air; and thence, as the cold continues to prevail, the ice increases, and thickens downwards: and therefore we see, that frogs retire themselves, in frosty weather, to the bottom of ditches, whence I have had many of them taken out, very brisk and vigorous, from under the thick ice that covered the water. And I have been informed by an observing person, that, at least in some places, it is usual, in winter, for shoals of fishes to retire to those depths of the sea, if not of rivers also, where they are not to be found in summer. Besides, if rivers were frozen at the bottom, we must very frequently meet, in the emergent pieces of ice, the shapes of those irregular cavities and protuberances, that are often to be found in the uneven soils, over which rivers take their course; whereas, generally, those emergent pieces of ice are flat, as those flakes, that are generated on the surface of the water. Moreover, if even deep rivers freeze first at the bottom, why should not very many springs and wells freeze first at the bottom too? the contrary of which nevertheless is obvious to be observed. In confirmation of all which, we may make use of what we formerly noted, (in the section of the *Primum Frigidum*) about the practice of the masters of the French salt-works, who, by overflowing the banks and causeways all the winter, keep them from being spoiled by the frost; which could not be done, if the waters, they stand under, froze as well at the bottom, as at the top.

But, I find, that that, which deceives our watermen, is, that they often observe flakes of ice to ascend from the bottom of rivers, to the

top; and indeed it often happens, that, after the hard frost has continued a while, these emergent pieces of ice do very much contribute to the freezing over of rivers. For, coming, in some of the narrower parts of them, to be stopped by the superficial ice, that reaches on each side of the river, a good way from the banks towards the middle, those flat icy bodies are easily cemented by the violence of the cold, and, by the help of the contiguous water, to one another, and by degrees freightning, and at length choking up the passage, they give a stop to the other flakes of ice, that either emerging from the bottom, or loosened from the banks of the river, or carried down the stream towards them; and these being also, by the same cold, cemented to the rest, the river is at length quite frozen over. And the reason, why so many flakes of ice come from the bottom of the river, seems to be, that, after the water has been frozen all along near the banks, either the warmth of the sun by day, or some of those many casualties, that may perform such a thing, does by thawing the ground, or otherwise, loosen many pieces of that ice together with the earth, stones, &c. that they adhered to, from the more stable parts of the banks; and these heavy bodies do, by their weight, carry down with them the ice they are fastened to; but then the water at the bottom of the river being warm, in comparison of the air, in frosty weather, (since that even common water is so, we have manifested by experience, where we shew how much sooner ice will be dissolved in water, than thawed in air) the dispersed ice by degrees so wrought upon, that those parts, by which it held to the stones, earth, or other heavy bodies, being resolved, the remaining ice being much lighter, bulk for bulk, than water, gets loose, and straightway emerges, and may perhaps carry up with it divers stones and clods of earth, that may yet happen to stick to it, or be inclosed in it, the sight of which persuades the waterman, that the flakes of ice were generated at the bottom of the river; whereas a large piece of ice may carry up, and support bodies of that kind, of a great bigness, in case the ice it self be proportionably great, so that the aggregate of the ice, and heavy bodies, exceed not the weight of an equal bulk of water. On which occasion I remember, that Captain *James Hall*, in a voyage extant in *Purchas*, relates, that, upon a large piece of ice in the sea, they found a great stone, which they judged to be three hundred pound weight. But, of the tradition of the watermen we shall say no more, than that this hath been discoursed, but upon no great information, though the best we could procure; so that, for further satisfaction, it were to be desired, that, either by sending down a diver, or by letting down some instrument fit to feel (if I may so speak) the bottom of rivers with, and to try, whether ice, if it met with any, be loose from, or uniformly coherent to the ground, and also bring up parcels of whatever stuff it meets with there, the matter were, by competent experiments, put out of doubt.

We took a sealed weather-glass, furnished with

In the Section touching the duration of ice.

with spirit of wine, and though not above ten inches long in all, yet sensible enough; and, having caused a hole to be made in the cover of a box, just wide enough for the small end of the glass to be thrust in at, we inverted the thermometer, so that the ball of it rested upon the cover of a box, and the pipe pointed directly downwards. Then we placed about the ball a little beaten ice and salt, and observed, whether, according to our expectation, the tinted spirit, that reached to the middle of the pipe, or thereabouts, would be retracted upon the refrigeration of the liquor in the ball; and accordingly the spirit did in a very few minutes ascend in that short pipe above an inch higher than a mark, whereby we took notice of its former station, and would perhaps have ascended much more, if the application of the frigorifick mixture had been continued; by which, and another succeeding experiment to the same purpose, it seems that the condensation of liquors by cold, is not always affected by their proper gravity only, which ordinarily may be sufficient to make the parts fall closer together: but whether in our case, the contraction be assisted by some little tenacity in the liquor, or by the spring of some little aerial, or other spirituous and elastick particles, from which the instrument was not perfectly freed, when it was sealed up, or which happened to be generated within it afterwards, will be, among other things, more properly inquired into in another place, where we may have occasion to make use of this experiment.

THERE is a famous tradition, that in *Muscovy*, and some other cold countries, it is usual out of ponds and rivers to take up good numbers of swallows inclosed in pieces of ice; and that the benumbed birds upon the thawing of the ice in a warm room, will come to themselves again, and fly about amazedly for a while, but not long survive so great and sudden a change. I have in another treatise already said somewhat about this tradition, and therefore shall now say no more of it, than these two things: first, that I since was assured by a person of honour, that is very curious, and was commanded by a (many ways) great prince to enquire out the truth of it, when he was in some of those countries, where the thing is said to be familiar enough, and that the eminentest and soberest persons he could ask affirmed the thing to be true: but, (secondly) having lately enquired about this matter of a knowing person of quality, that was born and bred in *Poland*, he answered me, that in the parts, where he lived, it was a very general and unquestionable opinion, that swallows often hid themselves all the winter under water in ponds and lakes, and sedgy places, and that the fishermen, when having broken the ice, they cast their nets for fish, to draw them up benumbed, but not dead, so that they quickly in stoves recover their wings, but seldom after that prolong their lives. But as for their being taken up in ice, he told me, he had not heard of it; though I see not, why in case they commit themselves to shallow waters, as those of ponds and sedgy places often are, a sharp lasting frost may

not sometimes reach them. And therefore that, which left me the greatest scruple about this tradition, is, that this gentleman, notwithstanding his curiosity, could not affirm, that ever he himself had seen any example of the thing he related.

BUT I will take this occasion to add, that having a mind in frosty weather to try some anatomical experiments about frogs, one, that I employed breaking in a ditch some ice, that was very thick, and of which he was to bring me a quantity, found in the water, that was under the ice, good store of frogs (besides some toads) which I found to be very lively, and divers of which I kept for certain uses a good while after.

To confirm, and to add some paralipomena unto what I have delivered in the second, and in the twentieth titles, about the frost's getting into hard and solid bodies, I shall here subjoin some particulars there omitted, which I have learned partly from experiments, and partly from persons worthy of credit, whom I purposely consulted about this matter.

AND first, as to the freezing of wood, we have sometimes tried it by purposely exposing partly other wood, and partly branches cut off from growing trees, to an intense degree of cold, by which the wood seemed in one night to be for some little depth manifestly enough invaded by the frost. But a domestick of mine having a little while since had occasion to fell an old apple-tree, on a day, that had been preceded by a fortnight's bitter frost, came and informed me, that he found, that the frost had evidently pierced into the very middle of it, though it were about a foot in diameter. And an experienced artificer, whose head and hand were much employed about the building of great men's houses, told me, that he had often seen here in *England* pieces of timber itself manifestly frozen, and rendered exceeding difficult to be sawed, the frost also appearing by evident signs to continue in the saw-dust. And therefore it will be the less strange, if in *Poland* the effects of cold upon wood be more conspicuous. For a learned native assured me, that in his country it was usual to have wood frozen so hard, that the hatchets would not cut it, but rebound from it; and that it was very usual to hear in the night a great many loud cracks, almost like the reports of pistols of the shingles or wooden tiles, wherewith in many places they cover their houses instead of slate; and this, (as I purposely asked) when the weather was dry, and excessively cold. When I likewise enquired about the thawing of wood, he told me, he had several times seen pieces of timber, which having been thoroughly frozen in the air, did, when brought into rooms, made warm by stoves, become covered with a kind of hoar frost; and made them look white, and that though his bow (which he shewed me) were very strong and tough, as being made not of wood, but horn, and other close materials, it would be so changed by the frost, that unless special care were had in the thawing of it, it would break

THAT

THAT marl and chalk, and other less solid terrestrial concretions, will be shattered by strong and durable frosts, is observed by husbandmen, who thereby find it the better fitted to manure their land; the texture of those bodies, during whose intireness the parts most proper to feed grass and corn, are more locked up, being by congelation in great part dissolved; but that true and solid stones, wont to be employed in noble and durable buildings, should be spoiled by the frost, will perhaps to most readers seem very improbable. And therefore I shall here add what I have learned by inquiry of the ingeniousest and most experienced mason I have met with, because it may not only surprize most readers, but prove an useful observation to him. Having then enquired of this tradesman, whether he did not find, that some free stone, a name vulgarly known, would not be spoiled by the frost, he told me, that he had often observed both free stone and harder stones than that, to be exceedingly spoiled by the frost, and reduced to crack or scale off, to the blemishing and prejudice of the houses, that are built of them. But because it may be objected against this, that experience shews us, that divers of the stateliest fabricks in *England* have these stones for their chief materials, and it endure very well the inclemencies of the air; the reply may be, that the difference may not consist in the peculiar natures of the stones employed, but in the several seasons in which the same kind of stones are digged out of the quarry. For if they be digged up, when the cold weather is already come in, and employed in building the same winter, they will, upon very hard frosts, be apt to be shattered or scale; but if they be digged early in the summer, suffered to lie exposed to the sun and air, during all the heat of the summer, these seasoned stones, if I may so call them, may out-last many sharp winters unimpaired. It seems to me worth trying, whether during their insolation, if that term may be allowed me, there do not, by the operation of the heat and air upon them, exhale a certain unripe mineral, sap or moisture (whose recess may perhaps be discovered by weight) which, if it remain in the stone, may, by very piercing frosts, be congealed almost like the sap in timber-trees, and shatter the texture of the stone, which agrees well with what was told me by an understanding person, that is master of a great glass-house, of whom having purposely inquired, whether he did not find, that his great earthen pots, which is made up with as little water as is possible, and are deservedly famous for their durable texture, had not that texture altered and impaired by very piercing frosts; he assured me, that if he did not take care to keep the frost (as they speak) from getting into them, those great and solid vessels, wherein he used to keep his glass in fusion, would, in the fire, scale or crack (and perhaps fly) and become unserviceable no less than some weeks sooner, than if they had never been impaired by the frost. And when I inquired, whether also glass itself would not be much prejudiced

thereby, he affirmed to me, that oftentimes in very hard frosts many glasses, that had continued entire for many weeks (for that circumstance I was solicitous to ask about) would as it were of their own accord crack with loud noises. But whatever prove to be the issue of such trials, it will not be amiss to confirm the phenomenon itself, by the testimony of an illiterate but very experienced French author, who, on a certain occasion, tells us, (as I also take notice in another * treatise) 'That he * ^{Of the} knows the stones of the mountains of *Ar-* ^{imperfection of Phys-} *denne* (famous enough in *France*) are harder ^{sicks. Mai-} than marble, and yet the inhabitants of that ^{stre Ber-} country do not draw them out of the quarry ^{nard Pa-} in winter, because they are subject to the ^{liffy.} frost. And it has been divers times seen, that upon thaws, the rocks, without being cut, have fallen down and killed many.'

BUT it may yet seem far more unlikely, that frosts should get into metals themselves, and yet having asked the newly-mentioned Polonian, whether he had observed any thing of that kind; he answered, that he had often by drawing out his sword and pulling out his pistols, when he had been long in the field, and came into a hot room, found them quickly almost whitened over, by a kind of small hoar frost. But whether this were, as he conceived, any thing, that was drawn out of the steel, and settled on the surface of it, I want circumstances enough to make me willing to determine. But if we will credit *Olaus Magnus*, it must be confessed, that considerably thick pieces of iron and steel itself will, in the northern regions, be rendered so brittle by the extreme frost, that they are fain to temper their instruments after a peculiar manner: his words, which being remarkable I forbear to alter, are these; *Videntur præterea ferrei ligones certa ratione fabricati, quia his spissa atque indurata glacies cæteris instrumentis ferreis non cedens facilius infringitur, dum aliæ secures chalybe permixtæ, in vebementi frigore ad solum glaciei vel virentis arboris iclum instar viri rumpuntur, ubi ligones prædicti sive ferreæ hæstæ fortissimi manent.* Which testimony, notwithstanding what some have written to this author's disparagement, does not seem to me at all incredible. For I remember, that even here in *England* I have had the curiosity to cause trials to be made in very frosty weather, whereby, if an expert smith I then used to employ, did not *gratis* deceive me in the irons I employed, that metal may by such degrees of cold, as even our climate is capable of, be rendered exceeding brittle, as he several times affirmed to me, that there are some kinds of iron, which he could hammer, and turn, as they phrase it, cold in open weather, which yet in very hard frosts would become so brittle, as by the same way of working easily to break, if not to fly asunder. And this he affirmed both of iron and steel; of which latter [metal another very skilful workman, whom I also consulted, certified the like: but though this disagreed not with trials purposely made on iron rods, as they had informed me, yet presuming, that in such a nice piece of work as a spring, some further satisfaction about this matter might

might be obtained, I inquired of a very dexterous artificer, that was skilled in making springs for others, whether or no he found a necessity of giving springs another temper in very frosty weather, than at other seasons; and he answered me, that in such weather, if he gave his springs the same temper, that he did in mild and open air, they would be very apt to break. And therefore in very sharp seasons he used to take them down lower, as they speak, that is, give them a softer temper than at other times; which, as it makes it probable, that the cold may have a considerable operation upon bodies, upon which most men would not suspect it to have one; so that discovery may afford a hint, that may possibly reach further than we are yet aware of, touching the interest, that cold may have in many of the phenomena of nature.

I SHOULD here subjoin, that in prosecution of what is delivered in the XXth section about the weight of solid bodies, that I there wished might be exposed to a congealing air, I did cause some trials of that kind to be made in a very frosty night, especially with bricks; but something, that happened to the only scales I then had fit for such an experiment, made me doubt, whether some little increase of weight, that seemed to be gained by congelation, were to be relied upon, though there did not appear any hoar frost, or other thing outwardly adhering, to which the effect could be ascribed.

It is a tradition, which the schools and others have received with great veneration from their master *Aristotle*, that hot water would sooner freeze than cold; but I do not much wonder, that the learned *Cabeus*, as I find him quoted by *Bartholinus*, should contradict this tradition, though he be himself a commentator upon that book of *Aristotle*, wherein it is delivered. For I could never satisfy myself, that there is (at least without water, and in our climate) any truth in the assertion, though I have made trial of it more ways than one; but it may very well suffice to mention a few of the plainest and easiest trials, with whose success I am well satisfied as to the main, as the reader also will, I doubt not, be; though not having, for want of health, been able to have so immediate an inspection of these, as of the rest of my experiments, I was fain to trust the watchfulness of my servants (whom I was careful to send out often) to bring me word, how long after the first freezing of the cold water, it was before the other began to be congealed.

WE took then three pottingers, as near of a size as we could; and the one we filled almost to the top with cold water, the other with water, that had been boiled before, and was moderately cooled again, and the third with hot water: these three vessels were exposed together in the same place to the freezing air.

In the entry of one of the trials, I find, that being all three put out at half an hour after eight of the clock, the pottinger, that contained the cold liquor, began to freeze at $\frac{1}{4}$ after ten.

THAT, which contained the water heated and cooled again, began to freeze. $\frac{3}{4}$ past ten.

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AND that, which contained the hot water, at half an hour after eleven, and somewhat better. So that though all froze within the compass of two hours, yet the cold water began this time to freeze an hour and $\frac{1}{4}$ sooner than the hot.

THESE pottingers were earthen, but I elsewhere made the trial of others of metal, and there also the cold water began to freeze, both before that, which had been heated and cooled again, and long before the hot.

ANOTHER time I measured out the water by spoonfuls into pottingers (not having then by me any fit scales to weigh it) to be the more sure, that the quantities of water should not be considerably unequal, and then also the cold water froze a considerable while before the hot.

BUT my usual jealousy in the making nice experiments tempting me to enquire, whether the water in some of the former trials had not been heated in a stone bottle, nor a skillet, it was confessed, that it was so, but that the bottle used to contain nothing but beer, and had been washed before-hand: and though I did not think, that the bottle could have any considerable influence on the experiment; yet lest it should be suspected, that the scalding water might have imbibed some spirituous parts remaining yet among the minute dregs of beer in the pores of the bottle, for the greater security I caused the water to be heated in a skillet; and because in one of the trials made in a village, where we had not choice of pottingers, the cold water chanced to be put into one, that afterwards seemed less, than that wherein the hot was exposed, I did this very day repeat the experiment, by putting the cold water into a somewhat larger pottinger, heating the other water in a skillet, and the event of the trial is this;

THAT the cold water being put out with the rest, at $\frac{1}{4}$ after 6, began to freeze somewhat before $\frac{1}{2}$ after 7.

THE water heated and cooled again began to freeze $\frac{1}{4}$ after 7. And having these frozen waters a little while by me, I sent in, for my own further satisfaction, for the hot water, and found it not to be, in the least, frozen at half a quarter after eight. So that supposing it to continue half a quarter of an hour longer before the beginning of its congelation*, it was twice as long ere it began to freeze, as the cold water had been. * As it afterwards did at the least.

By which we may see, how well bestowed their labour hath been, that have puzzled themselves and others, to give the reason of a phenomenon, which perhaps with half the pains they might have found to be but chimerical.

I HAVE been the more circumstantial in setting down these trials, that I may express a civility to so famous a philosopher as *Aristotle*; and also because artificial congelations, which we can commonly best command, and which we have the ofteneft used about our other experiments, are not so proper for this. For having formerly had the curiosity to take two pipes of glass made of the same cylinder, that they

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they might be of equal bore, and having sealed each of them at one end, and having filled both to the same height, and then stirred them to and fro together in a mixture of beaten ice, water and salt, (which mixture I make use of for the effecting sudden congelations) I found both waters to freeze too quickly to make a notable disparity in the length of times, that they remained uncongealed: and we will not, on this occasion, omit one phænomenon afforded us by these trials, because it may admonish men, how cautious they ought to be in making nice experiments. For having once made the formerly mentioned trial, with glass pipes, that were but slender (as not exceeding the bigness of a man's fore-finger) and having for greater caution put the hot water first into one glass, and then into another, we found one time, that the hot water froze first, and wondering at it, we examined the glasses, and perceiving one of them to be more conical or acuminate, where it had been sealed up, than the other, it seemed probable, and afterwards appeared true, that the water in this acuminate part, being suddenly frozen by reason of the slenderness of the glass there, promoted and accelerated the congelation of the rest; so that whether it were the cold or the hot water, that was put into that pipe, it would thereby gain a manifest advantage.

In the foregoing experiments (made in pottingers) I made use not only of cold and hot water, but of water that had been heated and cooled again, though not reduced to its full pristine coolness, to prevent the objections of some, that might pretend, that such water would have frozen sooner than cold, which yet would not solve the common opinion which specifies not such water.

P O S T S C R I P T.

AND it seems, that such cautions, as I have been mentioning, are not altogether useless. For accidentally casting my eye upon the *Circulus Pisanus* of *Berigardus* upon *Aristotle's* meteors, I somewhat wondered to find, that an author, who is looked upon to be a great adversary of *Aristotle*, except in his dangerous and ill-grounded conceit of the eternity of the world, and some other erroneous opinions, does yet endeavour to justify *Aristotle* by affirming, that this experiment will succeed, if by heated water we understand that, which having been heated, is suffered to cool again, till it be reduced to the temper of other water, which was not heated. For this refrigerated water, he says, he has found to congeal much sooner than the other water: but this I confess I am very unapt to believe. For having divers times caused cold water to be exposed to the air in frosty weather, with that, which had been heated and cooled again, and having set sometimes one of my domesticks, sometimes another, to watch them, the events did very much disfavout the assertion of our author, though care was had of the circumstances most considerable

in such an experiment, as the matter, size and shape of the vessels; the equal degree of cold in the two several parcels of water (into both which I sometimes dipped my finger to judge of them before they were exposed) and the place, in which they were put both together to be frozen. But for further satisfaction, we elsewhere took two pottingers, bought purposely for the making of experiments, of the same size and shape, and in the same shop: one of these we almost filled with cold water out of a glass, wherein we marked, how high that water reached, that by filling the same glass to the same height with the refrigerated water, we might be able to measure out the same quantity into the other pottinger. This done, I appointed one, whose care I had no reason to distrust, to examine the tempers of these several waters, with a more than ordinarily sensible weather-glass, as a far safer criterion, than the bare touch, to judge of the coldness of liquors. These being reduced to the same temper, were exposed to a very sharp air, and there watched by the person, whom (being not well, and unable to support such weather my self) I appointed to attend the experiment, and he, according to direction, finding them begin to freeze, as it were at the very same time, brought me in the two pottingers, in each of which I saw the beginnings, and but the beginnings of congelation, where the upper surfaces of the waters were contiguous to the containing vessels. So that having made this experiment with much greater exactness than probably *Berigardus* did, or, for want of such instruments as I used, could make it, I cannot but suspect, supposing the common waters, he and I used, to be of the same nature, that he was either negligent or over-seen in affirming, that heated and refrigerated water will cool so much sooner*. And as I am not convinced by experience, that it will freeze sooner at all, so till he have better made out the reason he seems to give of the phænomenon, I must question, whether he rightly ascribe after *Cabeus* (if I much misremember not) the congelation of water to a certain coagulum, distinct from the cold spirits, that plentifully mingle with the water, which coagulum it seems (for his style is not wont to be very perspicuous) that he would have to consist of certain dry corpuscles, no less necessary to conglaciate water, than runnet to curdle milk: and for what this author says †, that he must have employed boiling or scalding water, who affirms it to be less congealable than other, that mistake may be sufficiently disproved by the several above recited trials, wherein we found water, moderately refrigerated, to freeze much later than cold. And whereas *Berigardus* intimates, that the person, whosoever he be, that he differs from, does unskilfully suppose warm salt-water to be the less disposed to congelation for being salt, our author is therein also mistaken; for though it be true, what he alledges, that salt outwardly applied promotes the congelation of water,

* Quare ferventem aquam adhibuisse oportet, qui asserit eam esse minus gelabilem, præcipue salfam, pag. 571.

† Tam cito illa congelabat, ut eximiam ex eo crustam unam aut alteram antequam non calefacta vel levissime concrevisset, pag. 572.

yet that, dissolved in water, has a contrary effect, may appear by the familiar observation, that sea-water is more difficult to be congealed than fresh water. And to shew, that it is not a property of sea-water, but a water impregnated with common salt, I have several times tried, that a strong solution of such salt in ordinary water, will not at all be congealed by the being exposed to the air, even in very sharp frosts; as may be easily collected from some of the experiments mentioned in the former part of this book. Another particular there is (about the use of alum in reference to freezing) in this often-cited passage of *Beringardus*, which I might here examine, if my haste and my indisposedness to engage in a controversy of small moment, did not injoin me to defer it till a fitter occasion.

Here the
postscript
ends.

To confirm the power ascribed in the sixth section to cold, as to the long preservation of bodies from corruption, it will not be amiss to add these two remarkable passages, the latter of which affords a good instance of the improvement, that may be made of some degrees of cold to the uses of human life.

THE first observation is afforded us by some of our country-men, in a voyage extant in *Purchas*, where the writer of it speaks thus, of the *Samojeds*, whose country he visited: ' Their dead they bury on the side of the hills, where they live (which is commonly on some small islands) making a pile of stones over them, yet not so close, but that we might see the dead body, the air being so piercing, that it keepeth them from much stinking savour: so likewise I have seen their dogs buried in the same manner.'

Purchas,
lib. 4.
cap. 19.
pag. 844.

THE other observation is given us in the description of *Ireland* (made by one that visited it) to be met with in the same *Purchas's* collections, where among other things he gives us this account; which, if I mistake not, I have had confirmed by others, of their strange way of ordering and preserving their fish. ' Having taken them, they pluck out the bones, and lay up their bowels, and make fat or oil of them. They heap up their fish in the open air; and the purity of the air is such there, that they are hardened only with the wind and sun, without salt, better surely than if they were corned with salt. And if they kill any beast, they preserve the flesh without stink or putrefaction, without salt, hardened only with the wind.'

Lib. 5.
cap. 22.

I KNOW not, whether it will be worth while to add to the fifth and sixth numbers of the seventh title, that, for further confirmation of our opinion, that it is not nature's abhorrency of a vacuum, but the distension of the water, that breaks glasses, when the contained liquors come to be congealed, I did on set purpose fill several phials (some at one time, and some at another) to the lower parts of their necks (most of which were purposely made long) with common water, and though they were

all left unstopped, that the external air might come in freely to them; yet not only one of them, that I stirred up and down in a mixture of beaten ice, salt, and water, was hastily broken upon the congelation of the contained water, but several others, that were exposed to be frozen more leisurely by the cold air only, were likewise broken to pieces, by the expansion of the freezing water, as appeared both by the gaping cracks, and also by this, that the ice was considerably risen in the necks above the water's former stations, which had been noted by marks before; and if it had been more easy for the included water to make it self room, either by stretching the glass, or (rather) leaving the superficial ice congealed at first in the neck, or by both those ways together, than to break the vessel, the phial would probably have remained intire.

I SAY probably, because I am not sure, that there may not sometimes intervene, in these experiments, somewhat, that may need further observation and inquiring. For as it seems, that what I have been lately saying may be confirmed by an unstopped phial, which was exposed at the same time to congelation, with this success, that without breaking the phial the water was frozen, and the ice in the neck impelled up a good way above the height, at which the liquor rested before it began to congeal; so, on the other side, I remember, that I have sometimes had a good store of liquor frozen in a phial, without breaking the glass, though a phial were stopped: as if the difference, that I have on other occasions observed betwixt glasses, whereof some are very brittle, and others more apt to yield, might have an influence on such experiments, or that some peculiar softness, or other property of the ice, that afforded me my observation, or else some other thing not yet taken notice of, were able to vary their success.

IN confirmation of what is delivered in the seventh section, about the expansion of water by freezing, I shall add, that having caused some strong glass-bottles of a not inconsiderable bigness to be filled with a congealable liquor, excepting the necks, which were filled with sallet-oil, I observed, that in a somewhat long, and very sharp frost, the contained water was so far expanded by congelation, that it not only thrust up the corks, but the cold having taken away the defluency of the oil, that liquor together with the water, that could no longer be contained in the cavities of the glasses, being, as it seemed, frozen as fast as it was thrust out of the neck, there appeared quite above the upper part of the bottles, cylinders of divers inches in height, consisting partly of concreted oil, and partly of congealed water, having on their tops the corks, that had been raised by them.

IT is a tradition very current among us, that when ponds or rivers are frozen over, unless the ice be seasonably broken in several places, the fishes will die for want of air*. And I find

3
* Volentes igitur piscari sub glacie duo magna foramina, latitudine 8. vel 10. pedum centum & quinquaginta vel 200. passibus a se invicem directa distantia, aperiant, inter quae 30. vel 40. minora foramina, latitudine unius pedis & semis, ab utroque latere distantia 30. pedum intermedia constituent, tum per ea, &c. Olai Mag. lib. 20.

find this tradition to be more general, than, before I made particular enquiry into it, I knew of. For *Olaus Magnus* mentions it more than once, without at all questioning the truth of it, but rather, as if the general practice of the northern nations to break in divers places their frozen ponds and rivers, were grounded upon the certainty of it. In the twentieth book (which treats of fishes) after having spoken of the reasons, why the northern fishermen employ so much pains and industry to fish under the ice; and having said among other things, that the nature of the fish exacts it, he adds this reason, that, * *Nisi glacie perforata respiracula susciperent, quotquot in flumine vel stagno versantur, subito morerentur.* Another passage of the same author, and taken likewise out of the same (20th) book you may meet with in the margin, though in another place he seems to intimate another, and not an absurd, reason of the death of fishes in winter; where advertising the reader, that ponds and lakes did generally begin to freeze in † *October*, he adds, that fishes are usually found suffocated, when the thaw comes, where veins (or springs) of living water do not enter: by which passage he seems to make the want of shifted water co-operate to the suffocation of the fishes. And to the same purpose I shall now add, that having enquired of a learned native, that had lived about *Cracovia*, (whose territory is said to abound much in ponds) whether the Polanders also used the same custom; he answered me, that they did, and that sometimes in larger ponds they were careful to break the ice in eight or ten several places, to make so many, either vents or air-holes, for the preservation (as they supposed) of the fish. And when I inquired of the often-mentioned Russian emperor's physician, whether in *Muscovy* the frost killed the fish in the ponds, in case the ice were not broken to give them air; he answered, that in ordinary ponds it were not to be doubted, but that in great lakes he could not tell, because the fishermen used to break many great holes in the ice for the taking of the fish. For at each of these holes they thrust in a net, and all these nets are drawn up together in one great breach made in some convenient place near the middle of the rest.

It appears then, that the tradition is general enough; but whether it be well grounded enough, I dare not determine, either affirmatively or negatively, till trial have been made in ponds with more of design or of curiosity, and watchfulness, than I have known hitherto done; men seeming to have acquiesced in the tradition without examining it, and to have been more careful, not to omit what is generally believed necessary to the preservation of fish, than to try, whether they would escape without. Wherefore, though, for aught I know, the tradition may prove true, yet to induce men not to think it certain, till exper-

ience has duly convinced them of it, I shall represent, that as much as I have in other treatises manifested how necessary air is to animals; yet whether fishes may not live, either without air, or without any more of it, than they may find interspersed in the water they swim in, has not yet, that I know of, been sufficiently proved. For what we have attempted of that nature, in our pneumatical engine, whether it be satisfactory or not, is not yet divulged. And I remember not to have hitherto met with any writer, (except *Olaus* be construed to intimate so much) that affirms upon his own observation, that the want of breaking ice in ponds has destroyed all the fish. Besides, that possibly in frozen ponds, there may be other reasons of the death of fishes, that there are killed (if any store of them be so) by very sharp frost. For who knows what the locking up of some kinds of subterranean steams, that are wont freely to ascend through water unfrozen, may do to vitiate and infect the unventilated water, and make it noxious to the fishes, that live in it? perhaps also the excrementitious steams, that insensibly issue out of the bodies of fishes themselves, may, by being penned up by the ice, contribute, in some cases, to the vitiating of the water, at least in reference to some sort of fishes. For being desirous to learn from a person curious of the ways of preserving and transporting fish, whether some fishes would not quickly languish, grow sick, and sometimes die out-right, if the water they swam in were not often shifted, he assured me, that some kinds of them would: and it has not yet, that I hear of, been tried, whether or no, though ponds seldom freeze to the bottom, yet the water, that remains under the ice (in which itself some fishes may be now and then intercepted) may not, even whilst it continues uncongealed, admit a degree of cold, that though not great enough to turn water into ice, may yet be great enough, when it continues very long, to destroy fishes, though not immediately, yet within a less space of time, than that, during which the surface of the pond continues frozen. But it is not worth while to be solicitous about conjectures of causes, till we are sure of the truth of the phenomenon; and these things are proposed not so much to confute the tradition, we have been speaking of, as to bring it to a trial, which, having no opportunities to make in ponds, I endeavoured, as well this winter as formerly, to obtain what information I could from trials made in small vessels, with the few fishes I was able to procure. And I shall subjoin most of these trials, not because I think them very considerable, but because they are, for aught I know, the only attempts of the kind, that have yet been made.

To satisfy myself, whether the ice's denying access to the air was that, which destroyed fishes in frozen ponds, I thought upon this expedient;

* *Olaus Mag. Titulo, De cursu glaciali, pro piscibus. Quæ (Anguillæ) si totaliter glacie constrictæ fuerint, simul omnes respiraculum ab aëre non habentes pariter suffocata moriuntur.*

† *Premittendum est quod generaliter omnes lacus & stagnales aquæ in mense Octobri incipiunt congelari, glaciæque ab isto frigore in plerisque locis tantum condensari, ut ubi venæ lacu & stagno viventiæ aquæ non intrant, pisces suffocati tempore resolutionis glaciæ inspiciantur; verum ne hæc suffocatio tam dispendiosa fiat, diligentia piscatorum continue glaciæ ipsa perfringitur, ne congeletur.* *Olai Magni, lib. 1. Titulo de transitu glaciali, &c.*

pedient ; I procured a glass vessel with a large belly, and a long neck, but so slender, that it was only wide enough for the body of the fishes to pass through : and then having filled the vessel with some live gudgeons, and a good quantity of water, the neck of it was made to pass through a hole, that was left, or made for it in the midst of a metalline plate, or wooden trencher, which could descend no lower than the neck, because of the inferior part of the glass, that would not suffer it, and which served to support a mixture of ice (or snow) and salt, which was applied round about the extant neck of the glass. By this contrivance I proposed to myself a double advantage: the first, that, whereas in broad vessels it is not always so easy, as one would think, to be sure, that the surface of the water is quite frozen over in every part ; by this way I could easily satisfy myself, by inverting the glass, and observing, that the ice had so exactly choaked up and stopt the neck, that no drop of water could get out, nor any bubble of air get in, and yet the fishes had liberty enough to play in the subjacent water. The other conveniency was, that the frigorifick mixture being applied to the neck, no water was congealed, or extremely refrigerated, but that, which was contained in the neck ; so that there seemed no cause to suspect, that in case the fishes, thus debarred of air, should not be able to live in the water, it was rather cold, than want of air, that killed them. But though not having then been able, by reason of a remove, to prosecute these trials to the utmost, nor to register all the circumstances, I shall not lay much weight upon it ; yet I remember, that the included fishes continued long enough alive, to make me shrewdly suspect the truth of the vulgar tradition.

ANOTHER time being destitute of the conveniency of such glasses, I caused some of the same kind of fishes to be put into a broad and flat earthen vessel, with not much more water, than sufficed perfectly to cover them ; and having exposed them all night to a very intense degree of cold, I found the next morning, that some hours after day, they were alive, and seemed not to have been much prejudiced by the cold, or exclusion of air. It is true, that there was a very large moveable bubble under the ice ; but that seemed to have been generated by the air, or some analogous substance, emitted out of the gills or bodies of the fishes themselves : for, that the surface of the water was exactly frozen over (which does not in such trials happen so often, as one would think) I found, by being able to hold the vessel quite inverted, without losing one drop of water. And that this large bubble might possibly proceed from the fishes themselves, I was induced to suspect, because having at different seasons of the year, for divers purposes, kept several sorts of fishes, and particularly gudgeons, for many days in glass vessels, to satisfy myself about some phænomena I had a mind to observe, I have often, by watching them, seen them lift up their mouths above the surface of the water, and seem to gape and take in air, and afterwards let go under water out of their

mouths and gills divers bubbles, which seemed to be portions of the air they had taken in, perhaps a little altered in their bodies. And particularly in lampreys (of which odd sort of fishes I elsewhere make mention) I have, with pleasure, both observed and shewed to ingenious men, that being taken out of the water into the air, and then held under water again, they very manifestly appeared to squeeze out, and that not without some force, at those several little holes, which are commonly mistaken for their eyes, numerous and conspicuous bubbles of air, which they seemed to have taken in at their mouths, if not also at those holes. But of these matters, a fitter occasion may perhaps invite me to say more. To return now to our gudgeons, I shall add, that to satisfy myself further, what cold and want of air they may be brought to support, I exposed a couple of them in a basin, to an exceeding bitter night ; and though the next day I found the ice frozen in the vessel to a great thickness, and one of the fishes frozen up in it, there remaining a little water unfrozen, the other fish appeared through the ice to move to and fro ; and the ice being afterwards partly thawed, and partly broken, not only that fish was found lively enough, but the other, which I alone judged not to be quite dead, though, when the ice was broke, it lay moveless, did, in a few minutes, so far recover, as to tow after it (if I may so speak) a good piece, into which his tail remained yet inserted. And though one of these, and some other gudgeons, that had been already weakened by long keeping, were once more exposed in the basin to the frost, and suffered to lie there, till they were frozen up ; yet the ice being broken, in which they were inclosed, though their bodies were stiff and crooked, and seemed to be stark dead, lying in the water with their bellies upwards, yet one of them quickly recovered, and the other not very long after began to shew manifest signs of life, though he could not in many hours after so far recover, as to swim with his back upwards. It is true, that these fishes did not long survive ; but of that, two or three, not improbable reasons, might be given, if it were worth while to name here any other than this, that the ice, they had been frozen up in, or the violence, that was offered them by the fragments of it, when it was broken, had wounded them, as was manifest enough by some hurts, that appeared upon their bodies ; yet some other gudgeons were irrecoverably frozen to death, by being kept inclosed in ice, during (if I misremember not the time) three days. And as for other animals, I caused a couple of frogs to be artificially frozen in a wide-mouthed glass, furnished with a convenient quantity of water : but though they seemed at first inclosed in ice, yet looking nearer, I found, that about each of them there remained a little turbid liquor unfrozen, as if it had been kept so by some expirations from their bodies. Wherefore causing either the same, or two others, (for I do not punctually remember that circumstance) to be carefully frozen, and for a considerable while, I

found, that notwithstanding the ice, into which most part of the water was reduced, not only one of them before the ice was broken appeared to be perfectly alive, but the other, that was moveless and stiff, and lying with the belly upwards in a basin of cold water, whereinto it was cast, did in a very few minutes begin to swim about in it. I should have made more trials at least, if not also more satisfactory ones, if I could have had fishes, and vessels, and cold weather at command: but upon the whole matter, though the tradition, we have been examining, may perhaps have something of truth in it, yet it seems to deserve to be further inquired into, both in reference to the truth of the matter of fact, *the death of fishes in frozen ponds and rivers*, and in reference to the cause, whereto that effect is imputed.

I MET with an odd passage in Captain *James's* voyage, which, if it had been circumstantially enough set down, might prove of moment in reference to the weight of bodies frozen and unfrozen; and therefore, though I would not build any thing on it, yet I shall not omit it. 'The ninth (says he, pag. 82.) 'we hoisted our beer and cyder, and made a 'raft of it, fastning it to our shoar-anchor. 'The beer and cyder sunk presently to the 'ground; which was nothing strange to us, 'for that any wood or pipe-staves, that had 'lain under the ice all winter, would also sink 'down so soon as ever it was heaved over 'board.'

ABOUT the duration of ice I forgot, through haste, to add a relation of Captain *James's*, whereby it may appear, that though wine abounds with very spirituous and nimble parts, whence it resists congelation far more than water, yet if even this liquor came once to be congealed, the ice made of it may be very durable. For he sets down in his journal, that when he came to his ship again, he found a butt of wine, that had been all the winter in the upper deck, 'to continue as yet all firm frozen, though it 'were then the month of *May*. (pag. 47.)

WHEN I treated of the great proportion in some pieces of ice, that were aground, instead of taking notice of a great piece of ice mentioned by *Gerat de Veer*, to be 52 fathom deep, the passage, that was to be transcribed, was this other, hard by, which contains two examples of towers of ice, where the extant part reached upwards more than half as much as the immersed part reached downwards. 'We saw ' (says he) another great piece of ice not far 'from us, lying fast in the sea, that was as 'sharp above, as if it had been a tower; where- 'unto we rowed, and casting out our lead, 'we found that it lay 20 fathom fast on the 'ground under the water, and 12 fathom a- 'bove the water.—We rowed to another 'piece of ice, and cast out our lead, and 'found that it lay 18 fathom deep, fast on the 'ground under the water, and 10 fathom a- 'bove the water.'

THAT snow lying long, and too long on the ground, does much conduce to the fertilizing of it, is a common observation of our husbandmen. And *Bartbolinus* in his treatise of

the *use of Snow*, brings several passages out of authors to make it good: to which I shall add the testimony of our learned English ambassador, *Dr. Fletcher*, who speaking of the fruitfulness of the soil, and hasty growth of many things in the great empire of *Russia*, gives this account of it.

'THIS fresh and speedy growth of the spring *Purchas*,
'there seemeth to proceed from the benefit *lib. 3.*
'of the snow, which all the winter time being *cap. 1.*
'spread over the whole country, as a white *pag. 415.*
'robe, and keeping it warm from the rigour
'of the frost, in the spring-time (when the
'sun waxeth warm, and dissolveth it into
'water) doth so thoroughly drench and soak
'the ground, that it is somewhat of a slight
'and sandy mold, and then shineth so hotly
'upon it again, that it draweth the herbs and
'plants forth in great plenty and variety, in
'a very short time.'

As we made some trials to discover, whether congelation would destroy or considerably alter the odours of bodies; so we had the like curiosity in reference to divers other qualities, not only those, that are reputed manifest, as colours and tastes, the latter of which we sometimes found to be notably changed for the worse in flesh congealed, but also those, that are wont to be called occult: and among the qualities of this sort, I had particularly a mind to try, whether the purging faculty of catharticks would be advanced or impaired, or destroyed by congelation; and for this purpose I caused to be exposed thereunto divers purging liquors, some of a more benign, and some of a brisker nature, and that in differing forms, as of syrup, decoction, infusion, &c. But for want of opportunity, to try upon the bodies of animals, what change the cold had made in the purging liquors, it had congealed, I was unable to give my self an account of the success of such experiments. Only since, in some of these trials I had a care to make use of cathartick liquors prepared by fermentation, (which way of preparing them is it self a thing I elsewhere take notice of, as not unworthy to be prosecuted;) I shall add on this occasion, that fermentation is so noble and important a subject, that the influence of cold upon it may deserve a particular inquiry. And I am invited to think, that that influence may be very considerable, partly by my having observed (upon a trial purposely made) both that raisins and water, (with which I was used to make artificial wines) did not in many days, whilst the weather was very frosty, so much as manifestly begin to ferment, though the water were kept fluid; and partly by my having observed, that beer will continue as it were new, and be kept from being, as they call it, ready to drink, much longer than one would readily suspect, if very frosty weather supervene, before it have quite finished its fermentation; insomuch, that an experienced person, of whom I afterwards inquired about this matter, assured me, that beer not duly ripe, would not sometimes in five or six weeks of very frosty weather, be brought to be as ripe as in one week of warm and friendly weather. But we have a nobler instance

influence to our present purpose, if that be true, which I learned from an intelligent Frenchman, whom I consulted about this matter. For, according to this experienced person, the way to keep wine in the must (in which state, its sweetness makes it desired by many) is to take newly expressed juice of grapes, and having turned it up before it begins to work, to let down the vessels (which ought to be very carefully closed) to the bottom of some deep well or river, for six or eight weeks, during which time the liquor will be so well settled (if I may so speak) in the constitution, it has so long obtained, that afterwards it may be kept in almost the same state, and for divers months continue a sweet, and not yet fermented liquor; which some, in imitation of the French and Latins, call in one word, *Must*. And how, by the help of cold well applied, some other juices, that are wont to work early, and to be thereby soon spoiled, may be long kept from working, the reader may perchance learn in another treatise, to which such matters more properly belong.

It is known, that the schools define cold by the property they ascribe to it, of congregating both heterogeneous and homogeneous things. I thought it not amiss to attempt the making some separations in bodies by the force of cold. For if that hold true in this climate, which has been observed by travellers and navigators in northern regions, that men may obtain from beer and wine a very strong spirit, and a phlegm by congelation; it seems probable, that in divers other liquors the waterish part will begin to freeze before the more spirituous and saline: and if so, we may be assisted to make divers separations, as well by cold, as by heat, and dephlegm, if I may so speak, some liquors, as well by congelation as by distillation. But I doubt, whether the ordinary frosts of this country can produce a degree of cold great enough to make such divisions and separations in bodies, as have been observed in the more northern climates. For though having purposely hung out a glass-bottle with a quart of beer in it, in an extraordinarily sharp night, I found the next morning, that much the greatest part of the beer being turned into ice, there remained somewhat nearer the middle, but nearer the bottom, an uncongealed liquor, which to me and others seemed stronger than the beer, and was at least manifestly stronger than the thawed ice, which made but a spiritless, and, as it were, but a dead drink; yet in some other trials, my success was not so considerable as some would have expected. For having put one part of high rectified spirit of wine to about five or six parts, if I misremember not, of common water, and having put them into a round glass, and placed that in beaten ice and salt, though the mixture were in great part turned into ice; yet I could not perceive, that even two liquors so slightly mingled were any thing accurately sever'd from one another, although once, to enable my self the better to judge of it, the spirit of wine I employed was beforehand deeply tinged with cochineal; and therefore I the less wonder,

that in claret wine I could not make any exact separation of the red and the colourless parts: however, I thought it not amiss to try, how far in some other liquors this way of separating the waterish, and more easily congealable part from the rest, would or would not succeed. And I remember, that a large glass vessel, wherein spirit of vinegar was exposed to the cold, a considerable part was turned into ice, whose swimming argued it to be lighter than the rest of the liquor. But though I put some of this ice in a glass by it self, to examine by its weight and taste, when thawed, how much it differed from the uncongealed part of the spirit, my hopes were disappointed by a misfortune, which was not repaired by my exposing afterwards a smaller quantity of spirit of vinegar to the nocturnal air; for that proved so cold, that the whole was turned into ice: wherefore I must reserve for another opportunity the prosecuting that experiment, as also the trying, whether a separation of the serous or the oleaginous parts of milk may be effected. For though once the frost seemed to have promoted a separation of cream, notwithstanding that the heat also may do it; and though another time there seemed to be another kind of division of parts made by congelation; yet for want of leisure to prosecute such trials, they proved not satisfactory, no more than did some attempts of the like nature, that I made upon blood by freezing it. But notwithstanding these discouragements, I resolved to try, what I could do upon brine. For calling to mind the relations mentioned in the XVth title, and elsewhere, which seem to argue, that in some cases the ice of the sea-water may, being thawed, yield fresh water; and being the more inclined to think it worth trial, by a physician, I since happened to discourse with about this matter, who affirmed to me, that sailing along the coast of *Germany*, he had taken out of the sea ice, that being thawed, he found to afford good fresh water; I began to consider, whether we might not, by cold, free salt-water at some seasons of the year from a great deal of the phlegm, which it is wont to cost much to free it from by fire, and other means. For a little help towards the diminution of the fresh water is looked upon as so useful an experiment, by many, that boil salt out of the salt springs, that in some countries, that are thought the skilfullest in that trade, they make their salt-water fall upon great bundles of small brush-wood, that being thereby divided, and reduced to a far greater superficies, there may, in falling through, some of the purely aqueous parts exhale away: wherefore, dissolving one part of common salt in forty-four times its weight of common water, that it might be reduced, either exactly, or near, to the degree of saltiness, that has been by several writers observed in the water of our neighbouring seas, and having likewise caused another and much stronger brine to be made, by putting into the water a far greater proportion of salt, (for so there is in many of our salt springs) we exposed these several solutions to the congealing cold of the air in frosty weather, where the last mentioned

mentioned solution being too strongly impregnated with the salt, continued some days and nights altogether uncongealed, but that weaker solution, which emulated sea-water, being exposed in a shallow and wide-mouthed vessel, (that shape being judged the most proper we could procure for our design) the large superficies, that was exposed to the air, did, as we expected, afford us a cake of ice; which being taken off, and the rest of the liquor exposed again to the air in the same vessel, we obtained a second cake of ice: and taking the remaining, which seemed to be indispersed enough to congelation, we found, that by comparing it with that, which was afforded us by the first cake of ice permitted to thaw, there appeared a very manifest difference betwixt the water, whereinto the ice was resolved, scarce tasting so much as brackish; whereas the liquor, that had continued uncongealed, was considerably salt in taste. And if I had had the conveniency of examining myself these two liquors hydrostatically, as I was fain to have them examined by another, I doubt not but by their weight I should have discovered precisely enough the difference between them (which the person I employed found to be considerable) and consequently should have been assisted to make an estimate of the advantage, that might be afforded by the operation of the cold towards freezing of the brine from its superfluous water. But though I had not a quantity of ice great enough to satisfy me, whether that little brackishness of taste, I have mentioned, proceeded from some saline corpuscles, that concurred to the constituting of the ice itself, or did only adhere to the lower part of it, among other particles of the liquor, that remained uncongealed; yet perhaps it were not amiss to try, whether in very large, though not deep vessels, this experiment, especially promoted by some expedients, that practice may suggest, may not, in some seasons and places, be brought to be of some advantage.

WHILST I was endeavouring by some of the above-recited experiments, to make some separations in liquors by congelation, I thought fit to try, by the same means, what separations I could make in some bodies, betwixt liquors, and those more stable parts, among which they were engaged; hoping, upon considerations, which it were too long to enumerate, that, if such attempts should succeed, they might afford hints of a luciferous nature. I took then divers vegetable substances of differing kinds, as turneps, carrots, beets, apples, and tender wood, freshly cut off from growing trees; as also divers animal substances, as muscous flesh, livers, brains, eyes, tongues, and other parts, and exposed them to a very sharp cold, that they might be thoroughly frozen. Now one of the chief things, that I proposed to myself in this attempt, was, to try, how far I could by congelation make discovery of any thing about the texture of animals and plants, that had not been taken notice of by anatomists themselves, and would scarce otherwise be rendered visible. And I easily found, that I had not ground-

lessly imagined, that in divers succulent bodies, both vegetable and animal, the sap or the juice, that was so dispersed among the other parts, and divided into such minute portions, as not to be manifestly enough discriminated, might, by congelation, be both discerned and separated from the rest. For in divers plants, I found the alimetal juice to be congealed into vast multitudes of distinct corpuscles of ice; some of which, when the bodies were transversely cut with a sharp knife, and left a-while in the air, might be wiped or scraped off from the superficies of the body, upon which it would after a while appear in the form of an efflorescence, almost like meal: but in others I took a better and quicker course, for by warily compressing the frozen bodies, I could presently make the icy corpuscles start in vast numbers out of their little holes; and though some of these were so minute as to invite me to use a microscope, that magnified a little, (not having then any of my best at hand) yet in some bodies, and especially in carrots and beets, the icy corpuscles were big enough to be distinctly or apart conspicuous, inasmuch that I was not mistaken in hoping, that the figures, as well as sizes, (for as to the colour, it was scarce discernible in the ice, produced in so deeply crimson a root, as the beet itself) of these little pieces of ice, might be guessed at by the bigness and shape of the pores, that were left in the more stable part, or (if I may so call it) the parenchyma of the root; though in making an estimate of these cavities, as well as in discovering the order, wherein they are ranged, I found it useful to cut the frozen roots, sometimes according to their length, and sometimes quite cross. For by that means there would appear in carrots, for example, of the larger sort, a great disparity in the order of the pores; which, when the root was divided by a plain parallel to the basis, appeared placed in lines almost strait, tending, almost like spokes of a wheel, from the middle to the circumference. But if the carrot were slit from one end towards the other, the icy corpuscles and pores would seem ranged in an order, that would appear very differing, but which I have not now the leisure to describe; no more than what I observed with a microscope, about the ice and pores of apples, the tongues of animals, chips of green and sappy wood, &c. exposed to congelation. Only this I shall not pretermitt, that as I many years since made (and, as I now find, too freely communicated) an experiment (mentioned long after in other papers) of freezing the eyes of oxen, and other animals, whereby the soft and the fluid humours of that admirable organ may be so hardened, as to become tractable, even to unskilful dissectors; so I did, on this occasion, apply that experiment to the brains of animals, which, though too soft to be easily dissected, especially by those who are not dexterous, may, by congelation, be made very manageable by them: and besides, that in dissecting the hardened brain, it sometimes seemed, that the knife did cut through multitudes of icy corpuscles (as when one cuts a frozen apple) the substance of the brain seemed also to the

Of the Usefulness of Experimental Philosophy.

eye to be stuffed with them, and the ventricles of it did at least conspicuously harbour pieces of ice, if it were not filled up with them. And the manifest difference of texture, that there is between the white and yolk of a thoroughly frozen egg, and also betwixt the crystalline and the aqueous, and the vitreous humours of the eye, wherein by congelation the crystalline alone loses its transparency, but acquires no conspicuous ice, whilst the others are full of ice, and that diaphanous; these and such like disparities, I say, may invite one to hope, that some things may, by congelation of bodies, be discovered about their texture, that may afford sagacious anatomists improvable hints.

I know not, whether it will be thought worth while to take notice, that neither an eye, nor a liver, nor a lean piece of flesh, nor a live fish, nor a living frog, being frozen and put into cold water, was observed to be upon its thawing cased with ice, as frozen eggs and apples are wont to be; because having forgot to make the experiment above once, I dare not much rely on it. But whereas we have formerly observed, that congelation does most commonly spoil, or at least impair eggs, and apples, and flesh, and many other bodies, I think it may not be unworthy to be considered, how far, and in what cases we may give a mechanical account of this phenomenon. For though the immersion of frozen bodies in cold water be allowed to thaw them, with less prejudice, than if they were thawed hastily by the fire, or suffered to thaw themselves in the air; yet there have been complaints made, that notwithstanding this expedient several bodies have been much the worse for having been thoroughly frozen, now since I have lately shewn, that in many stable bodies, the alimantal juice is by congelation turned into ice, and have formerly evinced, that water and aqueous liquors are expanded by congelation, I see not, why we may not suspect, that the innumerable icy corpuscles, into which the alimantal juice is turned by the frost, being each of them expanded proportionably to their respective bignesses, may not only prejudice the whole, by having their own constitution impaired, as has been formerly observed in Alicant, and other vinous liquors, but may, upon their expansion, crush in some places, and distend in others, the more stable parts, in whose cavities they were harboured; and thereby so vitiate their texture, as to impair some of their qualities, and dispose the compositum to corruption. How much confusion may prejudice tender bodies, and accelerate putrefaction, is evident in many fruits, especially the more tender ones, which having been bruised, quickly begin to rot in those parts, that have been injured. And it is agreeable to what has been formerly shewn, to conceive, that in congelation there seems to happen an almost innumerable multitude of little contusions, made by the fluid parts hardened and expanded by frost, of the formerly more stable parts every where intercepted between them: and though these icy corpuscles be but small, yet the sides of that stable matter, that separates them, and which they endea-

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avour to stretch or crush, are oftentimes proportionably thin.

AND we have formerly noted, that, besides that eggs will be burst by having their alimantal juice frozen, both shingles, and stones themselves may have their texture spoiled by the congelation of the mineral sap, that is in exceeding minute and insensible particles dispersed through those bodies: and the violation of the texture of plants, herbs, and animals, by the expansion of the aqueous and juicy particles, which, though they be not congregated, do abound in them, will be the less wondered at, if it be remembered, that our former trials manifest, that a few ounces of water congealed did not only burst glass and pewter vessels, but even the iron barrel of a gun.

WHILST I was upon these trials, I had also a curiosity to know, whether by freezing animals to death, I could discover any such change in the qualities or structure of their parts, as might help us to discover, by what means it is, that excessive colds kill men in northern countries, since such a discovery might probably be of good use to the people that live in those gelid regions: but having taken a young rabbit, as the tenderest and fittest beast, I could then procure for such a trial, and having exposed him all night to an extraordinarily bitter frost, without finding him otherwise mischieved by it, than that one of his legs was swelled and grown stiff, I was more inclined to resign over to others, than to repeat myself what seemed to be an ill-natured experiment, though perhaps it may have much less of cruelty than one would think, since some of our former observations have made it probable, that oftentimes the extinction of life by cold is a more indolent kind of death than almost any other. But in a rabbit purposely strangled, and presently exposed intire to a bitter cold, we found ice produced in such parts, as would have made us prosecute the trial, had the want of such animals and of leisure not hindered us.

IT is affirmed by divers eminent writers, and those modern ones too, that water impregnated with the saline parts of the plants, and afterwards frozen, will exhibit in the ice, the shape of the same plant; and the learned, but I fear too credulous, *Gaffarel* tells us, that this is no rarity, being daily shewn by one *Monsieur de la Clave*. But to what we have already published in another treatise*, to shew that this experiment, as it is wont to be delivered, is either untrue, or very contingent; we shall need but to add, that, since the experiments there mentioned, we did again lately try, what could be done with decoctions, that were richly imbued, and highly tinged with the spirituous parts of the vegetables; but this ice was by no means so figured as the patrons of the tradition promise: and I remember, that having also made, for curiosity sake, a lixivium with sixteen parts of water, and but one of salt of potashes, that the mixture might be sure to freeze; and having exposed the liquor in a thin glass phial to an exceeding cold air, we found the copious ice produced to lie on

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the top in little sticks, not unlike those prismatic bodies, wherein salt-petre is wont to roch; and those parts of this ice, that were beneath the water, were shot in thin parallel plates, exceeding numerous, but (as one of our notes expressly informs us) no way in the shape of trees, by whose incineration nevertheless Polonian potashes (as eye-witnesses, that deal in them, inform me) are made.

LONG after the making of the newly recited experiment, I chanced to find, that the learned *Bartholinus* in the treatise, we have often had occasion to take notice of, says, ‘* That the water, wherein cabbage has been decocted, will, when frozen, represent a cabbage; the vegetable spirits being, as he supposes, concentrated by the cold.’ How well this experiment may succeed, when made in a cold country like his, I do not know; but not having my self, when I first took notice of it, the opportunity to try it satisfactorily by help of a frosty night, all I could do, was, to take a good decoction of cabbage, and filtrate it through cap paper, that it might be, though yellow, yet clear; and then by the circumposition of our frigorifick mixture, we froze this liquor in a thin glass phial, but the ice did not, either to me or others, appear to have any thing in it like a cabbage, or remarkably differing from other ice. And being afterwards befriended with two or three frosty nights, we exposed a decoction of cabbage, to be congealed by the nocturnal air alone, without the help of art; but neither this way did the experiment succeed well. And tho’ once a few ounces of the decoction being lightly frozen in a phial, there appeared in the thin ice, that adhered to the inside of the glass, a figure not so very unlike that of a cabbage-leaf, but that some such accident may have invited our learned author to think, that the representations of cabbages would constantly appear in their frozen decoctions; yet I was inclined to think this figuration rather casual, by the curiosity I have had to freeze the decoctions of several herbs, some of them spirituous enough, as rosemary, and penny-royal, without being able to find in the ice, I obtained from them, any conviction of the truth of the tradition we are examining. And I have lately had more than once, by freezing fair water alone, after a certain manner, ice, that seemed much more to exhibit the shapes of vegetables, than any decoctions of them, that I have made. And particularly I found more than once, that by putting hot water into a somewhat slender cylinder of glass, and agitating it in a frigorifick mixture, consisting of beaten ice, salt, and water, so that it was very speedily frozen thereby, it was congealed into an ice much more regularly and prettily figured, than I have seen it in divers of the waters impregnated with the fixed salts of plants, though of these we are told such wonders.

SUCH particulars as these, joined with what I have elsewhere observed to the same purpose, make me, I confess, somewhat surprized to

meet in *Berigardus*’s forecited discourse upon *Aristotle*’s meteors such a passage as this; *Pau-* Pag. 573.
cis notum est, cur intra glaciem cernuntur interdum multiformes stirpium imagines in ampullis vitreis, aquæ superficie tenuis congelatæ plenæ. Hoc autem fit injecto in phialas sale diversarum stirpium, nam ubi erit sal alicujus plantæ & artemisæ, in suo lixivio glacies adhaerens vitro refert ejus folia laciniosa: similiter in alia phiala videbuntur folia plantæ, cujus sal in suam aquam fuerit injectus. Et ne quis hoc fortuito cadere putet, in aquâ sæpius solutâ & congelatâ eadem imagines semper occurrent, ut vel ex eo dixeris multiplicem spiritum salis in principiis naturalibus esse ponendum. Thus far this author, who would have done well, if he had been so much more lucky than other men, as to have performed these things, to assure expressly of his having done so those many ingenious men, that much distrust the relations of those chymists, that are not of the best sort; and it is of such suspicious authors, that I here declare once for all, that I would have the reader understand all the passages of this book, wherein I may seem to say any thing (for avoiding of tediousness) indefinitely to the disparagement of chymists. And in case he had not tried them, he should, in gratitude to the authors of them, have told us, he had, what he delivers of them, but from others, and not have authorized the untried reports of writers, not always too voracious, by his building theories upon them. And as for what he immediately subjoins, and seems to rely on, out of *Quercetan*, (and other spagyric writers, who possibly had it themselves from him) about the seminal virtues surviving in the ashes of burnt plants; though I will not here examine, or absolutely reject the opinion, because the discussion of it belongs to another place; yet as to the experiment, whereon *Berigardus* and others rely, namely, that the lixiviums made of the ashes of plants, will exhibit, being congealed, the figures of the pristine vegetables; besides that a general conclusion, as to other plants, seems to be inferred from what happened in nettles only, I much doubt, whether that famous experiment it self of the frozen lixivium of nettles were more than casual, if it were not also assisted by an indulgent fancy. For having, after divers experiments made with other fixed salts, purposely repaired, for greater security, to the notedest chymist in *England*, to obtain from him some fixed salts, very faithfully prepared, and intimating withal, that it was to try such an experiment (which he was a favourer of) I did, by mingling these salts each in a distinct phial, sometimes with one, and sometimes with another proportion of water, and afterwards exposing them to the cold air, obtain indeed divers portions of ice, but without any such figurations, as the learned *Berigardus* would have expected; though some of these trials were made more than once, as well with the lixivium of nettles, as with the lees of other plants. So that I doubt this author is more scrupulous in admitting some important truths,

* *Rem vero adeo obscuram exemplis similibus illustrabo brassicæ: aqua congelata brassicam representat, spiritibus vegetabilibus à frigore concentratis.* Tho. Bartholinus de usu nivis, pag. 17.

truths, in which the best philosophers, as well heathen as Christian, agree, than in examining the uncertain traditions of the chymists, whose unsatisfactory way of setting down matters of fact I am induced to take notice of his imitating, by finding, that in the very same page (that I have newly cited) he relates another chymical experiment in these terms: *Velim porro ostendere mirabili experientia, quàm sint penetrabiles aliqui spiritus corporei: exarentur in charta literæ, aceto albo, quarum nullum vestigium deprehendatur, claudaturque primis foliis crassissimi alicujus libri. Paretur alia charta, quæ insiciatur aqua illa fetida, ubi dilutum fuerit auripigmentum, & exsiccata claudatur postremis foliis ejusdem libri leviter compressi, statim videbis in priori charta literas conspicuas, perinde ac si atramento ductæ fuissent.* Now, though something like what is here proposed to be done, may be performed, and other phænomena of the experiment, such as he seems not to have been acquainted with, may be also exhibited, after the manner I have * elsewhere particularly set down; yet he must have good luck, that performs it only by the directions here given by our author, who by omitting one of the chief ingredients, and some requisite circumstances, appears indeed manifestly enough to have heard of such an experiment, but without seeming to have sufficiently known, what he pretends to teach, (at least as far as his bringing this experiment as a proof, and the obscure style, he is wont to employ in the little I have yet read of his book, permits me to judge.)

* In the unpublished section of the Usefulness of experimental philosophy.

BUT to return to the figurations of ice, notwithstanding such unsuccessful trials about them, as I have been mentioning, I will not deny it to be possible, that a prepossessed and favourable spectator may think himself to have discerned in the ice, the figures he looked for there. For since the writing of the essay not long since quoted, we have found, that several bodies, and even sea-salt, and alum, to whom nature has given their own determinate figures, have, when dissolved in water, concurred with it to exhibit an ice very oddly, as well as prettily, figured, (nor will I presume to determine the utmost, that a lucky observer may sometimes meet with in this kind;) but to name at present no other arguments, the figures this way produced were too various and extravagant, not to be referred to chance, and not to afford instances, how much that can perform in the exhibiting of such apparitions.

Of the Unsuccessfulness of experiments.

ON which occasion I shall add, that I remember, I once shewed at the Royal Society a glass head, whose inside was lined with a certain substance, that passed for saline, fashioned into the figures of trees, as curious, as if they had been drawn by a limner: and yet as I produced these figures, only by rectifying common oil of turpentine, from sea-salt (which salt I elsewhere shew not to be necessary) in a certain degree of heat; so by varying that degree of heat, I could make the ascending steams settle in other figures. And I can easily produce very pretty shapes of trees by distillation of that, which belongs not to the vegetable, but

the animal kingdom. And to these I could add divers other instances of the like tendency, to make it still the more probable, that though oftentimes one may happen to find pretty ideas, or apparitions in ice; yet the like, or as fine, may be produced by chance. And I have sometimes obtained by freezing infusions, decoctions, spirits, solutions, and other liquors, as vinegar (and particularly) milk, and even common water, figures, that were so pretty, but withal so unconstantly produced, and so easily variable by circumstances, that as it would fill a book particularly to describe them (which for that reason I hope to be excused for declining) so they would much delude him, that should expect to find them every time the same, that he had found them once.

AND to intimate that by the by, to make several trials in a short time, and thereby produce variety of figures, it is not an ill expedient to expose the liquor one would have congealed, in very shallow vessels; or, if it be put into other vessels, to leave it, but of very little depth. And if the vessel it self be highly refrigerated, either by the cold air, or by having salt and ice applied to the outside of it, the congelation may succeed much the more nimbly; so that within a short while the same liquor, being divers times thawed and frozen again, may possibly exhibit variety of figures. And the production of ice may be also much accelerated, by dipping into the liquor, one would have congealed, the convex surface of some glass or other smooth body, that will not imbibe water; for thereby the depth of the liquor will be exceedingly extenuated, and how much such a thinness or want of depth, may dispose a liquor to be speedily penetrated and congealed by the cold, may be guessed, by what is above delivered in the section out of *Olearius*, of the way of multiplying ice in *Persia*, by making water thinly diffuse it self over a plate of ice, or some other aptly figured, and very cold body: in confirmation whereof, I will add on this occasion, that I have seen a pair of stairs, on which, though they were situated near to three chimneys, commonly furnished with fire, almost all the day long, the water, that was employed to wash them, being thinly spread with a mop, would presently congeal (though they assured me it was hot, when it was begun to be laid on) and cover the stairs with glossy films of ice. And I have likewise observed in a very sharp night, that the water, which dropped down from the nose of a pump, was so well congealed, as it was sliding away, that the ice thus arrested in its passage (in which it will easily be granted that it spreads it self very thinly) had raised a kind of icy pyramid of a considerable bigness and height.

I FORGOT to mention in due places (and therefore think fit to take notice of it here) that when I was considering of the ways, whereby it might be manifested to those, that want nice scales, or distrust their skill to use them, whence that ice comes, that appears on the outside of frozen eggs put to thaw in cold water, I found it somewhat difficult to pitch upon

upon such a liquor as I desired. For if common water be the liquor employed, it may be said, that it affords the matter, whereof the ice in question is made: and if I employed liquors, that were spirituous or saline, it might be pretended, that the frost (as they speak) did indeed come out of the frozen egg, though the shell did not appear cas'd with ice, because as fast as the frost came to the outside of the egg, it was resolv'd by the spirituous or saline corpuscles of the liquor: wherefore as an expedient, I resolv'd to make use of oil of turpentine, as a liquor, which I had found uncongealable by the greatest cold I had observed in our climate, and which yet (as may appear by the third paragraph of the XVth title) was more indispos'd, than common water itself, to thaw any icy efflorescence, that might be emitted by the egg. But the experiment was tried, without uniformity in the successes. For the first time I put a frozen egg into oil of turpentine, I did not observe, that any ice was produced on the outside: neither was the event differing, when another time I put two frozen eggs together into a small vessel full of that oil, though to refrigerate the liquor, the vessel was for a while placed upon a mixture of salt and ice, though also the egg-shells at their gaping cracks (produced by congelation) discovered, that the contained liquor was well frozen. I intended to prosecute the experiment another time (wanting ice to do it then) because that once, when during the trial I was hindered from watching it, one of my domesticks, whom I ordered to look after it, assured me, that the egg, that was put to thaw in the oil of turpentine, had there obtained ice on the outside of it; which I should readily have believed, upon the score of a like observation, I had made my self, in two eggs that were frozen to the bottom of the vessel, wherein they had been put to thaw, were it not, that one or both of them had been, by a mistake, dip't in water, before they were put into the above mentioned oil.

SOME readers may have expected to find, among the examples recited of the influence of cold upon the air, that strange story, which is related by the learned *Josephus Acofta*, of the mountains of *Pariacaca*, (which he several times travers'd: *) but besides that I have delivered a great part of it already in another treatise, I was loth to say more, till I had leisure (which I have not now) to discuss the scruples, that I have not so much about the matter of fact, as about the cause, which perhaps may be something besides cold. But since I have mentioned this XVIIIth section, I will here take notice of what I then intended, but forgot to set down; namely, that to the instances alledged to shew the coldness of regions not to be always proportionate to their greater and less vicinity to the pole, we may add a memorable one afforded us by a country so well known to many of us, as *New England*; where, though the winters are so long and bitter, as we have formerly related out of *Mr. Wood's* prospect of that

country, (which has been confirmed to me by an American physician, that lived there;) yet that region, which is so very much colder than ours, is in many places no less than ten or eleven degrees remoter from the pole.

I SHALL add to the same XVIIIth section, that as to the experiment I there mentioned concerning winds, and which I associate with the testimony of the newly named *Mr. Wood*; I find, that the season of the year, and some other circumstances, may vary it more than one would easily have suspected. For though I faithfully recited the phenomena, as I then (and that sometimes with witness) took notice of them, yet some months after, and in other weather, having occasion to repeat the former part of that experiment, I was somewhat surprized at the success. For coming to blow upon the ball of a sealed weather glass, which though in its kind very tender, might be probably presumed to be less so, than a thermometer made with a pendulous drop of water (such as that, mentioned in the foregoing paragraph) I found, that if I continued to blow any thing long and briskly, the highly rectified spirit of wine (which circumstance I therefore name, because possibly the nature of that may somewhat alter the case) would sometimes manifestly enough subside. And in that paragraph of the 18th title, where I recited the experiment of the in-frigidating winds, I should more expressly have taken notice of this circumstance, that to satisfy my self, that it was not the bare wind, as such, whose operation upon the air included in the ball of a weather-glass, made the liquor to ascend, we put a mark upon the height it stood at, when we had a pretty while blown upon it; and then, without removing the bellows, put ice and salt about the iron pipe of it. By which mixture the air, that was afterwards blown through that pipe, was so cooled in its passage, as to make the liquor very manifestly to ascend, even in a weather-glass, where I did employ (as I have elsewhere declared, that I often do) quicksilver instead of water, or spirit of wine. And lest the vicinity of the frigorifick mixture should be suspected to have caused this contraction of the included air, we did sometimes purposely intermit the moving of the bellows, without removing the weather-glass; and though, notwithstanding that vicinity, the liquor would begin a little to subside; yet when ever the cold spirits, or the corpuscles of the highly refrigerated air, were, by the playing of the bellows anew, approached to, or rather brought to touch in swarms the globular part of the instrument, the mercury would manifestly ascend. And since we are speaking of weather-glasses, I shall on this occasion subjoin, that certain circumstances may also vary the success of another experiment (somewhat of kin to that lately repeated, about the pendulous drop) which is briefly mentioned not far from the beginning of the first preliminary discourse. For though the common thermometers, that are here wont to be sold in shops, have usually the pipe of the bolt-head very large in

* Where a wonderfully piercing, though not sensibly violent cold, does sometimes suddenly kill men, and yet preserve their bodies untainted whole years together.

in proportion to the ball, and therefore are in that place said to be weather-glasses not nice; and though on such instruments in certain temperatures of the air (intimated by the word *sometimes*, employed in that passage) the air blown out of a pair of bellows against some part of the included air, would not, especially at the beginning, make the air sensibly contract itself, and the liquor ascend; though at the very first and second blast, the coldness of this artificial wind might be very sensible to the touch (which was the thing intended to be taught in that passage) yet having the curiosity with other bellows, at another season of the year, to blow long upon the ball of a not common, but nice weather-glass of my own making, furnished with a pipe, that was very slender, I divers times (but not always) found the tinted liquor manifestly enough to ascend, as if the wind, consisting of a more compressed air, did, by containing a greater number of cold particles in the same room, more affect the internal air, than the contact of the calm and lax outward air did before; which disparity of events has given me the design of making further trials with differing thermoscopes, at other seasons of the year, to see if I can bring the matter to some certainty, by discovering the cause of this contingency, in which I afterwards suspected, that some light degree of warmth or coolness in the bellows themselves, which, as being unmanifest to the sense, escaped unheeded, might have an interest. When I was about some of the former experiments, I would willingly have had an opportunity of trying, with a good sealed weather-glass, what difference there would be, betwixt the cold of the nocturnal air in a frosty night, in places, where the air was kept calm, by being sheltered from the wind, not by inhabited buildings, but by some wall, or other body, whence any warm effluvia were least to be expected; and betwixt the cold of the same air, in places, where cold winds, especially northerly or easterly, did freely and strongly blow. But my occasions then confining me to a town, I had not conveniency to make any secure observations of that nature; and even in a more commodious place, unless it were determined, whether there be corpuscles properly and constantly frigorifick, upon whose account some winds are so much colder than others, there may arise more scruples about this matter, than I must now stay to discuss.

THERE is one thing more, that, it may be, is not impertinent to mention, before I take leave of the XVIIIth title: for in confirmation of what is there delivered, concerning the vicissitudes of these troublesome degrees of cold and heat, within the compass of the same natural day, complained of by the patriarch *Jacob*, and by *Olearius*, I shall add, that having since had opportunity to inquire about such matters of a learned physician, lately come from the *Indies*, he assured me, that notwithstanding the violent heats of the day, he usually observed the nights to be so very cold, that he was positive some frigorifick steams did, in the night, ascend out of the earth, and make

it very expedient, if not necessary, for those English, that live in the warmer parts of *America*, to imitate the natives, in keeping fires under their hammocks, or hanging-beds.

I THOUGHT it might be a luciferous experiment, in relation to an hypothesis, that might be proposed about cold; to try, whether, if two such liquors were provided, as by being mixed together, would so far forth lose their fluidity, as to obtain at least the consistency of an unguent, this impediment, put to the former confused and greater agitation of their parts, would produce any sensible degree of cold; this I thought fit to try, by immersing, for a competent time, the ball of a tender sealed weather-glass into each of the liquors apart, and then into the soft mixture, their coalition would compose. To produce such a mixture more ways than one, it was not difficult for me, by the help of some experiments, I had provided to add to my *History of Fluidity and Firmness*. But though a strong solution of minium (or calcined lead) in spirit of vinegar, or a very strong infusion of good quick-lime in water, will either of them (and one of them I did make use of, though I have forgotten which) coagulate a just proportion of good fallad-oil (to name no other made by expression) into such a consistence as I have been speaking of; yet for want of a sealed thermoscope, tender enough, I cannot now repeat the experiment, and till I do, I dare not draw any experiment from it; though, if I much misremember not, when I shewed it an ingenious person, neither he nor I could perceive, that the liquors, by being deprived of their fluidity, had acquired any thing of coldness discoverable by the sealed weather-glass.

IT is much controverted among the curious, whether water be capable of compression; and divers have of late inclined to the negative, upon observing a want of cogency in the experiments, that have been brought to evince the affirmative. What trials and observations we long since made about this matter, may be met with in some of our other treatises, wherefore I shall now subjoin, that having imagined, that cold might afford a hopefuller way, than (for aught I know) any man has used, of bringing this controversy to the decision of an experiment, I made that attempt, that is mentioned in the XIIth title; in prosecution of which, as soon as I could procure some, though but some of the accommodations, which I long wanted, I made an experiment, which I shall subjoin, because though it be not so considerable, as with better implements I could have made it, yet the way I chose, has (as I partly intimated elsewhere) these two advantages; that the force employed to compress the air, is both very great, and very gradually, and slowly applied; and that the vessel will not, like those, that have been hitherto made use of, give any passage through its pores to water, though violently compressed.

WE took then a round ball of glass, furnished with a moderately long pipe, and having filled it with water, till the liquor reached

X x x x

within

within some inches of the top, it was hermetically sealed up, and then the water, by a mixture of beaten ice and salt, was made to freeze from the bottom upwards; and that without breaking the glass, the unfrozen water, by the expansive endeavour of that which was freezing, might be impelled upwards, and so at once both compress the air, and be pressed upon by it, having by this means condensed the air, as far as we thought safe to do in a glass, that was not strong, we cropt off the small apex of the glass, and immediately the compressed air flew out with a great noise, and that part of the pipe which was unfilled with water, was filled with smoke, that made it look white, and great store of little bubbles hastily ascended from the lower parts of the water, to the upper (where most of them quickly broke) in such a way, as put me in mind of what usually happens upon the opening of vessels that contained bottled beer. But that, which was principally to be noted, was this, that besides the bubbles or froth, the water itself (at least supposing, that no little unheeded bubbles, that did not quite emerge, could sensibly contribute to its height) immediately ascended in the pipe about $\frac{3}{4}$ of an inch, which (having carefully marked the first and second stations, with a diamond on the outside of the glass) it was easy for us to measure.

I HAVE elsewhere proposed a suspicion, that in the attempts, that had been till then made, to compress water, the condensation (in case there were really any) might perchance proceed from the compression of the aerial particles, that I have shewn to be wont to lie dispersed in the pores of common water. But though the considerable expansion of water, notwithstanding the breaking of the bubbles in our present experiment, seems manifestly to argue, that this could be but a concurrent cause (if it had any sensible effect at all) of our phenomena, yet I dare not absolutely rely, even upon an experiment, that seems so cogent, till I have satisfied myself, that no springiness, which I have sometimes suspected might be in the ice, had any interest in the produced effect; and that the great pressure of the forcibly condensed air, did not make the glass itself stretch or yield. For if it were able to do so, then the parts of the violently distended glass, upon the removal of the forcible pressure of the air (which must cease upon the breaking of the hermetical seal) returning to their former straitness below, will make the water ascend somewhat higher in the pipe. But though I could not procure glasses, as well very thick, as conveniently shaped, wherewith to examine this suspicion, which I likewise would have tried by the bulk of the glass in water, before and after the letting out of the compressed air; yet because most readers will probably think so much caution more than necessary, I shall add, that if I had not wanted

conveniencies, and had not had mischances, the experiment would, in likelihood, have been advanced; especially care being taken, that the air left in the pipe should be well refrigerated before its being sealed up, (as we sometimes did by ice and salt, applied in a perforated box to the outside) lest part of its spring should depend upon an evanid degree of heat; upon which account the pipe ought beforehand to be drawn so slender, that the glass may be melted together in a trice. For though for want of strong glasses, and the best sort of instruments to seal up such with, the success was not still so considerable as I hoped for; yet as four or five other trials, made, as well with another liquor, as with water, did exhibit a manifest intumescence of the liquors (without computing the froth produced at the top;) so in the experiment lately mentioned, if we had judged them strong enough to endure such a compression of the included air, as we have often made on other occasions, the effect would probably have been much more considerable. For though the difference betwixt the length of the same water compressed and uncompressed amounted to an aqueous cylinder of $\frac{3}{8}$ of an inch in height, yet the air, that made this compression of the water, was itself reduced but from eight inches to five; so that it took up almost half its former room, whereas we have sometimes reduced it to an 18th or 20th part thereof. If I had been accommodated with one of my pneumatical engines, I should have tried, whether water being first carefully freed from the latent air in the exhausted receiver, and then compressed after the manner hitherto recited, the event of the trial would have been considerably varied.

I MIGHT add, as other phenomena of our experiment, that when we broke off the sealed apex of the glass, before the included air was much compressed, there neither would be any great noise made, nor any considerable froth produced, at the top of the water; and that having had the curiosity to repeat the experiment in one of the same glasses, that had been already used and with the same water, that had been already compressed in it, we found, that upon the breaking off the hermetical seal the second time, the water did nevertheless ascend into the pipe betwixt $\frac{1}{8}$ and $\frac{1}{4}$ part of an inch. And to these particulars I could both add other circumstances, that I took notice of in the same experiment, and subjoin many other experiments and observations, but that I am already tired. And though I have not found cold to be a subject over-fruitful in experiments pleasing and curious, yet now I am grown somewhat acquainted with it, I find it may suggest so many other new ones, that since the barrenness of my theme will not easily put a period to this treatise, it is fit that now at length I should let my weariness and want of leisure do it.

A N

EXAMEN of ANTIPERISTASIS,

A S

It is wont to be TAUGHT and PROVED.

THEMISTIUS, CARNEADES, ELEUTHERIUS.

THEMISTIUS.

1. **A**S for *Antiperistasis*, the truth of it is a thing so conspicuous, and so generally acknowledged, that I cannot imagine what should make some men deny it, except it be, that they find all others to confess it. For though in other cases they are wont to pretend experience for their quitting the received opinions, yet here they quit experience it self for singularity, and chuse rather to depart from the testimony of their senses, than not to depart from the generality of men.

2. AND to evince, that this is not said *gratis*, I might observe to you, that there are no less than three grand inducements, that have led both the vulgar and philosophers (two sorts of men, that seldom agree in other things) to consent in the acknowledgement of *Antiperistasis*; authority, reason, and experience. But though I think fit to name them all three, yet since the first of them, by having, as I just now noted, invited our adversaries to dissent from the truth, is a somewhat unlikely medium to prevail on them to acknowledge it, I shall insist only on the two latter; having once declared, that I lay aside the first, not as worthless in it self, but needless to my cause.

3. To begin then with the arguments afforded us by reason.

WHAT can there be more agreeable to the wisdom and goodness of nature, who designing the preservation of things, is wont to be careful of fitting them with requisites for that preservation; than to furnish cold and heat with that self-invigorating power, which each of them may put forth, when it is environed with its contrary. For the order of the universe requiring, that cold and heat should reside in those bodies, that often happen to be mingled with one another, those two noble and necessary qualities would be too often destroyed in the particular subjects, that harboured them, if provident nature had not so ordered the matter, that when a body, wherein either of them resides, happens to be surrounded by other bodies, wherein the contrary quality is predominant, the besieged quality, by retiring to the innermost parts of that, which it possesses, and thereby recollecting its forces, and as it were animating it self to a vigorous defence, is intended or increased in its degree; and so becomes able to resist an adversary, that would otherwise easily destroy it.

4. To illustrate as well as supply this argument drawn from reason, we shall need but to subjoin the other afforded us by experience, which does almost every day give us not only

opportunity to observe, but cause to admire the effects of this self-invigorating power, which, when occasionally exerted, we call *Antiperistasis*: and these phænomena ought the more to be acquiesced in, because they may safely be looked upon as genuine declarations, which nature makes of her own accord, and not as confessions extorted from her by artificial and compulsory experiments, when being tortured by instruments and engines, as upon so many racks, she is forced to seem to confess whatever the tormentors please.

5. To proceed then to the spontaneous phænomena of nature I was recommending, we see, that whereas in summer the lowest and highest regions of the air are made almost unsufferable to us by their heat, the cold expelled from the earth and water by the sun's scorching beams retires to the middle region of the air, and there defends it self against the heat of the other two; though in the one, that quality be assisted by the almost perpendicular reflection of the sun-beams, and in the other it be rendered very considerable by the vastness of the upper region of the air, and its vicinity to the element of fire.

AND as the cold maintains it self in the middle region, by virtue of the intenseness, which it acquires upon the account of *Antiperistasis*; so the lightning, that flashes out of the clouds, is but a fire produced in that middle region, by the hot exhalations penned up, and intended in point of heat by the ambient cold, to a degree, that amounts to ascension.

6. BUT though these be unquestionably the effects of that excessive coldness; yet we need not go so far as the tops of mountains to fetch proofs of our doctrine, since we may find them at the bottom of our wells. For though *Carneades* perhaps will not, yet the earth as well as the air doth readily acknowledge the power of *Antiperistasis*. And if the reason above alledged did not evince it, our very senses would. For as in summer, when the air about us is sultry hot, we find, to our great refreshment, that the air in cellars and vaults, to which the cold then retreats, is eminent for the opposite quality; so in winter, when the outward air freezes the very lakes and rivers, where their surfaces are exposed to it, the internal air in vaults and cellars in winter, which becomes the sanctuary of heat, as in summer it was of cold, is able not only to keep our bodies from freezing, but to put them into sweats. And not only wells and springs, upon the account of their resting in, or coming out of the deepest parts of the earth, continue fluid, whilst all the waters, that are contiguous to the air, are by

by the excessive cold hardened into ice; but the water freshly drawn from such wells feels warm, or at least tepid to a man's hand put into it. And as if nature designed men should not be able to contradict the doctrine of Antiperistasis, without contradicting more than one of their own senses, she has taken care, that oftentimes the water, that is freshly drawn out of the deeper sorts of wells and springs, should manifestly, as I have seen it, smoke, as if it had been but lately taken off the fire. And this may be said, without a metaphor, to demonstrate *ad oculum* the reality of Antiperistasis; there being no other cause, to which this warmth can be attributed, than the retiring of the heat from the cold external air to the lower parts of the earth and water; since both these elements themselves being naturally cold, and one of them in the supreme degree, the heat we are mentioning, is so far from being likely to be generated in so unfit a place, that, if it were not very great, it must be extinguished there, by the coldness of the superiour air, and that of the inferiour parts of the earth.

ELEUTHERIUS. 7. That *Carneades* may have but one trouble, to answer the allegations to be made in favour of Antiperistasis, I hope he will give me leave, (according to my custom of siding with either party, as occasion invites me) to add to the familiar observations mentioned by *Themistius* some others, that are less obvious. For I frankly confess to you, that when I consider, what interest the unheeded dispositions of our own bodies may have in the estimates we make of the degrees of cold and heat, in other bodies; I should not lay much weight upon the phænomena, that are wont to be urged as proofs of Antiperistasis, if some instances, somewhat less liable to suspicion, did not countenance the doctrine they are urged for. I know, that *Carneades* being wont so to propose his opinion about Antiperistasis, as only to deny, that it is clearly made out by the reasons or experiments, that are commonly produced to evince it, it were somewhat improper to urge him with observations, that are not familiar, and wont to be employed; but I know too, that he is not so rigid an adversary, as not to allow me to mention some uncommon relations, that I learned from men of good credit. I shall tell you then, that having purposely inquired of ingenious men, that had been very deep under ground, some in coal-pits, and some in mines; one of them affirmed, that, at the bottom of the grove (as they call it) or pit, he found it very hot in *September*. And another, that he often found it hot enough, to be troublesome in winter. And a third, (who is himself a great seeker for mines, and a master of considerable ones) that he found it to be hot all the year long. And to manifest, that such observations will hold even in gelid regions, I shall repeat to you, what I remember I read in the voyage of that ingenious navigator, Captain *James*; who, giving an account of *Charleton Island*, which, by his relation, seems to be as cold as

Iceland itself, says, (pag. 36.) That his men found it more mortifying cold, to wade through the water in the beginning of *June*, when the sea was full of ice, than in *December*, when it was increasing. And he adds, that which makes more to our present purpose, and proves the other part of the doctrine of Antiperistasis; That, from their well, out of which they had water in *December*, they had none in *July*. And, to strengthen the observation yet further, I will acquaint you with a relation to this purpose, not unworthy your notice: for, hearing of an ingenious physician, that lived some years in and about *Moscow*, I applied myself to him, (as possibly you may have done; for, if I mistake not, I have seen you together) to know, whether, in that frozen region, he observed the cellars to be hot in winter. And his answer to that, and some other questions of the like nature I put to him, amounted in short to this; that when I inquired, whether their springs and wells were not all frozen in the winter, he told me, that he saw some springs, whose waters froze not at all near the spring-heads, but, at a good distance from thence, it began to be thinly cased over with ice. He added, that his own well was about six fathoms deep, between the surface of the earth, and that of the water, and that the water in it was, as I remember, about three or four fathoms deep; and that not only this well froze not all the winter, but that the well of his neighbour, which was but one fathom deep to the superficies of the water, did not freeze neither. And, to satisfy my curiosity about the steams of this water, he told me, that when a bucket of water was newly drawn, if it were agitated, it would smook; but that, from the well itself, when the water in it was left quiet and unstirred, he did not perceive any smook to arise.

8. To all this, I shall add this further circumstance, that, having purposely inquired, whether, in the winter, he found it as hot in cellars at *Moscow*, as it is wont to be, in that season, in our's? he answered me, that when the doors and windows were carefully shut, to hinder the immediate commerce betwixt the included and external air, he often found, if he stayed long in his cellar, it would not only defend him from the sharpness of the Russian cold, as bitter as that is wont to be in winter, but keep him warm enough, to be ready to sweat, though he laid by his furs. So that, if we may rely, either upon the testimony of our senses, we must necessarily admit cellars to be warmer in winter, than in summer, and consequently allow an Antiperistasis.

CARNEADES. 9. Though I were not in haste, I should not think it necessary to reply any thing else to the first part of what was said by *Themistius*, than that, what he alledges of the universality of the opinion he maintains, may serve to recommend that, which he opposes. For the vulgar doctrine about Antiperistasis being, as he urges, received and taught in all the schools, the innovators, he declaims against, must have learned it there, among the other Peripatetick tenents, that youth is wont

to be imbued with in those places; so that it may rather seem the love of truth, than of singularity, that engages them against an opinion, which before was their own, as well as that of the generality of scholars; and consequently, against which they cannot maintain a paradox, that does not imply a retractation. But I shall not prosecute my answer to *Themistius's* preamble, since *Eleutherius*, whom I am chiefly to speak to, is too much a philosopher, to think truth less herself, for being slenderly attended; or to think any men the less like to be her followers, because they are but few. To come then directly to the controversy itself, I think, I need not tell one of you, that the other mistakes my opinion about it. For I perceive, *Eleutherius* hath not quite forgotten, that I have not been wont to deny an Antiperistasis, as it may be, but only as it was wont to be, explicated. But since *Themistius* seems to be willing to have me his antagonist in this controversy, and since *Eleutherius* himself seems to conspire with him, I am content to act, for a while, the part, you gentlemen would have me take upon me, and will propose to you part of what I would say for the opinion you impute to me, in case I were really of it.

10. To come then to the controversy itself, though *Themistius* has drawn his proofs for the Antiperistasis of the schools, partly from reason, and partly from experience; yet the very same two topicks seem to me to afford considerations, that may justly warrant our calling it in question.

11. AND first, if we look upon the reason of the thing, considered abstractedly from the experiments, that are pretended to evince an Antiperistasis, we cannot but think, it may be very rational, I say not, to doubt of it, but to reject it. For, in the first place, according to the course of nature, one contrary ought to destroy, not to corroborate, the other. And next, it is a maxim among the Peripateticks themselves, that natural causes always act as much as they can. And certainly, in our case, wherein we treat not of living creatures, I cannot but think the axiom physically demonstrative. For inanimate agents act not by choice, but by a necessary impulse; and, not being endowed with understanding and will, cannot of themselves be able to moderate or to suspend their actions. And as for what *Themistius* alleges, that it was necessary for the preservation of cold and heat, that they should be endowed with such a power of intending themselves, I must freely confess, that though, in living creatures, and especially in the bodies of the perfecter sorts of animals, I do, in divers cases, allow arguments drawn from final causes; yet where only inanimate bodies are concerned, I do not easily suffer myself to be prevailed upon, by such arguments. Nor is there any danger, that cold and heat, whose causes are so radicated in nature, should be lost out of the world, in case each parcel of matter, that happens to be surrounded with bodies, wherein a contrary quality is predominant, were not endowed with an incomprehensible faculty of self-invigoration. And nature either does not

need the help of this imaginary power; or oftentimes has recourse unto it to very little purpose: since we see, that these qualities subsist in the world, and yet, *de facto*, the bottles of water, wine, and other liquors, that are carried up and down in the summer, are regularly warmed by the ambient air. And in *Muscovy*, and other cold northern countries, men, and other animals, have oftentimes their vital heat destroyed by the cold, that surrounds them, being thereby actually frozen to death. And I somewhat wonder, that the followers of *Aristotle* should not take notice of that famous experiment, which he himself delivers, where he teaches, that hot water will sooner congeal than cold. For, if the matter of fact were true, it would sufficiently manifest, that the heat harboured in the water is destroyed, not invigorated, by the coldness of the air, that surrounds it; so that *Themistius* must, I fear, on this occasion, take sanctuary in my observation; and to keep *Aristotle* from destroying his own opinion, with his own experiment, had best say, as I do, that it is not true. And though it is not to be denied, that white surrounded with black, or black with white, becomes thereby the more conspicuous; yet it is acknowledged, that there is no real increase, or intension, of either quality, but only a comparative one, in reference to our senses, obtained by this collation. Nor does a pumice-stone grow more dry than it was in the fire or earth, by being transferred into the air or water, and consequently environed with either of those two fluids, which *Themistius* and his schools teach us to be moist elements; neither will you expect to find a piece of dim glass become really more transparent, though one should set it in a frame of ebony, though that wood be so opacous as to be black. And whereas it is commonly alleged, as a proof of the power, nature has given bodies, of flying their contraries, that drops of water falling upon a table will gather themselves into little globes, to avoid the contrary quality in the table, and keep themselves from being swallowed up by the dry wood; the cause pretended has no interest in the effect, but little drops of water, where the gravity is not great enough to surmount the action of the ambient fluid, if they meet with small dust upon a table, they do, as they roll along, gather it up, and their surfaces being covered with it, do not immediately touch the board, which else they would stick to. And to shew you, that the globular figure, which the drops of water, and other liquors, sometimes acquire, proceeds not from their flying of dryness, but either from their being every way pressed, at least almost equally, (for in some cases also they are not exactly round) by some ambient fluid of a disagreeing nature, or from some other cause, differing from that the schools would give; I shall desire you to take notice, that the drops of water, that swim in oil, so as to be surrounded with it, will likewise be globular; and yet oil is a true and moistening liquor, as well as water. And the drops of quicksilver, though upon a table they are more disposed, than water, to gather themselves into

into a round figure; yet that they do it not as humid bodies, is evident, because quicksilver, broken into drops, will have most of them globular, not only in oil, but in water. And to shew you, that it is from the incongruity it has to certain bodies, that its drops will not stick upon a table, nor upon some other bodies, but gather themselves into little spheres, as if they designed to touch the wooden plain but in a point; to manifest this, I say, we need but take notice, that though the same drops will retain the same figure on stone or iron,

See the History of Fluidity, Sect. 19.

yet they will readily adhere to gold, and lose their globulosity upon it, though gold be a far drier body than wood, which, as far as distillation can manifest, must have in it a store of humid parts of several kinds, (I mean both watery and unctuous.) But this may relish of a digression; my task being only to examine the Antiperistasis of cold and heat, concerning which, I think, I had very just cause to pronounce the vulgar conceit very unbecoming to the nature of inanimate beings. For the Peripateticks talk of cold and heat surrounded by the opposite quality, as if both of them had an understanding, and foresight, that, in case it did not gather up its spirits, and stoutly play its part against the opposite, that distresses it, it must infallibly perish; and as if, being conscious to its self, of having a power of self-invigoration, at the presence of its adversary, it were able to encourage itself, like the hero in the poet, that said,

Nunc animis opus est, Eneid, nunc pestone firmior
Which indeed is to transform physical agents into moral ones.

EXAMEN. 12. The validity of the Peripatetick argument, drawn from reason, considered abstractedly from experience, I shall leave *Themistius* to dispute out with you, at more leisure. And since you well know, that the only arguments I assege to countenance Antiperistasis, were built upon experience, as judging them either the best, or the only good ones, I long to hear what you will say to the examples, that have been produced of that,

CARNEADES. 13. That, *Eleutherius*, which I have to answer to the examples, that are urged, either by the schools, or by you, in favour of Antiperistasis, consists of two parts. For, first, I might shew, that, as reason declares openly against the common opinion, so there are experiments, which favour mine, and which may be opposed to those you have alledged for the contrary doctrine. And, secondly, I might represent, that of those examples, some are false, others doubtful; and those, that are neither of these two, are insufficient, or capable of being otherwise explicated, without the help of your hypothesis. But, for brevity's sake, I shall not manage these two replies apart, but mention, as occasion shall serve, the experiments, that favour my opinion, among my other answers to what you have been pleased to urge on the behalf of *Aristotle*.

14. To begin then with that grand experiment, which, I remember, a late champion for Antiperistasis makes his leading argument to establish it, and which is so generally urged on that occasion; I mean, the heating of quicklime in cold water: I confess, I cannot but admire the laziness and credulity of mankind, which have so long, and generally, acquiesced in what they might so easily have found to be false. This I say, because I was possibly the first, that has had both the curiosity and boldness to examine so general and constant a tradition; yet I doubt not, that you will soon be brought to take it, as well as I, for as great, as popular, an error. For, to let you manifestly see, how little the incalcescence of the quicklime needs be allowed to proceed from the coldness of the ambient water, if, instead of cold water, you quench it with hot water, the ebullition of the liquor will not only be as great, as if the water were cold, but oftentimes far greater. As I have sometimes, for curiosity, removed boiling water from the fire; and when the liquor had left off boiling, but was yet scalding hot, I put it into a convenient quantity of quicklime; and, after a while, the water, which, as I said, had ceased from boiling, began to boil afresh, with so much vehemence, and such large and copious bubbles, that it threatened to run over the pot, of which, before the effervescence, a considerable part was left unfilled. And this was no more, than what I might well look for, hot water being much fitter than cold, to pervade nimblely the body of the lime, and hastily dissolve, and set at liberty the igneous and saline parts, wherewith it abounds. And how much a greater interest salts may have in such incalcescencies, than cold, I have also taken pleasure to try, by pouring acid spirits, and particularly spirit of salt, upon good quicklime. For, by this means, there would be a far greater degree of heat excited, than if I had, instead of spirit of salt, used common water; and this, whether I employed the spirit cold or hot. For in either case, so small a portion, as about the bigness of a walnut of lime, put into a small glass, would, by the addition of a little spirit of salt, put to it by degrees, both hiss and smook, and boil very surprizingly; and, notwithstanding the small quantity of the matter, would conceive so great a heat, that I was not able to hold the glass in my hand. And to shew some friends, how little heat excited in quicklime by cold water proceeds barely from the coldness of that liquor, I caused a parcel of good lime to be beaten small, and putting one part of it into a glass vessel, I drenched it plentifully with oil of turpentine, more than it would imbibe, and the other portion of the lime I likewise drenched with common water: both these liquors having stood in the same room, that they might be reduced by the same ambient air, to a like degree of coldness, the event of this trial was (what I looked for) that the oil of turpentine, notwithstanding its actual coldness, and the great subtilty and piercingness of parts, which it has in common

common with other chymical oils, being of an incongruous texture, seemed not to make any dissolution of the powdered lime, and did not, for several hours, that I kept it, produce, that I perceived, any sensible heat in the lime. Whereas, to shew, that it was not the fault of the lime, that part of it, on which common water had been poured, did, after a little while, conceive so strong a heat, that it broke a large open-mouthed glass, into whose bottom it was put; and not only grew so hot, that I could not endure to hold it in my hand, but sent out at the mouth of the glass, though that were considerably distant from the lime, a copious white fume, so hot, that I could not well suffer the holding of my hand over it. And, to prevent a possible, though invalid, objection, which I foresaw might be drawn against the experiment made with oil of turpentine, from the oleaginous nature of that liquor, I covered a piece of the same sort of quick-lime, I have been speaking of, with highly rectified spirit of wine: but though I left them together all night, yet I perceived not, that the liquor had at all slacked the lime, which continued in an entire lump, till, upon the substituting of common water, it did, as I remember, quickly appear to be slacked, since it fell asunder into a kind of minute white powder, which was (bating the colour) almost like mud, and would easily, by a little shaking, be dispersed, like it, through the water.

ELEUTHERIUS. 15. I ingenuously confess to you, *Carneades*, that what you say surprizes me; for I thought it superfluous to try my self so acknowledged an experiment, being not able to imagine, that so many learned men, for so many ages, should so unanimously, and confidently, deliver a matter of fact, of which, if it were not true, the falsity could be so easily discovered.

CARNEADES. 16. For my part, *Eleutherius*, I confess, I am wont to doubt of what they teach, that seldom or never doubt. And I hope you will forgive me, if, having found an assertion so general and uncontroled, of a falsity so easy to be disproved, I be inclinable to suspect the truth of their other inferior traditions about Antiperistasis; and of these I will mention the two chiefest I have met with among the moderns, (for being contrived experiments, I presume you will easily believe, they came not from *Aristotle*, nor the ancient schoolmen, that commented upon him.)

17. THE first of these is the freezing a pot to a joint-stool, by a mixture of snow and salt, by the fire's side; in which case it is pretended, that the fire does so intend the cold, as to enable it to congeal the water; that stagnated upon the surface of the stool, betwixt that and the bottom of the pot. But how little need there is of Antiperistasis in this experiment, you may guess by this, that I have purposely made it with good success in a place, in which there neither was, nor ever probably had been, a fire, the room being destitute of a chimney. And this trial of mine I could confirm by divers other experiments of the like nature, but that this one is sufficient.

18. I PROCEED therefore to the other experiment, which is delivered by very learned men, and for whom I have a great respect; according to these, if you take a somewhat large pot, and having filled it almost with snow, place in the middle of the snow a phial full of water; this pot being put over the fire, the coldness of the snow will be so intended by the heat, from which it flies into the water, that it will turn that liquor into ice. But though I several times tried this experiment, yet neither in earthen, nor in silver vessels, could I ever produce the promised ice. And I remember, that an eminently learned man, that wondered to find me so diffident of what he said, he knew to be true, readily undertook to convince me, by an ocular proof; but with no better success, than I had had before. So that the argument may be plausibly enough retorted upon them, that urge it.

19. AND in case the trial should succeed some time or other, (for that it doth not ordinarily, I have shewn already) yet will there be no necessity of deriving the effects from Antiperistasis. For though, in such cases, the fire would contribute to the production of the effect, by hastening the dissolution of the snow; yet the heat of the fire does but remotely, and by accident, cause the production of ice; since other agents will do the same thing, that are qualified to make a quick dissolution of the snow, whether they be hot or no; as I have tried, that spirit and crude salt of nitre will either of them, by a due application, bring snow, by dissolving it, to congeal water, though the spirit and the nitre be generally agreed upon to be actually cold, and one, if not both of them, to be potentially cold too.

20. HAVING thus dispatched the experiments, pretended to evince an Antiperistasis, I must now examine the observations, that are alledged to that purpose, of which the principal, if not the only, are these; the coldness of the middle region of the air; the increase of mens stomachs in winter; the generation of hail; and the heat and cold in cellars, and other subterranean places, when the contrary quality reigns in the air.

21. TO begin with the first of these: I will not now dispute, whether the second region of the air have really that coldness, that is wont to be ascribed to it; though our friend *Mr. Boyle* seems to doubt, whether that region's being always and every where cold, hath been as strongly proved, as asserted. But passing over that question, I see no need of imploring the help of Antiperistasis, to keep the second region of the air for the most part cool. For without at all taking in the cause imagined by the schools, an obvious and sufficient one may be easily assigned. For the air being, as to sense, cold of its own nature, so that when we feel it hot, it is made so by some adventitious agent; and that agent being for the most part the sun, who heats the air chiefly, though not only, by its reflected beams; their heat is so languid, by that time they arrive, dispersed, at the second region of the air; that they are not able to overpower its

its natural coldness, increased perchance by some frigorifick spirits, that may find a more commodious harbour there, than in other parts of the atmosphere. And whatever be the true cause of the coldness in the middle region of the air, I cannot but admire to find that coldness so confidently ascribed to Antiperistasis, by *Themistius* and his friends the Aristotelians: for, according to them, it is the nature of the element of air to be as well hot as moist, and according to the same Peripateticks, both the upper region of the air always, and the lower in summer is hot; the former by the neighbourhood of the imaginary element of fire, and the latter by the reflexion of the sun-beams from the earth: which two positions being laid together, I would fain learn of any Aristotelian, how Antiperistasis comes to take place here? For, according to them, those bodies have their cold and heat increased by Antiperistasis, that are on both hands assailed by bodies of a contrary quality, to that which is natural to the surrounded body: whereas the whole element of air, and consequently the middle region, being, as they would persuade us, hot, of its own nature; what shadow of probability is there, that the highest and lowest regions, by being hot, should make the middle region, which is also naturally hot, intensely and durably cold? But though the objection is so clear, that it needs not to be insisted on; yet, because it is but an argument *ad hominem*, I shall add this, for their sakes, that are not in this point Peripateticks: that it does not appear to me, that if the air be naturally rather cold than hot, the second region must owe the intenseness of that quality to an Antiperistasis. For the ground of the opinion, I oppose, being this, that both the first and the third regions are considerably hot, I would gladly find it proved as to the upper region. I confess, I have not found the assertion contradicted, but that as little convinces me, as the uncontroledness of the tradition about quick-lime, that I lately confuted. It is true, there are two reasons alledged, to evince the heat of the supreme region of the air, but neither of them to me seems cogent. For the first is, that the vicinity of this region to the element of fire makes it partake a high degree of heat. But if we consider the distance of that element, which they place contiguous to the orb of the moon, and how little nearer to it the concave part of the upper region is, than the convex of the middle, we may easily conceive, that in two distances, that are both of them so immense, so small a disparity cannot be much (if at all) more considerable, than the greater nearness of one side of a sheet of paper, held at three yards distance from an ordinary fire, in comparison of the distance of the other side of the same paper; or than the distances of a small wart, and of the neighbouring parts of the face, when a man comes within two or three yards of the fire. But it is not worth while to prosecute this consideration, because the argument against which it is alledged, is built upon the groundless supposition of the element of fire, a figment, which many

of themselves do daily grow ashamed of, as indeed its existence is as little to be discovered by reason, as perceived by sense.

22. THE other argument for the heat of the third region of the air is, that fiery meteors are kindled by it. But not now to question, whether all meteors, that shine, and therefore pass for fiery, are really kindled exhalations; we see, that in the lower region of the air, and in winter, those fires, which are called either *Helena*, or *Castor and Pollux*; are generated in great storms, and hang about the sails and shrouds of ships. Nay, do we not much more frequently see, that lightning is produced at all seasons of the year? for in warmer countries thousands have observed it to thunder (and so have I in winter) in the middle region of the air. And since it is not the heat of the inferiour part of the air, that kindles those exhalations; and if notwithstanding the coldness of the second region, fiery meteors may be frequently generated there; I see no reason, why the production of such meteors should argue the heat of the third region of the air. And if that region be not hot, then it will, I presume, be easily granted, that the coldness of the second must very improperly be attributed to such an Antiperistasis, as it is generally ascribed to.

23. I COME next to consider that aphoristical saying of *Hippocrates*, *Ventres hyeme esse calidiores*, together with the observation, whereon it seems to have been grounded: I will not now examine, whether any arguments for the contrary may be drawn from the heat and thirst men feel in summer, and the refreshment they then find by drinks and fruits, and other aliments that are actually cold. For that, which I principally intended to say, is this, that I much more doubt the matter of fact delivered in the aphorism, than that, in case it be true, it may be made out without the help of Antiperistasis, in the vulgar and scholastic notion of that term.

24. I CONSIDER then first, that the proof, that is wont to be brought of the greater heat of men's stomachs in winter, is, that men are wont to have then a greater appetite to their meat. But though I pay so much respect to the great *Hippocrates*, as to allow the aphorism in a sense; yet I admit it to be true but upon an hypothesis, that I do not admit to be so. For the aphorism supposes, that the digestion of meat in the stomach is made by heat; and consequently, that the stronger digestion, that is wont to be made in winter, is an argument of the stomach's being then hotter, than at other seasons of the year. But the erroneousness of this supposition, I think, I need not solemnly prove to *Eleutherius*, who, I doubt not, has taken notice of several things in nature, that agree not with it, and particularly of the strong concoction, that is made in the stomachs of divers ravenous fishes, whose stomachs and blood are yet, as I have purposely observed, sensibly cold: but if it should in some cases prove true, that there is really in men's bodies a far greater heat in winter than in summer, yet this would not infer an Antiperistasis in the sense.

fenſe, wherein I oppoſe it. For the vital heat lodged in the heart, always generating out of the blood and juices, that continually circulate through that part, great ſtore of ſpirits and warm exhalations, which are wont to tranſpire through the pores of the ſkin in much greater quantities, than, notwithstanding the affirmations of *Sanctorius*, any thing but my own trials could have perſuaded me; theſe warm ſteams finding the pores of the ſkin ſtraightened and ſhut up, grow more and more copious in the body, and thereby heat the ſtomach, as well as the other internal parts of it: and perhaps alſo the ſame frigoriſick corpuscles or temperature of the air, that produce cold in winter, may, by ſhutting in certain kinds of effluvia, or perhaps altering the motion or texture of the blood, reduce it to ſuch a diſpoſition, as that the appetite ſhall be increaſed, as well as the concoction in the ſtomach promoted by the ſtomachical menſtruum, or ferment, which either is newly generated in winter, or more copiouſly ſupplied (by the circulating of the blood to the ſtomach) in that ſeaſon than in others. And to ſhew, that a good appetite may be procured by agents endowed with very diſtinct and contrary qualities; do not we ſee, that ſpicy ſauces, wine and vinegar, do all of them, in moſt men, beget an appetite, though the two former be confeſſedly hot, and the latter cold? And ſo wormwood and juice of lemons have both of them frequently relieved dull and weak ſtomachs, though the one be confeſſedly a hot ſimple, and the other a cold. And in ſome caſes, either the frigoriſick corpuscles themſelves, and perhaps ſome other unknown to us, that they may bring along with them, may ſo ſollicit the ſtomach, as to breed an eager appetite, not precisely by their being cold or hot, but by their peculiar nature; as we have inſtances of ſome, that in theſe parts by walking on the ſnow, procure to themſelves a bulimia. And the learned *Fromundus* relating, how he himſelf, by walking along on the ſnow, was ſurprized with ſuch a Βελιμία, takes notice, that the chief cauſe of the fainting was in the ſtomach; and that he found by his own experience, that that part was diſcompoſed, convelled, and provoked to caſt. To which he adds, (what makes much for my preſent purpoſe) that he thinks now the chief cauſe of the bulimia to conſiſt in certain ſteams, that do peculiarly affect the ſtomach, which they gnaw and diſtend. And juſt before he obſerves, that ſtraining to fetch deep coughs is a preſent remedy in this diſtemper, by diſcharging the ſtomach and lungs of thoſe ſnowy ſpirits, which were either attracted in reſpiration, or had ſome other way inſinuated themſelves in thoſe parts: ſo that beſides the cold abſtractedly conſidered, the ſtomach may be peculiarly affected by other, either attributes or concomitants, of the frigoriſick corpuscles, that grow powerful in froſty weather; with which it well agrees, that divers have been obſerved to be ſubject to bulimia's in theſe parts of the world, though in our warmer climates ſuch men endure nothing near ſo great a cold, nor are ſo much in-

convenienced by it, as multitudes of others, that in *Nova Zembla*, and other gelid regions, never complained of having contracted, even in the miſt of winter, any ſuch diſeaſe.

25. ANOTHER argument, that is ſpecious enough, urged in favour of Antiperiſtaſis, is borrowed from the production of hail, which is preſumed to be generated in ſummer only, not in winter; and, according to *Ariſtotle*, and the ſchools, is made in the loweſt region of the air, by the cold of the falling drops of rain ſo highly intended by the warmth it meets with in the air near the earth, as to congeal the water, wherein it is harboured. But though I freely confeſs to you, that I think the generation of hail difficult enough to be ſolidly explicated; yet I ſcruple not to reject the received doctrine about it, for ſeveral reaſons, of which I will now name four.

26. FOR in the firſt place, it is not univerſally true, as is ſuppoſed, and the Ariſtotelian doctrine requires, that hail falls not but in ſummer, or very hot weather. For I have myſelf obſerved it within this twelvemonth, to hail at the latter end of *November*, and that, when ſome froſty days have preceded, and when the coldneſs of the weather was complained of. Nay, the longeſt ſhower of hail, that either I, or ſome others, remember ourſelves to have ever known, I obſerved to fall about a week before the end of *January*, on a night preceded by a very froſty day, which itſelf was preceded by a ſharp fit of froſty weather. And here I muſt not pretermiſt this circumſtance, that when the tedious ſhower was over, there came to the houſe, where I then was, a maid, that is ſervant to one of my domeſticks, and related to her maſter, and others, how ſhe was for a good while miſſed out of the beaten way, where the ſtorm found her, by an *Ignis fatuus*, which ſhe followed, till by its paſſing over a place, where ſhe found an unpaſſable hedge, it both ſhewed her, that ſhe was out of her way, and that it was no candle, though ſhe had ſo confidently thought it one, that ſhe called out to the party, ſhe preſumed it to be carried by. I will leave *Themiſtius* to unriddle, how the nocturnal air could kindle a fiery meteor by its coldneſs, and at the ſame time congeal the falling drops of water into ice by its warmth; and ſhall only add, that I doubt not but other obſervations of the like kind have been often made, though perhaps ſeldom recorded. For within the compaſs of a very few weeks of the ſtorm, ſome ſervants of mine affirmed themſelves to have obſerved it to hail two or three times, beſides that already mentioned.

27. NEXT, if *Ariſtotle* have rightly aſſigned the cauſe of hail, it is ſomewhat ſtrange it ſhould not fall far more frequently in ſummer, and eſpecially in hot climates, than it does, conſidering how often in all probability the drops of rain fall cold out of the ſecond region into the warm air of the firſt. And more ſtrange it is, that even in thoſe parts of *Egypt*, where it rains frequently enough and plentifully (for ſo *Proſper Alpinus*, that lived long there, affures us it does) though not about *Grand Cairo*,

Cairo, yet about *Alexandria* and *Pelufium*, it should never hail no more than snow, as the same learned physician (a witness above exception) affirms. Besides, whereas it is pretended, that snow is generated in the upper region of the air, and hail always in the lower; my own observation has afforded me many instances, that seem to contradict the tradition. For I have observed in I know not how many great grains of hail, that, besides a hard transparent icy shell, there was as it were a snowy pith of a soft and white substance, and this snowy part was most commonly in the middle of the icy, which made me call it pith, but sometimes otherwise. And lastly, whereas the favourers of Antiperistasis would have the drops of rain, in their descent, to be congealed apart in the ambient air; not to urge, how little the irregular and angular figures, we often meet with in hail, do countenance this doctrine; hail often falls in grains, too great by odds to be fit to comply with *Aristotle's* conceit. For not to mention the grains of hail I have observed my self to be of a bigness unsuitable to this opinion, divers learned eye-witnesses have informed me of their having observed much greater than those I have done: and particularly an eminent Virtuoso of unquestionable credit affirmed both to me and to an assembly of Virtuosi, that he had some years ago, at *Lyons* in *France*, observed a shower of hail, many of whose grains were as big as ordinary tennis-balls, and which did the windows and tiles a mischief answerable to that unusual bulk. And *Bartholinus* affirms, that he himself observed, in another shower of hail, grains of a more unwonted size; a single grain weighing no less than a whole pound. But though this it self is little in comparison of what I remember I have somewhere met with in learned authors, yet it may abundantly suffice to disprove the vulgar conceit about the generation of hail, till we meet in these countries with showers of rain, whose single drops prove to be of such a bigness; which I presume those, that ascribe hail to Antiperistasis, will not easily shew us.

28. I COME now to consider the last, and indeed the chiefest example, that is given of Antiperistasis; namely, the coldness of cellars, and other subterranean vaults in summer, and their heat in winter. And as the argument, wont to be drawn from hence, consists of two parts, I will examine each of them by it self.

29. AND first, as to the refreshing coldness, that subterranean places are wont to afford us in summer, I both deny, that they are then colder than in winter; and I say, that though they were, that coldness would not necessarily infer an Antiperistasis.

30. WE must consider then, that in summer our bodies having for many days, if not some weeks, or perhaps months, been constantly environed with an air, which, at that season of the year, is much hotter, than it is wont to be in winter, or in other seasons, our senses may easily impose upon us, and we may be much mistaken, by concluding upon their testimony, that the subterranean air we then find so cool, is really colder than it was in winter, or at the

spring; as they that come out of hot baths think the air of the adjoining rooms very fresh and cool, which they found to be very warm, when coming out of the open air, they went through those warm rooms to the bath, and the deepness and retiredness of these subterranean caves keep the air, they harboured, from being any thing near so much affected with the changes of the season, as the outward air that is freely exposed to the sun's warming beams, which pierces with any sensible force so little away into the ground, that diggers are not wont to observe the earth to be dried and discoloured by them beyond the depth of a very few feet. And I have found, that in very shallow mines not exceeding six or seven yards in depth, though the mouth were wide, and the descent perpendicular enough, the air was cool in the heat of summer; so that the free air and our bodies, that are always immersed in it, being much warmer in summer than at other times, and the subterranean air, by reason of its remoteness from those causes of alteration, continuing still the same, or but very little changed, it is no wonder, there should appear a difference as to sense, when our bodies pass from one of them to another.

31. AND supposing, but not yielding, that the air of cellars and vaults were really colder in summer than in winter, that is, were discovered to have a greater coldness, not only as to our sense of feeling, but as to weather-glasses; yet why should we for all that have recourse, for the solution of the difficulty, to an Antiperistasis, which it is much harder to understand, than to find out the cause of the phænomenon, which seems in short to be this; that whereas (which I shall soon have occasion to manifest) there are warm exhalations, that in all seasons are plentifully sent up by the subterranean heat, from the lower to the superficial parts of the earth, these steams, that in winter are in great part repressed, or checked in their ascent, by the cold frost or snow, that constipates the surface of the earth, and choaks up its pores; these exhalations, I say, that being detained in the ground would temper the native coldness of the earth and water, and consequently that of springs, and of the subterranean air, are by the heat, that reigns in the outward air, called out at the many pores and chinks, which that heat opens on the surface of the ground, by which means the water of deep springs and wells, and the subterranean air, being deprived of that, which is wont to allay their native or wonted coldness, are left to disclose a higher degree of it, and seem to have that quality increased, when indeed it is but freed from the mixture of its contrary, that weakened it.

32. As for the heat, we find in cellars and vaults in winter, the solutions already given will be applicable to that phænomenon also, which by this way is yet more easy to be accounted for than the other. For having first questioned the matter of fact, it will not be difficult to shew, that, though it were true, it need not be ascribed to Antiperistasis.

33. I THINK then, that it may be justly questioned, whether cellars in general are hotter in winter than they are in summer. For as

for the testimony of our senses, upon which alone men are wont to conclude the affirmative, it may in this case easily and much delude us. For those places being sheltered from the winds, and kept from a free communication with the outward air, are much less exposed than others to the action of those agents, whatever they be, that produce cold in the air. So that our bodies being constantly immersed in the air refrigerated by the winter, and consequently brought nearer to the temper of that air, when we bring those bodies into cellars, the subterranean air must seem warm to us, though in it self it were unvaried as to its temper.

34. Now that many cellars are indeed colder in the midst of winter, than in the heat of summer, though not in respect of our senses, yet in respect of other bodies, that have not the same predispositions, I am induced to believe by some experiments of mine own, purposely made. And first in a frosty evening having hung out in a garden two sealed weather-glasses, that they might be reduced as near as could be to the temper of the ambient air, I brought one of them into a cellar, and it soon began manifestly to rise, and in two or three hours ascended five or six divisions, whilst the water in another sealed weather-glass, that continued suspended in the same part of the garden, did rather a little subside, than at all rise, which is agreeable to the first part of what I was saying; namely, that the air, harboured in cellars, is not so powerfully affected by the ordinary efficient of cold, as the free and external air. And now as to the second part of what I was saying, that the subterranean air, though it be less affected by the outward cold, may be somewhat affected by it, instead of growing hotter by Antiperistasis; I shall add, that early in the morning in frosty weather the liquor in the same weather-glass appeared more subsided, than over night, which shews, that the external air did lessen, not increase the warmth of the air in the cellar. And having there placed a wide-mouthed glass of oil, which in thawing weather remained all night fluid as before, the same liquor, the very next night, which was a bitter frost, was so far frozen and congealed, as to sink in other oil, and keep its surface exactly, though the glass were inclined and turned upside down. And prosecuting my trial, I found, that in a sharp frost, and great snow, the liquor, that on the Thursday night was beneath the fourth knob or mark of division, a sudden thaw coming with a south wind, the next morning in the same cellar the liquor was ascended to the eighth mark. And continuing the weather-glass in the same cellar for a good while, to watch its alterations every night and morning, I remember I met with, and registered more observations, that confirmed me in my opinion, though it is so long ago, that I have forgot the particular circumstances. And after these trials meeting with a learned Polander, I did, without declaring my opinion, inquire of him, whether in his country he had at any time observed beer to freeze in cellars in frosty weather; to which he answered, that in the coldest winters, if the beer were small, the barrels

would oftentimes be frozen, but not if it were strong. But I need not have recourse to foreign testimony, having my self observed here in *England*, more than one barrel of beer to be frozen in the cellar in exceeding cold weather. Insomuch that one of the barrels being full, and the liquor expanded by freezing, was forced out at certain chinks, which seem to have been made by that expansive force, and the liquor so ejected, adhered in a considerable lump to the outside of the vessel; and yet this cellar had its windows carefully shut, and not only was near a kitchen, where fire was constantly kept, but, which was more considerable, it had this principal mark of being a good cellar, that in the heat of summer it used to afford me drink sufficiently cool. And now to requite *Eleutherius* with the testimony of that very person, physician to the Russian emperor, whose authority he lately alledged against me, I shall confess, that as he suspects I had conference with this doctor, and when I diligently enquired of him, whether their cellars at *Muscow* were really very cold in summer, he answered me, that they were not, and that they had distinct cellars for summer and for winter; that their small beer would quickly grow sour in their cellars in summer, if their vessels were not kept in snow; that therefore their way was to make at the bottom of their summer cellars (to which belonged a well, to receive the water dropping from the melted snow) a deep layer of snow, on which they afterwards cast a convenient quantity of water, that the whole mass might be turned into a kind of ice. In this snow they keep their casks, making sometimes a layer of snow, and a layer of cask, and digging out their vessels, as they had occasion to use them. By all which it may appear, how groundlessly it is universally affirmed of cellars, that as they seem to the sense, so they really are hotter in winter than in summer.

35. BUT if it should happen, (as in some places it is not impossible, but that it may) that some vaults and cellars are really warmer in summer than in winter; yet I see not, why this should reduce us to the acknowledgement of an Antiperistasis; for neither could the effect be made out by that, nor would there be any necessity to have recourse to it.

36. AND first I might content my self to repeat, what I have formerly said, to shew the incongruity of Antiperistasis in general to nature's ways of acting. And I might add, that to imagine with some late Peripateticks, (whom all their reverence to *Aristotle* has not so far blinded, as not to let them see the unreasonableness of his conceit) that in winter the warmth of the ambient air retreats into cellars and vaults to shun its contrary, is to make meer accidents, or at best inanimate agents, act with knowledge and design. But I will rather represent, that, though Antiperistasis were intelligible, it were improper to alledge it in our case. For to invigorate the warmth of the air by the cold, the air must, according to them, be environed with other cold bodies, and the heat must retire it self as far as it can from them. And accordingly it is observed, that

in winter the deepest cellars are warmest; but in the case before us the subterranean air, though above, it have the cold that reigns in winter; yet beneath, the subterranean heat makes the earth very warm. This I shall not wonder, if you look upon, as new and paradoxical; and therefore I shall apply myself to the proof of it, and to convince you, I shall not imploy the observations of chymists and mineralists, for fear you should suspect them of ignorance or design; but I will use only the authority of a learned physician, who, I think, was also a professor of mathematicks, who, in but too many points, is a stout Peripatetick, and who, above all this, professes himself to be an eye-witness of what he relates. This author then informs us, that about the year 1615, he had a curiosity to visit the mines of *Hungary*, and particularly to go down into the deep golden mine at *Cremnitz*; and that after he had descended fourscore or a hundred fathoms, he found it excessively hot, though he had but a slight linen garment on; and though he be a maintainer of Antiperistasis, yet he affirms, that not only the overseer and workmen of that mine, but also those of divers other mines, unanimously assured him, that that lower region of the earth was all the year long very hot, and as well in winter, as he found it in summer. So that it seems, in winter the heat of the subterraneous parts less remote from the superficies, cannot be intended by the coldness of the more internal parts of the earth, those parts being themselves not always cold, but always hot.

ELEUTHERIUS. 37. But you may, *Carneades*, remember, that this very author tells you *, that he found the supreme region of the earth, as he calls it, which is that next the air, exceedingly cold, both as he went down into the mine, and as he came up again, and that he ascribes that coldness to Antiperistasis.

CARNEADES. 38. Right, but you may remember too, that he relates †, that it was in *July*, and in very hot weather, that he went down into the mine, and that, to avoid fouling his clothes, he put them off, and exchanged them for a light loose linen garment, such as the diggers wore; and this himself mentions, as that which much increased the coldness he felt. So that if, besides this, we consider, that he descended into a cooler place, with a body already affected with the great heat which he elsewhere takes notice, that that season had given the outward air, and perhaps much heated by riding or walking to the mine, we shall not wonder, that he found the change very sensible as he went down. And we shall less wonder, that he found the upper region of the earth, as he calls it, more cold, when he came up again; since, besides the toil of going to and fro, and ascending through narrow, low, and difficult passages, he came out of a place

excessively hot; insomuch that he tells us, that the overseer of the mine would not go back with him the same way he came, but took a far shorter, though it were a more dangerous way, causing himself to be drawn up in a perpendicular groove; and rendering this reason, that it was very unhealthy, when one comes out of a place, where the diggers work naked, and where one is even melting into sweat, to make any long stay in the superiour region of the earth. So that besides that this author, altho' he maintains Antiperistasis, yet he allows this upper region to be hot in winter, as well as cold in summer; and consequently, that in winter it has not a cold region beneath, as well as above it: which is enough to vindicate the thing, for which I first alledged his testimony. Besides this, I say, to me, who, though I willingly thank him for his narrative, am much more swayed by what he relates, than by what he thinks; the matter of fact seems very favourable to my opinion: for you see, that I can justly refer the cold he felt near the surface of the earth, to the deception of his sense, but the heat he felt within the bowels of the earth cannot be referred to the same cause; since he tells us, that at the top of that great and perpendicular groove, by which the mine-master was drawn up, there ascended a plentiful smoke, that was, even above the mouth of it, felt actually hot: and, besides his own confession, that the deep parts of the mine were more than seemingly hot, I can draw further proofs from these two circumstances, that I have elsewhere met with, in his narrative; the one, that on the surface of the earth, it was then excessively hot; another, that the smoke, which, notwithstanding this heat, appeared hot, had in its ascent passed through four or five hundred foot of a cold region of the earth, whereby it may well be supposed, to have been much in frigidated. To these relations of the learned *Morinus*, I will add, that the archbishop of *Upsal* affirms **, that in the year 1528, being in *Poland*, he went to visit those deep mountains, (as he terms them) whence they dig solid salt, and having descended fifty ladders, found, in the deeper places, that the workmen were naked, because of the heat. So that supposing the time of the year not to be considerable in this case, it seems by this relation, that, provided a man descends low enough into the bowels of the earth, he will find it very hot, even in places that want those metals, or marchasites, or other like mineral substances, by the action of saline liquors, or exhalations, upon which you, *Eleutherius*, have, I remember, sometimes suspected, that the heat observed in mines may be produced.

39. I HAVE hitherto shewn, that the heat of cellars and vaults in winter has been very improperly, and now I come to shew, that it has

*—*Cepimus in hanc fodinam per gradus valde strictos profunde admodum descendere, per regionem certe frigidissimam, quam solis vestibus metallicis opertus, multo frigidioris sensu, &c. p. m. 130.*

†—*In quam descendi mense Julio, quo anni tempestas vigeat calidissima, siccissimaque. p. m. 130.*

‡—*Exhalatio aere levior per ipsum puteum ascendit magno impetu, in ejus summitate adhuc sensibilibus calida ipsa astate, licet supremam terrae regionem tunc frigidissimam permeat. Pag. 128. See also page 125.*

**—*In Polonia vero montes profundissimi salis sunt, praesertim in Vielisca & Bochna, ubi videndi causa transcensit scalis, videt in profundioribus locis laboratores nudos ob calorem, ferreis instrumentis eruere opulentissimum thesaurum salis, veluti aurum & argentum ex mineris inexhaustis. Olaus Mag. lib. 13. p. 382.*

has been as unnecessarily ascribed to Antiperistasis. For as the air of those places is protected from the greatest part of the adventitious coldness, that reigns in the outward air, so the subterranean air has a positive cause of heat in winter, that it has not in summer. For, as I formerly took notice, in summer the pores of the earth, being dilated and opened by heat, the warm exhalations, that were wont to be mingled with moist vapours in the bowels of the earth, are called out, and exhaled away. For as in the winter, the surface of the earth being hardened by frost, or the pores of it choaked up, or at least much obstructed, the hot steams, that, as I lately proved by our French author's testimony (to which I could add that of eminent chymists and mineralists) do continually, and copiously enough ascend from the warm region, or lower parts of the earth, are in great part detained and imprisoned in cellars, and other subterranean cavities, where consequently they produce such a heat, as to those, that come out of the cold air, may be very sensible. And the rather, because whilst men, by the coldness of the season, are more than ordinarily careful, to stop up the passages, at which the external air may get in, they do, though designlessly, stop up the vents, at which the subterraneous exhalations might get out. And to shew you, that this last circumstance is not impertinently taken notice of, I shall tell you, that a very grave author having occasion to mention cellars, relates it, as a practice in divers houses of a town, where he had been, to keep vents in their deep cellars, which in the summer were from time to time opened, partly to keep the places sweet and wholesome, and partly to let out the warm exhalations; that would else hinder their liquors from keeping so fresh, and well. And these steams were affirmed to have been several times taken notice of, to ascend visibly into the free air like a smoke; which several phænomena, and particularly what I formerly related of the hot fumes, that manifestly ascended out of the great grove in the Hungarian mine, may keep us from thinking incredible.

40. AND NOW, by what I have hitherto discoursed, I have made way for the solution of a phænomenon, that is wont to be much urged in favour of Antiperistasis; namely, the smooking of water, that is drawn in frosty weather out of deep wells and springs.

41. BUT, first, I must advertise you, that it is improperly enough, that some urge for Antiperistasis such examples, as the strange spring near the temple of *Jupiter Ammon*, which *Lucretius* and others have observed to have been exceeding cold in the day-time, and as hot at night: for, not now to examine, whether this story be not fabulous, or might not be ascribed to some crafty trick of the idolatrous priests, that had a mind to impose upon *Alexander*, as well as others, and procure an admiration to the place; I consider, that this, and other the like cases, such as are the springs mentioned

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in the islands of *Maldivia*, by *Pyrrard* (a French author, that was shipwrecked, and lived long in those parts) must be referred to the peculiar nature of the springs, or some other hidden cause: since, if the water of them were but ordinary, and the phænomena were the effects of Antiperistasis, it might justly be expected, that the like should happen in all springs, or at least in very many, which, that it does not, common experience shews us. And I would say, that this might be the case of the spring, you mention out of *Captain James's* voyage, (pag. 63.) but that besides, that he does not say expressly, that it was frozen in *July*, but only, that then it afforded him no water, which might happen upon divers other accounts: and besides, that it is manifest, that in far hotter countries, where the excessive heat of the air might more intend the subterranean cold, if Antiperistasis could do it, there is no talk of any such degree of cold in summer, as to freeze the springs; besides this, I say, there seems to be, through some mistake or other, a contradiction in the relation itself, since in the same voyage, speaking of the same month of *December*, he expressly says, that their well was then frozen up; so, (pag. 58.) *that dig as deep as they could, they could come by no water*. And he complains, on that occasion, of the unwholesomeness of melted snow-water. It is true, that he soon after mentions a spring, that he found under a hill's side, which did not so freeze, (pag. 59.) but that he could break the ice and come to it; but by his very sending far from his house to the spring, it appears to have been a consequence, and therefore a proof, of the uselessness of his well in *December*; as his affirmation, that it continued all the year so, as to be serviceable, when the ice was broken, shews, that the Antiperistasis did not freeze it up in summer. And having cleared myself of such a testimony of this ingenious navigator, as would appear very illustrious, if there had been no mistake about it, I shall not scruple to add, that the late publisher of the Latin description of *Denmark* and *Norway* informs us, that in or near that little Danish island *Hueena*, wherein the famous *Tycho* built his *Urani-Burgum*, there is one spring among many ordinary ones, that even in the coldest winter is never frozen; which, subjoins my author, does in these regions exceeding rarely happen to be found. *Olaus Magnus* * also relates, that in another part of the King of *Denmark's* dominions, namely near *Nidrosia*, one of the chief cities of *Norway*, there is a lake, that even in that northern region never freezes. And the learned *Josephus Acosta* mentions †, that among a very great number of hot springs to be met with in *Peru*, *At the baths, which they call the baths of Ingua, there is a course of water, which comes forth all hot and boiling; and joining unto it there is another, whose water is as cold as ice*. He adds, *That the Ingua (or the Peruvian emperor) was accustomed to temper the one with the other, and that it is a wonderful*

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* *Hancque nativam, lacum similem, prope metropolin Nidrosensem regni Norwegiæ, habere compertum est, eo præcipue argumento, quod in mediis frigoribus nunquam congelatur. Lib. 2.*

† *Joseph. Acost. Hist. Ind. pag. 174.*

derful thing to see Springs of so contrary qualities, so near one to another. These relations, as I was saying, I scruple not to mention, though at first sight they may seem to disavour my cause. For by these and some others it may appear, that Springs may obtain very peculiar and strange qualities, from the nature of the places whence they come, or through which they pass, or from some other causes, that are as hidden from us, as the originals of these rare waters. And this being once proved, who knows what interest such causes, as we are strangers to, may have in some phenomena, that are wont to be wholly ascribed to the heat and cold of the superficial part of the ground, and what influence they have upon many other Springs (besides those above-mentioned) some of which, that are very deep, may rise from the warm region of the earth, where they may be affected by the place, as both these and others may be by mineral juices and steams, (such, perhaps, as we know nothing of) though we well know, that some of them, that are saline, without being at all sensibly hot, will powerfully resist congelation.

42. BUT having hinted thus much on this occasion, I shall now proceed to consider the smoking of waters drawn from deep places in frosty weather; and shew, that it does not necessarily conclude such water to be warmer in winter, since that effect may proceed not from the greater warmth of the water in such weather, but from the greater coldness of the air. For we may take notice, that a man's breath in summer, or in mild winter weather, becomes very visible, the cold ambient air nimbly condensing the fuliginous steams, which are discharged by the lungs, and which in warmer weather are readily diffused in imperceptible particles through the air. And I have observed, upon the opening of issues in some men's arms, that though no smoke be visible in summer, it will be very conspicuous in exceeding sharp weather; though men's arms, at least the external parts of them, seem to have less heat in frosty weather, than in summer; since in the former of those seasons, they are wont to be manifestly more slender, the fleshy parts and juices being condensed by the coldness of the air. And though the insensible transpirations, that continually exhale from all the parts of our bodies, are not wont to be visible here, even in winter; yet in extremely cold countries, as *Nova Zembla*, or *Charleton Island*, those effluvia have been observed, not only to be thickened, but to be turned into ice itself, sometimes within the seamen's shoes. And here in *England*, having not long since employed a labouring man to dig a deep hole in very frosty weather, two servants of mine, that stood by to see him work, did both of them assure me, when they returned, that the steams of his heated body were frozen upon the outside of his waistcoat, which, one of them, whilst the other was about to give me notice of it, inconsiderately wiped off.

43. AND since we see, how fast the water in ponds and ditches wastes and decreases in summer, there is no cause to doubt, but that

it does then continually emit exhalations, as well, if not much more plentifully, than in winter: which may be manifestly confirmed by this, that in the summer one shall often see, in the mornings or evenings, the face of the water covered with a mist or smoke, that rises out of it. And I have sometimes taken pleasure to see this aggregate of exhalations hover over the water, and make, as it were, another river of a lighter liquor, that conformed itself, for a considerable way, to the breadth and windings of the stream, whence it proceeded. And I think it will be easily granted, that the water in summer-time is at least as warm at noon, when such exhalations are not visible, as in the morning when they are, though the air be colder at this part of the day, than at that; which observation gives us the true reason of the phenomenon.

44. AND though, notwithstanding all this, it were made to appear, that in some cases, the smoking water of Springs may be really warmer in winter than in summer; yet a sufficient reason of the phenomenon may be fetched from what I have already delivered about the detention of the warm subterranean vapours by the frost, and snow, and rain, that make the earth less perspirable in winter.

45. AND because I know *Themistius* will look upon a thing so disagreeable to the vulgar opinion, of the coldness of the whole element of earth, as a paradox; I will take this opportunity to add a further confirmation to what I have been saying.

46. AND first, that there arise copious and warm steams from the lower parts of the earth, may be proved, not only by what I have already mentioned, touching the Hungarian mines, but by the common complaint of diggers in most, though not in all deep mines, that they are oftentimes troubled, and sometimes endangered by sudden damps, which do frequently so stuff up and thicken the subterranean air, that they make it not only unfit for respiration, but able to extinguish the lamps and candles, that the miners use, to give them light to work by. And I remember, that I have visited mines, where having enquired of the diggers, whether those hot exhalations, that compose their damps, did not sometimes actually take fire within the bowels of the earth? I was answered, that in some of their pits (and particularly in one, that they shewed me) though not in all, they did; inasmuch that the exhalation suddenly kindling, would make a report at the mouth of the pit like a musquet, or a small piece of ordnance, and the flame would actually burn off the hair, and scorch the skins of those workmen, that did not seasonably get out of the pit, when the exhalation appeared to be near in ascension, or did not nimbly fall down flat with their faces to the ground, till the flame was gone out. And one of these workmen, that I asked, affirmed himself to have been several times, to his no small trouble, so burned, and that (if I much misremember not) twice in one day. And it seems to me as well as to *Morinus* very probable, that those great quantities of rain and snow, and storms, and

and (perhaps) some other meteors, that are taken notice of in winter, may rather consist of these subterranean steams, than the vapours and exhalations attracted by the sun, (or at least may as much consist of the former, as the latter.) For his heat is then very languid, and acts upon the ground but during the day-time, which is very short, (whereas those meteors are generated indifferently at all hours of the day and night;) and the sky is oftentimes, for many days together, quite overcast with clouds, and the surface of the ground so constipated with frost, that it will sometimes freeze even in the sun-shine: so that it is not near so likely, that the heat of the sun, in the midst of all these disadvantages, should be able to elevate so great a plenty of exhalations and vapours, as are requisite to compose the rain, and snow, and storms, that sometimes last almost all the winter, as that they should be supplied by subterranean steams copiously sent up from the heat, that continually reigns in the lower parts of the earth, and by traversing the sea, and at other vents, get up into the air.

47. To make out this, my formerly quoted French author (*P. m.* 136.) relates a very memorable thing, that was told him by the masters of those mines in *Hungary*, (which are at least as deep as any that I remember I have seen or read of;) namely, that the miners were able certainly to foretel sooner than any other mortals, the tempests and sudden mutations, that were to happen in the air. For when they perceived by the burning blue of their lights, and by other manifest signs, that they could easily take notice of in their grooves, that store of the tempestuous damp (if I may so call it) was ascending from the lower parts of the earth, though the sky above were clear, and the air calm; yet they could assuredly foretel the approach of a storm, or some other great alteration in the air, which would accordingly ensue within no very long time after. And to confirm this narrative, I shall add, not only that it is agreeable to what I lately told you was affirmed to me by other mine-men, but that having enquired of a very ingenious physician, who lived many years in *Cornwall*, (a country you know famous for tin-mines, some of which are infamous for the damps that infect them) he told me, that divers of the experienced fishermen assured him, that oftentimes they did perceive fishes shining in the night, sometimes in one place, sometimes in another, which was supposed to be kindled by the sulphurous and other subterraneous exhalations; and that, when they perceived those fires, (especially if any number appeared in several places) those, that were well acquainted with the coast, would not continue long out at sea, but rather quit an opportunity of catching fish, than not make seasonably to the shore; hav-

ing often observed, and particularly this last year, that bold and unexperienced mariners, by slighting these fore-runners of storms, were in few hours shipwrecked by them.

48. To this I shall add, what happened some years since, upon the Irish coast, near a strong fortress, called *Duncannon*, where divers of the ships royal of *England* lying at anchor, in a place where they apprehended no danger from the wind, there seemed suddenly to ascend out of the water, not far from them, a black cloud, in shape and bigness not much unlike a barrel; which mounting upwards, was not long after followed, as the most experienced pilot foretold, with so hideous a storm, as forced those ships to go to sea again, and had like to have cast them away in it. And this account was both written by the principal officers of the squadron to their superiours in *England*, and given, soon after it happened, by the chief of those eye-witnesses (and particularly by the pilot) to a very near kinsman of mine (well versed in maritime affairs) that commanded the land-forces in those parts, as a truth no less known than memorable.

49. AND on occasion of what I was saying, about the eruption of hot steams, in several parts of the earth, I now call to mind something, that I have met with in a very small, but curious dissertation, *De admirandis Hungaricæ aquis*; whose anonymous author I gather, from some passages in the tract itself, to have been a nobleman, governour of *Saros*, and some other places in *Hungary*, and to have written this discourse, both for, and to that inquisitive German Baron, *Sigismundus Liber*, famous for the account he gave the world of the embassy, whereon he was sent by the German to the Russian emperor. This anonymous, but noble writer, tells us then, that in that part of *Hungary*, which he calls * *Comitatus Zolienfis*, there is a gaping piece of ground, which does emit such mortal expirations, that they suffocate, not only cats and dogs, purposely held at the end of long poles over the cleft, but kill even birds, that attempt to fly over it. And in other places of the same tract, I have met with many other relations, which if I had time to make a particular mention of, would much countenance what I have been lately saying: but though I pretermit several other instances, I cannot but take especial notice of one, which (together with what I lately mentioned to have happened near *Duncannon*) may make it probable, that not only under the surface of the dry ground, but in that part of the terrestrial globe, that is covered with water, there may arise steams, (and consequently exhalations) actually, and that considerably hot. For in one † place he takes notice, that, not far from the well-known city of *Buda*, there is a hot spring (which they call *Purgatory*) which the waters

* *Qui vero in comitatum Zoliensem, dum aquas persequimur, ventum est, non possum preterire hiatum terre ipsam in locis famosum ob pestilentes expirationes, quibus aves supervolantes, & quævis alia animalia extingui constat, manifesto eorum experimento, qui, &c.* Pag. 74.

† *Ibidem est sub dio fons calidarum cæteris amplior, quem Purgatorium vocavere, ea nimirum ratione, quod, quemadmodum proditum est in purgatorio panas nocentium pro nozarum modo, alias acerbiores, alias mitiores, ita quedam insunt aquæ hoc in fonte discrimina, nam quæ in eum à Danubii ripâ aditus est, subfrigida primum, mox tepida, & quo in eum penetratis alius hoc magis calet. In recessu vero interiore tam est calida, ut ferri non possit. Est etiam is calor haud àmbie aquæ hujus proprius; nam alia, quæ dixi, temperamenta verisimile est à Danubio accedere, qui crepidinem hujus fontis lambit, & cum vel modicè excreverit, totum inundat, neque tamen ita restinguit, quin calent. Quin intra ipsam ripam, qua Danubio peruenit, curfus est calidæ ebulliant, ubi qui alius mergi volunt lavare consueverunt.* Pag. 57.

waters of *Danubius* itself are not able to keep from being hot : nay, within the very banks, betwixt which that great river runs, there boil up hot springs, where those, that will go deep enough into the water, may commodiously bathe themselves. And * elsewhere speaking of the river *Istroganum*, in the same county, he adds, that not only the banks of it, but within the very river itself, one may discover hot springs, by removing the sand at the bottom with one's feet. To this I shall add, that having heard of a ditch in the North of *England* (in some regards more strange, though less famous than the sulphureous grotta near *Naples*) whence not only subterranean steams, but those so sulphureous, as to be easily inflammable, did constantly and plentifully ascend into the air, I had the curiosity to make enquiry about it, of the minister of the place, (a very learned man, and conversant in mines) who then happened to be my neighbour, and he attested the truth of the relation upon his own knowledge. And it was confirmed to me by a very ingenious gentleman, who went purposely to visit this place, and found it true, that a lighted candle, or some such actual burning body being held, where this exhalation issued out of the earth, would kindle it, and make it actually flame for a good while, and (if I misremember not) as long as one pleased. And as this place was but a few years since taken notice of, so there may be probably very many others, yet undiscovered, that may supply the air with store of mineral exhalations, proper to generate fiery meteors and winds. I remember, that having lately asked an inquisitive gentleman, that is a great searcher after mines, whether he did not observe some meteors near those places, where he is most conversant? he told me, that it is very usual in some of them, to see certain great fires moving in the air, which in those places, diggers, because of some resemblance (real or imaginary) are wont to call dragons. [And the Russian emperor's physician, you were speaking of, informed me a while since, that he had, not long ago, observed in winter a river in *Muscovy*, where, though the rest of the surface was frozen, there was a part of it near a mile long, that remained uncovered with ice, which probably was kept from being generated there by those subterraneous exhalations, since he says he saw them ascend up all the way like the smoke of an oven.] And in case the matter of fact delivered by *Olaus Magnus* † be true, concerning the strange thaws, that sometimes happen, with terrible noises in the great lake *Veter*, those wonderful phænomena may not improbably be ascribed to the ascent of great store of hot subterranean steams, which suddenly cracking thick and solid ice in many places at once, produce the hideous noises, and the hasty thaw, that he speaks of. And this suspicion may be countenanced partly by this

circumstance, that before these sudden thaws, the lake begins with great noise to boil at at the bottom ; and partly by what is related by a more authentick writer, I mean that learned traveller the Jesuit *Martinus*, who witnesses, that at *Peking*, the royal city of *China*, it is very usual, that after the rivers and ponds have continued hard frozen over, during the winter, the thaw is made in one day ; which, since the freezing of the waters (as he tells us) required many, makes it very probable, that the sudden thaw is effected (as he also inclines to think) by subterranean steams, which I may well suppose to be exceeding copious, and to diffuse themselves every way to a very great extent, since they are able so soon to thaw the rivers and ponds of a large territory, and that (which makes mainly for my present purpose) beginning contrary to vulgar thaws, from the bottom upwards.

50. AND having thus manifested, that the lower parts of the earth do send up great store of exhalations and vapours to the upper parts, it will be obvious to conceive, that as in divers places of the terrestrial globe, these steams get into the air, either by the advantage of finding vents, such as those I have already mentioned, or by growing copious enough to force themselves a passage ; so in most other places, where the ascending steams find no commodious vents, or are too faintly driven up to gain themselves a passage, they must be repressed or detained beneath the surface of the earth, which has its pores in winter usually choaked up with snow or rain, or its surface constipated and hardened with ice or frost : so, that these exhalations being pent up, and receiving fresh supplies, from time to time, from beneath, it were no wonder, if they should somewhat warm deep cellars and wells, where they are thus detained ; and therefore our husbandmen do not speak altogether so improperly, when they say, that the snow keeps the ground warm. And I remember, that *Dr. Smith*, the learned English Ambassador into *Moscow*, makes it to be one of the principal reasons of the great fertility, he justly ascribes to the country thereabout, that during almost all the winter, the ground is to a great height covered with snow ; which does not only enrich it by the fertilizing salt, which the earth gains from the snow, when that comes to be melted, but does also contribute to its improvement, by choaking up, or obstructing the pores, at which the nitro-sulphureous, and other useful corpuscles, that are sent up by the subterranean heat, would easily get away. And lest, Gentlemen, you should think, that it is only by the ratiocination, that I conclude, that there is really great store of warm steams detained under ground in the winter ; I shall add this sensible observation, received from the Russian emperor's physician already often mentioned,

* *Neque in ripâ tantum eruuntur Calide, sed etiam intra annem, si fundum ejus pedibus suffodias. Calet autem immodicè, nec sunt idoneæ balneis, nisi temperentur, quod admisione frigida de proximo hauste in proclivi est.* Pag. 65.

† *Nec prætereundum hic puto Lacum esse LX. milliarum in longitudine, & XX. in latitudine Italicorum, Veter appellatum in Regno Ostrogothorum, quæ talis est nature, quod cum tempestuoso vento congelatus fuerit, & tempus resolutionis imminuat, vehementissimo strepitu incipit fundo ebullire & commoveri, magna violentia perrumpere in parvas rimas, vel scissuras, quæ sunt in glacie, & hæc in modico temporis spatio faciens valdè latus, licet pro tunc glacies in spissitudine habuerit, plusquam unum, vel duo brachia.* Lib. primo, pag. 23.

mentioned, by whom I have been assured, that about *Muscovy*, where the surface of the ground is far more constipated in winter, than it is in these parts, and where they are wont to keep their cellars much closer, the subterraneous exhalations being hindered to fly abroad, will in time multiply so fast, that he assures me, that upon the unwary opening of the doors of cellars, that have been long kept shut, there would fall out a warm smoke, and very thick, almost like that of a furnace, and sometimes the steam, that issues out, will be so gross and plentiful, that it has brought men into danger of being suffocated by it.

51. AND now, gentlemen, having shewn, that though experience be so confidently appealed to by the maintainers of Antiperistasis, yet she has not hitherto afforded them any thing, that much favours their cause; it remains, that I shew, that she bears witness against it. For besides that some passages of my late discourses do really contain phænomena, that not only do not favour Antiperistasis, but may justly be employed as experiments against it, I shall *ex abundanti* (as they speak) present you with something, which I necessitated experience to supply me with, that seems expressly to overthrow it.

52. I MIGHT urge against those, who, though they begin to be ashamed of the doctrine of the schools, would establish an Antiperistasis upon the account of what they call a *fuga contrarii*, that the very instance they are wont to bring for their opinion, may be retorted upon them. For when they tell us, that in winter, the heat, to fly the cold of the external air, retires itself into the lower parts of the earth, and there harbours in cellars and wells, as may be proved by the smoking of water drawn from deep wells, which argues its heat, the vapours, which fly away, being, as vapours, hot in comparison of the outward air; we may easily answer, by demanding, why, if the heat, that was harboured in a smoking bucket of water, have the wit or instinct to fly from its contrary, it does not in the bucket, as it is said to do in the well, retire it self as far as it can from the surrounding cold of the ambient air; but instead of retiring to the innermost parts of the water (those being remotest from that) it needlessly flies abroad, with the vapours it excites, and does, as it were, of its own accord cast it self into the arms of the enemies it should shun. And indeed what I just now mentioned to you, as related to me by Dr. *Sam. Collins*, the great duke of *Muscovy*'s physician, does sufficiently manifest, that the cause, why the corpuscles, that keep cellars warm, abide beneath the surface of the earth in winter, is not that they fly the cold as their enemy, but that they are pent up beneath the ground; since, when vent is given them, they immediately rush into the open air, without fearing the cold even of *Russia* in the very midst of winter.

53. BUT I shall press this no further, but rather add, that the doctrine of Antiperistasis is as little beholden to the following experiment, which I sometimes tried, in order to the disabusing some abettors of *Themistius*. I

took then an iron-rod, of about the bigness of a man's finger, having at one end of it a very broad and thick piece of iron (shaped almost like a spatule) that the quantity of the matter might, upon the ignition of the iron, make the heat very considerable: then having caused this thick end to be made red-hot in the fire, and having suddenly quenched it in cold water, I could not perceive, that the other end of the rod, by which it was wont to be held, did at all grow sensibly hot, as a favourer of Antiperistasis would have expected it should do to a very high degree, as presuming, that the innumerable particles of heat, that swarmed in the compact body of the red-hot part of the iron, must, to fly the cold of the water, retire in throngs towards the other extreme of the iron, and make it exceedingly hot. And lest any pre-existent warmth should hinder me from perceiving an increase of heat, in case any were produced in the handle of the iron, I caused it the next time the trial was made, to be kept in cold water; and yet even then, the immersion of the broad and candent end into the cold water brought as little of sensible heat to the other end, that I held in my hand, as it had done the time before; and having caused the experiment to be tried by another, the account I received was, that it succeeded with him, as it had done with me.

54. BUT this is not the main thing, gentlemen, that I intend to acquaint you with, there being an expedient, that I purposely devised to make one experiment, more considerable against Antiperistasis, than are the several mistaken observations of the Peripateticks to establish it.

55. I TOOK then a good sealed weather-glass, twelve or fourteen inches long, furnished with good spirit of wine, and having provided an open-mouthed glass of a convenient shape and size, and filled it but to a due height (that it might not afterwards run over) with common water, I so ordered the matter, that the stem of the thermoscope being supported by the cork, into which by a perforation or slit it was inserted, when the glass was stopped by the cork, the whole ball of the thermometer was immersed in the water, that filled the wide-mouthed glass, and did no where touch either the bottom or the sides of the glass, so that the ball or bubble was every way surrounded with water. The instrument being thus prepared, we observed at what station the ambient cold water had made the tinted spirit rest in the stem of the thermoscope; and then having provided a fit proportion of warm water in a commodiously shaped vessel, I removed the instrument into it, and placed it so, as that the external warm water reached to a convenient height on the outside of the open-mouthed glass: but though I carefully watched, whether the heat of the external water would increase or strike inwards the cold of that water, which did immediately encompass the ball of the weather-glass; yet I perceived no such matter, the tinted spirit in the stem keeping its station (without sinking beneath it) till the heat, after a while, having by de-

grees being diffused through the formerly cold water, by the intervention of that now warmed, the tinted spirits in the thermometer began to ascend.

56. AND to reduce the other part too of the doctrine of Antiperistasis, to the determination of an experiment, the same thermometer was placed in the same wide-mouthed glass just after the former manner; only instead of the cold water, that, which immediately surrounded the glass, was warm; and when the warmth had impelled up the tinted spirit, till its ascent began to be very slow, I immersed the instrument to a convenient depth in a vessel, that contained highly refrigerated water, mingled with divers pieces of ice. But notwithstanding my watchfulness, it did not appear to me, that the water, that did imme-

diately encompass the ball of the weather-glass, was at all increased or intended, by that liquor's being besieged by water exceeding cold; for the languid motion of the tinted spirit upwards was not hereby so much as sensibly accelerated, (as it must have been considerably, if the heat of the internal water had been so augmented, or struck inwards by the cold of the external, as the schools doctrine would have made one expect) but rather the ascent was, by the chillingness of the contiguous water, quickly checked, and the formerly ascending spirit was soon brought to subside again. And to give myself the fuller satisfaction about some of the chief phenomena of this, and the former experiment, I had the curiosity to observe them more than once.

P O S T S C R I P T.

A sceptical Consideration of the heat of cellars in winter, and their coldness in summer.

THE foregoing discourses of *Carneades* seem to have sufficiently shaken the foundations of the vulgar doctrine of Antiperistasis, so far forth as it is superstructed upon the vulgar observations and phenomena, whereon men are wont to build it; and it seems to have made it also highly probable, that in case some of the examples wont to be produced in favour of Antiperistasis should prove historically true, yet those phenomena may, more congruously to the wonted proceedings of nature, be explicated by the detention of calorifick or frigorifick corpuscles, by the operation of the external cold or heat, than to a certain inexplicable self-invigoration, which is commonly proposed in such a way, as invests inanimate bodies with the prerogatives of free agents. But though *Carneades* his adversaries seem not to have well made out the historical part of the received doctrine concerning cold; yet upon an impartial survey of what has been alledged on both sides, I freely confess, that to me some of the matters of fact themselves seem not yet so clearly determined as I could wish: for as to the obvious phenomena, that nature does, as it were, of her own accord present us, they seem to have been but perfunctorily considered, and our senses only being the judges of them, we may easily, as *Carneades* argues, be imposed upon by the unheeded predispositions of our organs. And as for contrived and artificial experiments, there scarce seem to have been any made fit to clear the difficulties, that invite me to suspend my judgment, as to the grand question (or fact) whether cellars, and other subterraneous places, be really hotter in winter than in summer.

It is true, that I have scarce met with any point, wherein the modern schoolmen seem to

have so much consulted nature, as in this of Antiperistasis. For enquiring what has been written of that subject, that may either confirm or oppose what has in the precedent dialogue been delivered about Antiperistasis; I found, that the curiousness and importance of the subject have made two or three of those writers less negligent than I suspected. But though I have lately met with in them an experiment or two, that seem cogently to evince, I do not say an Antiperistasis in the sense of the schools, but that subterraneous places are really hotter in winter than in summer, yet I must for a while longer continue my suspension of judgment, which that even such persons, as are circumspect themselves, may not think unreasonable, I will briefly subjoin the grounds of my scepticism about this matter.

FIRST then, the learned Jesuit *Zucchi*, who is wont to be far more industrious than other Aristotelians (and on some subjects is careful to propose experiments, though he be not so clear and happy in expressing his thoughts) assures us somewhere, that having kept a good sealed weather-glass, for three years together, in a good cellar, he found the water to rise by the coldness of the ambient air in the summer, and to be depressed by the rarefaction of it in the winter; which seems undeniably to infer, that whatever be the reason of it, the heat in subterraneous places is indeed greater in winter than in summer. And another recent schoolman, who, as I am told, is of the same order, though the learned man published his little book under one of his disciple's names, affirms, that he found by a weather-glass, that a well at the place, where he lived, was colder in summer, and hotter in winter. And these assertions of *Zucchi*, and the other Jesuit, do, I confess, restrain me for a while from yielding a full

full assent to what *Carneades* hath delivered, as to the matter of subterranean cold and heat. But on the other side, I am not hitherto reduced by these experiments, to declare with his adversaries against him, because of the following scruples.

FIRST then I consider, that it is not universally true, which is wont to be indefinitely affirmed, and believed, that cellars and other subterranean places are hotter in winter than in summer. For the instances produced by *Carneades* seem plainly enough to manifest the contrary, and my own observations made in a cellar with a sealed weather-glass do keep me from dissenting from *Carneades* as to that point. I would therefore make a distinction of subterranean places; for some are deep, as the best sort of cellars; others deeper yet, as the Hungarian mines, mentioned by *Carneades* out of *Morinus*; and some again are but shallow, as many ordinary cellars and vaults: of these three sorts of subterranean places, the deepest of all do not, as far as the authority of mineralists above alledged may be relied on (for I am yet inquiring further) grow hot and cold according to the several seasons of the year, as the vulgar doctrine of Antiperistasis requires, but are continually hot: the shallower sort of subterranean places, though by reason of their being fenced from the outward air, they are not so subject to the alterations of it, whether to heat or cold, as open places are; yet by reason of their vicinity to the surface of the earth, they are so far affected with the mutations, which the outward air is liable to in several seasons of the year, that in winter, though they be warm in respect of the colder air abroad, yet they are really (at least some of them) as far as I have tried, colder in very cold weather, and less cold in warm weather. And in this opinion I am confirmed by two things; the one, that having purposely inquired of the *Polonian* nobleman mentioned by *Carneades*, whether he had observed in his country, in sharp winters small beer would freeze in cellars, that were not very deep, but would continue fluid in those that were, he assured me he had taken notice of it: The other thing is the confession of the anonymous Jesuit lately mentioned, who acknowledges, that he found but little difference between the temperature of the water in the well he examined in summer and in winter, though it were a considerably deep one; and adds a while after, that at *Florence*, where the subterranean vaults are shallower, the air is observed to be colder in winter than in summer, though at *Rome*, in their deep cellars, the contrary has been found. So that the lowermost sort of subterranean cavities being, for aught appears, perpetually hot, and the upper or shallower sort of them being colder, not hotter in cold weather than it is in warm, it is about the temperature of the middle sorts of them, such as are the deeper and better cellars, that the question remains to be determined. And thus much of my first consideration.

THE next thing I shall offer to be considered is this; that it is not so easy a matter, as even

philosophers and mathematicians may think it, to make with the weather-glasses hitherto in use, an experiment to our present purpose, that shall not be liable to some exception, especially if the cellars or wells, where the observations are to be made, be very deep. For the gravity of that thick and vapid subterranean air, and the greater pressure, which the air may there have, by reason of its pressing, according to an atmospherical pillar lengthened by the depth of the cellar or well, may, in very deep cavities, as well alter the height of the water in common weather-glasses, as heat and cold do, and so make it uncertain, when the mutation is to be ascribed to the one, and when to the other; or at least very difficult to determine distinctly, what share is due to the pressure, and what to the temperature of the air. And this uncertainty may be much increased by this more important consideration, that not only in places, where the heights of the atmospherical cylinders are differing, the pressures of the air upon the stagnant water in the weather-glasses may be so too, but even in the self-same place, the instrument remaining unmoved, the pressure of the atmosphere may, as I have often observed, hastily and considerably alter, and that without any constant and manifest cause (at least that I could hitherto discover;) so that the erroneous estimate, that may be hereby suggested of the temperature of the air, can scarce possibly be avoided, without the help of a sealed weather-glass, where the included liquor is subject to be wrought upon by the heat and cold, not pressure of the air. So that to apply this to *Zucchius* his experiment, unless he had been aware of this, and unless I knew, that he had divers times made his observations, with the assistance of a sealed weather-glass, it may be suspected, that he might accidentally find the water in his common weather-glass (for such a one it appears he used, as probably knowing no other) to be higher, when he looked on it in summer, than when he looked on it in winter, not because really the subterranean air was colder in the former season, than in the latter, but because the atmosphere chanced then to be heavier. And when I remember, in how few hours I have sometimes, and that not long since, observed the quicksilver, both in a good barometer, and even in an unsealed weather-glass furnished with quicksilver, to rise almost an inch perpendicularly, without any manifest cause proceeding from cold; I cannot think it impossible, that in long weather-glasses furnished only with water, or some such liquor, the undiscerned alterations of the atmosphere's pressure, may produce very notable ones in the height of the water in such instruments. But this is not all, that a jealous man might suspect. For *Zucchius* having, for aught appears, made his observations but in one place, we are not sure, but that may be one of those, whereof there may be many, on which subterranean exhalations have a peculiar, and not languid influence; as *Carneades* has towards the close of his discourse made probable, out of the relations of *Olaus Magnus*, and *Martinius*, touching the great

See the second preliminary discourse, that accompanies the History of Cold.

and sudden thaws, that sometimes begin from the bottom, and thereby argue their being produced by copious steams, that ascend from the lower parts of the terrestrial globe; which may be further confirmed by what he formerly noted of the sudden damps, that happen in many mines. But that, which is of the most importance about our present inquiry, remains yet to be mentioned; which is, that having had the curiosity to inquire, whether no body else had made experiments of the same kind; I find, that the learned *Maignan* had the same curiosity, that *Zucchius* had, but with very differing success; and therefore, though this inquisitive person do admit, in his disputation about Antiperistasis, a notion, that I confess I cannot approve, (since to ascribe, as he does, a *fuga contrarii* * to cold and hot spirits, is, in my apprehension, to turn inanimate bodies into intelligent and designing beings;) yet he does justly and rationally reject, with *Carneades*, the vulgar doctrine of Antiperistasis, and confirms his rejection of it by two experiments. For first, he says, that he found with a thermometer, that when in winter a cold northerly wind froze the water without doors, it was no less cold in wine-cellars, than it was at the same season, and at the same hour of the day in his study, only the paper-shuts of his window, that regarded likewise the North, being put to. And though, if he had said nothing else, I should have suspected, that this might have proceeded from the shallowness of the cellars he made his trial in; yet he prevents that suspicion, by taking notice in one clause of his relation, that the cellars were of the very best of their kind, in which in summer the greatest cold was wont to be felt. But his next experiment is yet more considerable, which I shall therefore deliver in his own words that follow: *Expertus ego sum (says he) thermometro fidelissimo, & à precedente hyeme in sequentem aestatem prorsus invariato, instructo etiam tali aquâ, nempe in hoc ipsum ex præscripto Trebellii, ita comparata, ut non exhaletur, neque minuatur; expertus (inquam) sum in supradictis optimis cellis vinariis maximum, quod ardentissima aestate fuit, frigus non adæquasse illud, quod ibidem erat brumali tempore, ut dixi in supe-*

rriori experimento, siquidem in tubo vitrei thermometri quatuor circiter palmos longo, & in octo gradus graduumque minuta diviso, æquæ hyeme ascendit ad gradus 7. cum semisse, æstate autem vix gradum sextum superavit, cum tamen ad sensum multo magis vigeret frigus istud æstivum.

Thus far this learned, as well as resolute author, who seeming, by the mathematical part of his *Perspectiva Horaria*, to be an accurate and industrious maker of observations, we may oppose this newly-recited experiment to that of *Zucchius*, which it flatly contradicts: and therefore since the depth of the cellars is of great moment in experiments of this nature; since also the particular parts of the place or soil, where the cellars or other cavities happen to be, may, in some cases, not be inconsiderable; and since lastly, neither *Zucchius* or *Maignan* seem to have been aware of the differing weights of the atmosphere, in the self-same place, (as not having seen the XVIIIth of our *Physico-mechanical Experiments*, before which I never saw nor heard of any thing published, or otherwise written to that purpose) I hope I shall be excused, if I retain some scruples about the historical question I have been considering, till the experiment have been carefully made, for a competent space of time in several places, and that not with common weather-glasses (like those used by my two learned authors) wherein the liquor may be made to rise and fall by the differing gravities of the air, but with sealed thermoscopes, wherein the alterations may more safely be supposed to proceed only from its heat and cold.

And to conclude, since *Carneades* has speciously enough answered the other observations, that are wont to be produced in favour of the Aristotelian Antiperistasis, if *Maignan's* relation be better warranted by future experiments, than that of *Zucchius*, it will very much disfavour the whole doctrine itself, which seeming to have been devised, but to give an account of the phænomena, to which it is wont to be applied, considering men will be but little invited to imbrace it, if the matter of fact be as little certain, as what is proposed in the hypothesis is intelligible.

* My backwardness to admit a *fuga contrarii* may be somewhat confirmed by what I lately learned from the English extraordinary ambassador (the earl of *Carlisle*) into *Russia*, newly returned thence. For meeting the other day with an opportunity of asking his lordship a few questions (which he was pleased to answer with his wonted civility) about the cold in *Nuscovy*; I was informed by one of his answers, that his excellency had there the curiosity to observe some bottles of choice and strong wine, that were vehemently frozen, and the opportunity to take notice, that the liquor was quite congealed throughout, and turned into solid ice: whence he rationally inferred, that the spirituous parts of wine did not in these bottles (for aught he acknowledged, that in greater vessels, that may sometimes hold true, which is said of the production of spirit of wine by congelation) retire to the centre, and remain there unfrozen. And his lordship ingeniously pursued the experiment, and confirmed the conjecture, by causing the ice to be taken out of the broken bottles, to be thawed by degrees into several vessels, by which means he found, that the liquor afforded by the exterior parts of the resolved ice was very little, if a less strong, than that, which was obtained from the internal parts of the same ice. From which observation *Carneades* would argue, that at least it is not universal, but in particular cases, and therefore probably by accident, or upon particular accounts, that the concentration of the spirits of liquors is consequent upon being exposed to cold.

A N

E X A M E N

O F

Mr. HOBBS'S Doctrine touching COLD.

A D V E R T I S E M E N T.

THE author of the following discourse intending it should make a part of certain considerations upon the four famous hypotheses, or opinions, of the Nature and Cause of Cold; which (considerations) he thought fit to reserve for the latter end of the history of that quality, was invited to suppress it ever since the former part of the year, that preceded the last. And though this discourse, (both for other reasons, and because he found it more ready and finished, than some other papers, that belonged to the same part of the newly mentioned history) comes abroad unaccompanied; yet he judged it not amiss, to intimate thus much, that the reader may be informed, upon what account Mr. *Hobbes's* opinions come to be examined in an historical treatise; and may not wonder either to find, that divers passages of it are omitted, that are unfavourable enough to Mr. *Hobbes's* doctrine, or to meet with in a discourse postponed to the *History of Cold* some experiments, that seem to

argue it to have been written before they were cast into the order, wherein they now appear. To this I have nothing to add, but that whereas through haste the scheme referred to in the long citation out of Mr. *Hobbes's* has not been added to the others, that belonged to this book, I am not much troubled at the omission (as also that in other quotations the place is not always as well mentioned as the words,) because, that if any shall be found, that after having considered, what I urge against the (great, but imaginary) interest, Mr. *Hobbes* would ascribe to winds (whether he explicate their causes rightly or not) in the production of lesser degrees of cold, but (how improbably soever) of congelation itself, shall think the sight of that scheme of any importance; this learned man's book, *De Corpore*, is in so many hands, that any reader shall desire it, may very easily have an opportunity to consult the scheme in the particularly cited place.

1. **M**R. *Hobbes's* Theory concerning Cold does to me, I confess, appear so inconsiderately pitched upon, and so slightly made out, that I should not think it merited, especially in an historical treatise, a particular or serious examination, but that in proposing it, he scruples not to talk to his readers of his demonstrations; and the preference he is wont to give himself above the eminentest, as well of modern as of ancient writers, has had no small effect upon many, who not knowing, how indulgent some writers are wont to be to the issues of their own brain, as such, are apt to mistake confidence for evidence, and may be modest enough to think, that their not discerning a clearness in his explications and reasonings, is rather a fault of their understandings, than of his doctrine. Mr. *Hobbes* delivers his theory in the seven first articles of the 28th chapter of the fourth part of his elements. But because the whole discourse is too long to be here transcribed, and because in the 2d, 3d, and 4th sections, that, which he treats of, is the generation of winds, and, that which he handles in the 5th, is the notion of a hard body; we may safely leave out those four sections, especially since, though there be in them divers things about the motion of the sun, and other matters, that are more strongly asserted than proved, yet his

doctrine tending but to shew, how the winds are generated, though it were granted, would make but very little, if any thing at all, towards the evincing of his theory about cold.

2. AND that we may not be suspected to injure his opinion or his arguments, we will, though the citation will be somewhat prolix, first recite them, as himself delivers them in those three sections, that treat immediately of cold, and then we will subjoin our animadversions on them.

3. [THESE things, says he, being premised, *Artic. 6.* I shall shew a possible cause, why there is greater cold near the pole of the earth, than further from them. The motion of the sun between the tropicks, driving the air towards that part of the earth's superficies, which is perpendicular under it, makes it spread itself every way; and the velocity of this expansion of the air grows greater and greater, as the superficies of the earth comes more and more to be straitened; that is to say, as the circles, which are parallel to the equator, come to be less and less. Wherefore this expansive motion of the air drives before it the parts of the air, which are in its way, continually towards the poles more and more strongly, as its force comes to be more and more united, that is to say, as the circles, which are parallel to the equator, are less and less; that is, so much the more,

by how much they are nearer to the poles of the earth. In those places therefore, which are nearer to the poles, there is greater cold, than in those, which are more remote from them. Now this expansion of the air upon the superficies of the earth from east to west doth by reason of the sun's perpetual accession to the places, which are successively under it, make it cold at the time of the sun's rising and setting: but as the sun comes to be more and more perpendicular to those cooled places, so by the heat, which is generated by the supervening simple motion of the sun, that cold is again remitted, and can never be great, because the action, by which it was generated, was not permanent. Wherefore I have rendered a possible cause of cold in those places, that are near the pole, or where the obliquity of the sun is great.

Artic. 7.

4. How water may be congealed by cold, may be explained in this manner. Let A (in the first figure) represent the sun, and B the earth; A will therefore be much greater than B. Let E F be in the plain of the equinoctial, to which let G H I K and L C be parallel. Lastly let C, and D, be the poles of the earth. The air therefore by its action in those parallels will rake the superficies of the earth, and that with a motion so much the stronger, by how much the parallel circles towards the poles grow less and less. From whence must arise a wind, which will force together the uppermost parts of the water, and withal raise them a little, weakening their endeavour towards the center of the earth. And from their endeavour towards the center of the earth, joined with the endeavour of the said wind, the uppermost parts of the water will be pressed together and coagulated; that is to say, the top of the water will be skinned over and hardened, and so again the water next the top will be hardened in the same manner, till at length the ice be thick. And this ice being now compacted of little hard bodies, must also contain many particles of air received into it. As rivers and seas, so also in the like manner may the clouds be frozen. For when by the ascending and descending of several clouds at the same time, the air intercepted between them is, by compression, forced out, it rakes, and by little and little hardens them. And though these small drops (which usually make clouds) be not yet united into greater bodies, yet the same wind will be made; and by it, as water is congealed into ice, so will vapours in the same manner be congealed into snow. From the same cause it is, that ice may be made by art, and that not far from the fire; for it is done by the mingling snow and salt together, and by burying in it a small vessel full of water. Now when the snow and salt (which have in them a great deal of air) are melting, the air, which is pressed out every way in wind, rakes the sides of the vessel; and as the wind by its motion rakes the vessel, so the vessel by the same motion and action congeals the water within it.

5. We find by experience, that cold is always more remis in places, where it rains, and where the weather is cloudy (things being alike in all other respects) than where the air is clear. And this agreeth very well with what I said be-

fore; for in clear weather the course of the wind, which (as I said even now) raked the superficies of the earth, as it is free from all interruption, so also it is very strong. But when small drops of water are either rising or falling, that wind is repelled, broken and dissipated by them; and the less the wind is, the less is the cold.

6. We find also by experience, that in deep wells the water freezeth not so much, as it doth upon the superficies of the earth. For the wind, by which ice is made, entering into the earth (by reason of the laxity of its parts) more or less, loseth some of its force, though not much. So that if the well be not deep, it will freeze; whereas if it be so deep, as that the wind, which causeth cold, cannot reach it, it will not freeze.

7. We find moreover by experience, that ice is lighter than water, the cause whereof is manifest from that, which I have already shown, namely, that the air is received in, and mingled with the particles of the water, whilst it is congealing.

8. To examine now Mr. Hobbes's theory concerning cold, we may in the first place take notice, that his very notion of cold is not so accurately, nor warily delivered. I will not here urge, that it may be well questioned, whether the tending outwards of the spirits and fluid parts of the bodies of animals do necessarily proceed from, and argue heat. Since in our pneumatical engine, when the air is withdrawn from about an included viper (to mention no other animals) there is a great intumescence, and consequently a greater endeavour outwards of the fluid parts of the body, than we see made by any degree of heat of the ambient air, wont to be produced by the sun. This, I say, I will not insist on, but rather take notice, that though Mr. Hobbes tells us, that to cool, is to make the exterior parts of the body endeavour inwards; yet our experiments tell us, that when a very high degree of cold is introduced, not only into water, but into wine, and divers other partly aqueous liquors, there is a plain intumescence, and consequently endeavour outwards of the parts of the refrigerated body. And certainly cold having an operation upon a great multitude and variety of bodies, as well as upon our sensories, he, that would give a satisfactory definition of it, must take into his consideration divers other effects, besides those it produces on human bodies. And even in these, he will not easily prove, that in every case any such endeavour inwards from the ambient ætherial substance, as his doctrine seems to suppose, is necessary to the perception of cold; since, as the mind perceives divers other qualities, by various motions in the nervous or membranous parts of the sentient; so cold may be perceived, either by the decrement of the agitation of the parts of the object, in reference to those of the sensory; or else by some differing impulse of the sensitive parts occasioned by some change made in the motion of the blood or spirits, upon the deadening of that motion; or by the turbulent motion of those excrementitious steams, that are wont, when the blood circulates as

nimble,

nimbly, and the pores are kept as open as before, to be dissipated by insensible transpiration.

9. It may afford some illustration to this matter to add, that having inquired of some hysterical women, who complained to me of their distempers, whether they did not sometimes find a very great coldness in some parts of their heads, especially at the top, I was answered, that they did so; and one of them complained, that she felt in the upper part of her head such a coldness, as if some body were pouring cold water upon it. And having inquired of a couple of eminent physicians, of great practice, about this matter, they both assured me, that many of their hysterical patients had made complaints to them of such great coldness in the upper part of the head; and some also along the vertebra's of the neck and back. And one of these experienced doctors added, that this happened to some of his patients, when they seemed to him and to themselves to be otherwise hot. The noble * *Avicen* also somewhere takes notice, that the invenomed bitings of some kinds of serpents, (creatures too well known in the hot countries, where he lived) made those, that were bitten by them, either become or think themselves very cold. But that will perhaps seem more remarkable, which I shall further add, namely, that I know a nobleman, who followed the wars in several countries, and has signalized his valour in them; and yet though his stature be proportionate to his courage, yet when this person falls (as frequently he has done) in a fit of the stone, he feels an universal cold over his whole body, just like that, which begins the fit of an ague. And though he assures me, that the stones, that torment him, and which he usually voids, are but very small; yet whilst the fit continues, which oftentimes lasts many hours, he does not only feel an extraordinary coldness, but which is more strange, and which I particularly inquired after, cannot by clothes, or almost any other means, keep himself warm.

10. I ELSEWHERE take notice of some other observations, agreeable to these, by some of which we may be persuaded, that there may be other ways, besides those already mentioned, of perceiving cold, though the outward parts of our bodies were not pressed inwards. And whereas Mr. *Hobbes* infers that he, who would know the cause of cold, must find by what motion or motions the exterior parts of any body endeavour to retire inwards; that seems but an inconsiderable direction. For in compressions, that are made by surrounding bodies, there is produced an endeavour inward of the parts of the compressed body, though no cold, but sometimes rather heat be thereby generated. And I hope Mr. *Hobbes* will not object, that in this case the parts do not retire, but are thrust inwards, since, according to him, no body at all can be moved, but by a body contiguous and moved. But what I have hitherto taken notice of, being chiefly designed to shew, that the notion of cold in general is not so obvious a thing to be rightly pitched upon, as many think, and that therefore it needs be no

wonder, that it hath not been accurately and warily proposed by Mr. *Hobbes*; I shall not any further prosecute that discourse, but proceed to what remains. Next then, the cause he assigns, why a man can blow hot or cold with the same breath, is very questionable; partly, because he supposes in part of the breath such a simple motion, as he calls it, of the small particles of the same breath, as he will not easily prove, and as † eminent astronomers and mathematicians have rejected; and partly, because that without the suspected supposition, I could (by putting together the conjectures of two learned writers, and what I have elsewhere added of my own) give a more probable account of the phænomenon, if I had not some scruples about the matter of fact itself: which last cause I add, because, though I am not sure, that further trials may not satisfy me, that the wind or breath, that is blown out at the middle of the compressed lips, has in it such a real coldness, as men have generally ascribed to it, yet hitherto some trials, that my jealousy led me to make, incline me to suspect, there may be a mistake about this matter, and that in estimating the temper of the produced wind, our senses may impose upon us. For having taken a very good and tender sealed weather-glass, and blown upon it through a glass pipe (of about half a yard long) that was chosen slender, to be sure, that my breath should issue out in a small stream; by this wind beating upon the ball of the weather-glass, I could not make the included spirit of wine subside, but manifestly, though not much, ascend, though the wind, that I presently blew through the same pipe, seemed sensibly cold, both to the hand of by-standers, and to mine own, and yet mine was more than ordinarily cold. So that having no great encouragement to enter into a dispute about the cause of a phænomenon, whose historical circumstances are not yet sufficiently known and cleared, I will now proceed to add, that whatever be the cause of the effect, there are divers things that make Mr. *Hobbes*'s hypothesis of the cause of cold unfit to be acquiesced in. For we see, that the grand cause he assigns of cold and its effects, is wind, which, according to him, *is air moved in a considerable quantity, and that either forwards only, or in an undulating motion*: and he tells us too, that when the breath is more strongly blown out of the mouth, then is the direct motion prevalent (over the simple motion) which, says he, makes us feel cold; for, says he, the direct motion of the breath or air is wind, and all wind cools or diminishes former heat. To which words in the very next line he subjoins, that not only great, but almost any ventilation, and stirring of the air doth refrigerate. But against this doctrine I have several things to object.

11. FOR first, we see there are very hard frosts, not only continued, but oftentimes begun, when the air is calm and free from winds; and high and boisterous southerly winds are not here wont to be near so cold as far weaker

* Quoted by Paul Neweraatz: *De Purpura*, cap. 12.

† Dr. S. Ward, (now the worthy bishop of Exeter) and Dr. Wallis, the learned Savilian professor of Geometry, &c.

Chap. 28.
Sect. 2. at
the beginning.

weaker winds, that blow from the North-east.

12. NEXT, if Mr. *Hobbes* teach us, that it is the direct motion of the stream of breath, that is more strongly blown out, that makes us feel cold, he is obliged to render a reason, why in an æolipile with a long neck, the stream, that issues out, though oftentimes far stronger than that, which is wont to be made by compressing the lips, at a pretty distance from the hole it issues out of, is not cold, but hot.

13. THIRDLY, Mr. *Hobbes* elsewhere teaches, that when in our engine the pump has been long employed to exhaust, as we say, the receiver, there must be a vehement wind produced in that receiver; and yet by one of our other experiments it appeared, that for all this in a good sealed weather-glass placed there, before the included air begins to be, as we say, emptied, there appeared no sign of any intense degree of cold produced by this supposed wind, so that either the wind is but imaginary, or else Mr. *Hobbes* ascribes to winds, as such, an infrigidating efficacy, that does not belong to them.

14. FOURTHLY, we find by experience, that in hard frosts water will freeze, not only though there be no wind stirring in the ambient air, but though the liquor be kept in a close room, where, though the wind were high abroad, it could not get admittance; and some of our experiments, carefully made, have assured us, that water sealed up in one glass, and that glass kept suspended in another glass carefully stopt, to keep out not only all wind, but all adventitious air, may nevertheless be not only much cooled, but turned into ice.

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15. FIFTHLY, We found by other experiments, that a frozen egg, though suspended in, and perfectly surrounded with water, where no wind can come at it, will be every way crusted over with ice; in which case there is no probability, that the ice should be generated according to the way proposed by Mr. *Hobbes*. For he will scarce prove, nor is there any likelihood, that a wind pierced the shell and closer coats of the egg to get into the contained liquors, and freeze them: and a more unlikely assertion it would be, to pretend, (as he, that maintains Mr. *Hobbes*'s doctrine, must) that so very little air, if there be any, as is mingled with the juices of the egg, is, by the cold, which is not wont to expand air (nor water, till it be ready to make it freeze) turned into a wind subtle enough, freely to penetrate the shell and coats of the egg, and great enough to diffuse itself every way, and turn on every side the neighbouring water into ice; and all this notwithstanding, that not only it appeared not by bubbles breaking through the water, that there is any adventitious air, that comes out of the egg at all; but that also, supposing there

were some such contained in the egg, yet what shadow of reason is there to conceive, that the air which was ingaged in, and surrounded with the substances of the white, and the yolk of the egg, must needs be a wind, since, according to Mr. *Hobbes*, that requires a considerable motion of most of the parts of the moved air the same way, and, according to him also, a body cannot be put into motion, but by another body contiguous and unmoved.

16. SIXTHLY, Mr. *Hobbes* does indeed affirm, that all wind cools, but is so far from proving, that the highest degrees of cold must needs proceed from wind, that he does not well evince, that all winds refrigerate. Nor are we bound to believe it without proof, since wind being, according to him, but air moved in a considerable quantity, either in a direct or undulating motion, it does not appear, how motion should, rather than rest, make air grow cold. For though it be true, that usually winds seem cold to us; yet, in the first place, it is not universally true, since some, that have travelled into hot countries, and particularly the learned * *Alpinus*, have complained, that the winds coming to them in the summer from more torrid regions have appeared to them almost like the steam, that comes out at the open mouth of a heated oven. And if † *Marcus Polus Venetus* be to be credited, (for I mention his testimony but *ex abundantia*) the southern winds, near *Ormus* have been sometimes so hot, as to destroy an army itself at once. And secondly, even when the wind does feel cold to us, it may oftentimes do so but by accident; for, as we elsewhere likewise teach, the steams, that issue out of our bodies being usually warmer than the ambient air, (whence in great assemblies, even those, that are not thronged, we find it exceeding hot, and I have several times observed a hot wind to come from those throngs, and beat upon my face,) and the more inward parts of our bodies themselves being very much hotter than the ambient air, especially that, which is not yet full of warm steams, the same causes, that turn air into a wind, put it into a motion, that both displaces the more neighbouring and more heated air, and also makes it pierce far deeper into the pores of the skin, whereby coming to be sensible to those parts, that are somewhat more inward than the cuticula, and far more hot, the air turned into wind seems to us more cold, than the restagnant air, (if I may so speak) upon such another account, as that, upon which, if a man has one of his hands hot, and another not, the same body that will appear lukewarm to this, will appear cold to the other; because, though the felt body be the same, yet the organs of feeling are differently disposed. And to confirm this doctrine by an experiment, (which has succeeded often enough, and need not succeed always

See this
difficulty
more largely
by handled
in the first
preliminary
discourse.

* *Exiit, austrique venti à meridie loca arenosa summoque calore inflammata transeuntos, atque Ægyptum spirantes, tantum caloris æstus, pulverumque & inflammatarum arenarum evolvunt, ut ignitas fornacis flammæ, nec non pulveribus obscurissimas nubes eo asportasse videntur.* And elsewhere: *Prima æstatis parte calidissima inequalissimaque ob vehementissimum meridionalium ventorum calidorem, &c.* Prosper *Alpinus de Medicina Ægyptiorum.*

† From nine till noon, there blows a wind with such extreme heat from the sands, that it swallows up a man's breath, and stifeth him. The King of *Chernain* sent an army of sixteen hundred horse, and five thousand foot, against the Lord of *Ormus*, for not paying his tribute, which were all surpris'd and stifed with that wind. *Marcus Polus in Purchas's Pilgrims, lib. III. p. m. 71.*

always to serve our present purpose) we will add, that though air blown through a pair of bellows upon one's hand, when it is in a moderate temper, will seem very cold; yet, that the ambient air by being thus turned into wind, does indeed acquire a relative coldness, so as to seem cold to our senses, but yet without acquiring such a cold as is presumed, may appear by this, that by blowing the same air with the same bellows upon weather-glasses, though made more than ordinarily long, and by an artist eminent at making them, we could not observe, that this wind's beating upon them did sensibly refrigerate either the air, or the liquor. Though it is not impossible, but that in some cases the wind may cool even inanimate bodies, by driving away a parcel of ambient air, impregnated with exhalations less cold, than the air that composes the wind. But this is not much, if at all, more than would be effected, if, without a wind, some other body should precipitate out of the air near the weather-glass, the warmer effluvia we have been mentioning; especially if the precipitating body introduce in the room of the displaced particles, such as may in a safe sense be term'd frigorisick.

17. SEVENTHLY, nor can we admit, without a favourable construction, Mr. *Hobbes's* way of expressing himself, where he says, as we have lately seen, that all wind cools or diminishes former heat. For if we take heat in the most common sense, wherein the word is used, not only by other writers, but also by philosophers, to make wind the adequate cause of cold, it must in many cases do more than diminish former heat. For water, for instance, that is ready to freeze, is already actually cold in a high degree, and yet the wind (if Mr. *Hobbes* will needs have that to be the efficient of freezing,) must make this not hot, but already very cold liquor, more cold yet, before it can turn into ice.

18. THESE things thus established, it will not be difficult to dispatch the remaining part of Mr. *Hobbes's* theory of cold. For, to proceed to his sixth section, we shall pass by what a cosmographer would perhaps except against in his doctrine about the generation and motion of the wind upon the surface of the earth, and shall only take notice in the remaining part of that section of thus much: That the most of what Mr. *Hobbes* here shews us, is but, that there is an expansion of the air, or a wind generated by the motion and action of the sun; but why this wind thus generated must produce cold, I do not see, that he shews; nor does his affirming, that it moves towards the poles, help the matter. For besides that we have shewn, that wind, as such, is not sufficient to produce far less degrees of cold, than those, that are felt in many northern regions, there must be some other cause, than the motion of the air or steams driven away by the sun, to make bodies, not in themselves cold, (for so they were supposed not to be, when the sun began to put them in motion) become vehemently cold in their passage. For Mr. *Hobbes* cannot, as other naturalists, derive the coldness

of freezing winds from the cold steams they meet with, and carry along with them in their passage through cold regions; since then those steams rather than the wind would be the cause of that vehement coldness; and so it might justly be demanded, whence the coldness of these cold exhalations proceeds. Besides that, it is very precarious and unconsonant to observation, to imagine such a wind, as he talks of, to blow, whenever great frosts happen, since, as we noted before, very vehement glaciations may be observed, especially in northern regions, when the air is calm, and free from winds.

19. THE account he gives in his seventh section of turning water into ice, is the most unsatisfactory I have ever yet met with; for a good part of that section is so written, as if he were afraid to be understood. But whereas he supposes, that by the endeavour of the wind to raise the parts of the water, joined with the endeavour of the parts of the water towards the center of the earth, the uppermost parts of the water will be prest together, and coagulated, he says that which is very far from satisfactory. For, first, ice is often produced, where no wind can come to beat upon the uppermost parts of the water, and to raise them; and in vessels hermetically sealed, which exactly keep out air and wind, ice may be generated, as many of our experiments evince. And this alone were a sufficient answer, since the whole explication is built upon the action of the wind. But this is not all we have to object; for not to urge, that he should have proved, that the uppermost parts of the water must be raised in congelation, especially since oil, and divers other liquors, are contracted by it; not to urge this, I say, what shew of probability is there, that by the bare endeavour of the wind, and the gravity of the superficial parts of the water, there should be any such forcible compression made, as he is pleased to take for granted? And yet this itself is less improbable, than that supposing the uppermost parts of the water to be pressed together, that pressure is sufficient to coagulate, as he speaks, or rather congeal them into ice. So bold and unlikely an assertion should at least have been countenanced by some plausible reason, or an example in some measure parallel. For I remember not any one instance, wherein any degree of compression, that has been employed, much less so slight a one as this must be, considering the causes, whence it is said to proceed, can harden any liquor, into ice, or any other hard body. And in the experiment, we have elsewhere mentioned, of filling a pewter-vessel with water, and when it is exactly closed, compressing it by the knocks of a hammer, till the water be reduced to penetrate the very pewter, we found not that so violent a compression did give the water the least disposition to turn a hard body. And as for the way Mr. *Hobbes* assigns of increasing the thickness of ice, it is very difficult to conceive, how a cake of ice on the top of the water, being hard frozen to the sides of the containing vessel, and thereby severing betwixt

In the new experiments touching the spring of the air.

the included water and the external air; the wind, that cannot come to touch the water, because of the interposition of the hard and rigid ice, should yet be able, sometimes at the depth of nine or ten foot, or much further, to beat upon the subjacent water, and turn it into ice. And it is yet more difficult to conceive, how the wind must do all this, when, as was lately noted, the water doth freeze more and more downwards, to a great depth, in places where the wind cannot come to beat upon it at all. And as to what Mr. *Hobbes* fur-

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ther teaches, that the ice must contain many particles of air received into it, we have elsewhere occasion to show, how erroneously he discourses about those icy bubbles.

20. THE reason he assigns of the freezing of water with snow and salt, does as little satisfy as the rest of his theory of cold. For not to mention, that he affirms, without proving it, that snow and salt have in them a great deal of air; it is very precarious to assert, that this air must be prest out every way in wind, which must rake the sides of the vessel: for it is strange, that far more diligent observers than Mr. *Hobbes* should take no notice of any such wind, if any such wind there were. But this is yet less strange than that which follows; namely, that this wind must so rake the sides of the vessel, as to make the vessel, by the same motion and action, congeal the water within it: for what affinity is there between a wind passing along the outside of a glass, altogether impervious to it, and the turning a fluid body, included in that glass, into a hard and brittle body? The wind indeed may, perhaps, if it be strong, a little shake or agitate the particles, that compose the glass, and those may communicate some of their motion to the contiguous parts of the water: but why all this must amount to the turning of that water into ice, is more, I confess, by far than I can apprehend; especially seeing, that though you long blow upon a glass of water with a pair of bellows, where there is not an imaginary wind, as Mr. *Hobbes*'s, but a real and manifest one; yet the water will be so far from being frozen, that our formerly mentioned experiments (of blowing upon thermometers) make it probable, that it will scarce be cooled. And if sea-salt do contain so much air, by vertue of which, it, as well as the snow, produces so intense a degree of cold, how chance, that being resolved in a little water without snow, it does not produce at least a far greater degree of cold than we find it to do? Besides, in the experiment we made (and

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elsewhere mention) of freezing water sealed up in bubbles, though the bubbles were suspended in other glasses, whose sides nowhere touched them, and the remaining part of whose cavities were filled some with air, and some with unfreezing liquors; what likelihood is there, that Mr. *Hobbes*'s insensible wind should be able to occasion so many successive rakings through different bodies, as there must be, to propagate the congelative motion (if I may so call it) of the wind, through the first glass, to the included air or liquor, and through that new medium to the glass containing immediately

the water, and through that to the innermost parts of the sealed up water? And it might be further objected, if it were worth while, that Mr. *Hobbes* does not so much as offer at a reason, why spirit of wine, aqua fortis, or even brine, if it be of the strongest sort, are not either by this mixture, or (here in *England*) by the wind in open air, turned into ice, as well as many other liquors are.

21. THE reason, why cold is wont to be more remiss in rainy or cloudy weather, than in that which is more clear, is not better given by Mr. *Hobbes*, than by some others, that have written before him: for, not to mention, that I have seen great frosts, and lasting enough in cloudy, and sometimes very dark weather; that which he talks of the wind's being more strong in clear weather than in cloudy, is of no great importance; since common experience shews, that in clear weather the air may be very cold, and the frost very great, where no wind is felt to rake (as he would have it) the superficies of the earth. Nor does experience bear witness to what he not warily enough pronounces, that the less the wind is, the less is the cold. There are but two phenomena more, which in this section Mr. *Hobbes* pretends to explicate: the one is, that in deep wells the water does not freeze so much, as it does upon the superficies of the earth. But the reason of this we elsewhere take occasion to consider, and therefore in this place we need only note, that Mr. *Hobbes* has not rightly assigned it, by ascribing it to the wind's entering more or less into the earth, by reason of the laxity of its parts; since besides that it is very improbable, that the wind should not, as he says it does not, lose much of its force by entering into the earth at its pores, and other lesser cavities (for that seems to be his meaning by the laxity of the earth's parts) to so great a depth as water lies in several wells subject to freezing: besides this, I say, experience teaches us, that wells may be frozen, though their orifices be well covered, and the wind be thereby kept from approaching the included water by divers yards; and very many wells, that are subject to freeze, when northerly and easterly winds reign, will likewise be frozen in very cold winters, whether any winds blow, or not.

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22. THE other, and last phenomenon, Mr. *Hobbes* attempts to explicate, is, that ice is lighter than water. The cause whereof, says he, is manifest from what I have already shown; namely, that air is received in, and mingled with the particles of the water, whilst it is in congealing. But that this is not the true reason, may be argued from hence, that if a convenient glass-vessel be filled topfull with water, and exposed either unsealed or sealed to congelation, the ice will have store of bubbles, which, at least in the sealed vessel, cannot by Mr. *Hobbes*, who will not affirm glass to be pervious to the air, be pretended to proceed from bubbles, that got from without into the water, whilst it was in congealing. And we have sometimes had occasion to manifest, by particular experiments purposely made, how little of air there is even in those bubbles, that

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are

are generated in ice, made in vessels, where the air was not kept from being contiguous to the water.

23. AND thus have we gone through Mr. Hobbes's theory of cold. In his proposing of which, we wish'd he had in divers places been more clear; and in our cursory examination of which we have seen, that most of the particulars are either precarious or erroneous; and were they neither, yet the whole theory would, I fear, prove very insufficient. Since an attentive reader cannot but have marked, that this

learned author has past by far the greatest part even of the more obvious phænomena of cold, without attempting to explicate them, or so much as shewing in a general way, that he had considered them, and thought them explicable by his hypothesis: by which he, that will fairly explain all the phænomena recited in the notes we have been drawing together, and which yet contain but a beginning of the History of Cold, shall give me a very good opinion of his sagacity.

A P O S T S C R I P T.

THOUGH the haste I am obliged to comply with, keep me from annexing the historical papers, wherewith I had thoughts to conclude this book, concerning cold; yet since the nature of the past Examen gave me but little opportunity to teach the reader any thing more considerable, than that Mr. Hobbes's doctrine is erroneous; I am very inclinable to make him here some such little amends, as the time will permit, for that paucity of experiments. And therefore since in the last section of the foregoing History, upon occasion of an experiment very imperfectly, and not intelligibly delivered by *Berigardus*, I intimate my having elsewhere plainly set down either the same he meant, or one of that nature, and that with considerable phænomena unmentioned by him; I chuse rather to borrow some account of it from another treatise, to which it belongs, than not to gratify some of the curious to whom the phænomena I shew'd them of it, seem'd no less pretty than surprising.

THE way then I used in making this experiment, may be gathered from the following directions.

TAKE of good unslaked lime three parts (or * thereabouts) of yellow orpiment one part, of fair water 15 or 16 parts; beat the lime grossly, and powder the orpiment, (with care to avoid the noxious dust, that may fly up †) and having put these two ingredients into the water, let them remain there for two or three hours, or longer, if needs be, remembering to shake or stir the mixture from time to time. By this means you will obtain a somewhat fetid liquor, whereof by warily decanting, or by filtering it, the clear part must be sever'd from the rest.

In the mean time, take a piece of cork, and having lighted it so, that it is kindled throughout, remove it from the fire, whilst it is yet burning, and by a quick immersion quench it in fair water. And having by this means reduced it to a coal, you may (in case you have not erred in the operation) by grinding it with a convenient quantity of gum-water ‡, bring it to the colour and consistence of a good black ink, that you may use with an ordinary pen.

WHILST these things are doing, you may take what quantity you think fit of common minium **, and two or three times its weight of spirit of vinegar, (which needs not be for this purpose much stronger than phlegm, and to which even undistilled vinegar may be a succedaneum) and putting the powder and liquor into a glass-phial, or any other convenient vessel, let them infuse over hot embers, or in some considerably warm place for two or three hours more or less, till the liquor have acquired a very sweet taste.

ALL things being thus prepared, take a new, or at least a clean pen, and write with it some such thing, as you either desire or need not fear to have read, between (if you please) or, which is safer, †† over the lines, which contain your secret, and which are to be traced with the solution of minium; for this liquor, if it be either well decanted or filtered, will be so clear, that what is written with it by a new pen, will not be seen on the paper when it is dry.

LASTLY, When you would show the experiment, dip a small piece of sponge, or a linnen-rag (or, for a need, a little paper wreathed) in the water, that was made with lime and auripigmentum, and with this liquor, which,

* According to the goodness of the lime, of which, if it be very strong, two parts may serve the turn; and which, if it be too weak, may make the experiment miscarry.

† To prevent which, I usually cause the orpiment to be beaten, wrapt up in divers papers, or some other way secured from avolation, and from harming the vessel wherein it is pounded.

‡ Which for this use it will suffice to make by dissolving gum-arabick in a little fair water.

** This is known in the shops by the name of red-lead, and is here specified, as being cheap and easy to be procured, though I suppose, that other calxes or powders of the same metal, if they be not sophisticated, may serve the turn.

†† If you write first with the black ink, and then with the solution, the lines must be made somewhat distant, that those, which express your secret, may have room between the others; and therefore the better to avoid suspicion, I chose rather to write first with the invisible ink, and then over that with the black, as if I had writ on an ordinary piece of white paper, by which means I could write the black lines as close as I pleased.

which, though it smell ill, will look limpid and clear, wiping over the paper, it will presently, at once, both wipe out or obliterate what was written with the black ink, and make all that was written with the invisible ink, though perhaps in the self-same lines, appear black, so as to be very easily and plainly legible.

This is the way, to which many years ago my trials led me, of making this odd experiment. For the performing whereof, if any can propose a more easy and better way, (for I find by an inquisitive * traveller, that there are more ways than one) I shall willingly learn it. In the mean time, the reader may perceive, that I did not caustically intimate, that the learned *Berigardus*, though he would manifest a great thing in philosophy by this experiment, did yet either not understand himself that part of it he pretends to teach, or has omitted one of the main ingredients of the water of orpiment he speaks of. For I did not find, that even by a long infusion, nor by some decoction of the orpiment alone (without the quick-lime) there would be produced a liquor, either obviously fetid, or that would perform so much as a less matter, than what that, which he mentions, should. And whereas he seems to commend

this way (though but between lines written with common ink) for the writing of things one would not have to be discovered, and though I have yet met with nobody, that having seen the experiment, is not of his mind; yet I remember, that when, many years ago, I was making trials concerning the several ways of making invisible inks, my conjectures led me to discover, that I could very readily bring what was written, with a solution of minium, to be legible by the help of a fire; as well as I could also detect by the same way several invisible inks, which are believed to require appropriated liquors to make them confess their secrets. But I must reserve the reflections, and other particulars, that relate to this experiment, for the treatise, to which it belonged. Only I will now add, that besides the above-specified motives to communicate what I have at present written of it, I was the rather induced to do so, because I had mentioned, but not taught this experiment, in the History of Whiteness and Blackness; and because also *Berigardus* is not the only author of note I have met with, that having made particular mention of the experiment, has given the curious but a lame and unsatisfactory account of it.

A N

ADVERTISEMENT to the READERS

O F T H E

Following EXPERIMENTS, by the Author of the foregoing History.

AT the same time that the Royal Society required of me an account of what I had observed, or tried, concerning Cold †, they recommended the making of trials about that subject to the learned Dr. *C. Merret*, who having dispatched what he intended, much earlier than I could bring in my far more voluminous papers, he long ago presented his to that Illustrious Company: and since that, has thought fit to let them indear my treatise, by their being annexed to it, and composing a part of it; and that such a part, as much might be said of it, if after I have informed the reader of its having obtained the thanks of a society, that is too much accustomed to receive and produce excellent things, to be suspected of valuing trifles, I could think it needful and proper to give those papers any other elogium. And it falling out fortunately enough, that the doctor and I (being at some miles distance) did not communicate our designs to one another; as I knew nothing what he had been doing, till I heard it publicly read at *Gresham-College*, when far the greatest part of my experiments were (as

is known to more persons than one) already recorded; so I afterwards scrupulously abstained from borrowing the trials mentioned in his papers, to enrich mine. Which forbearance was the more easy to me, because after the first time I heard those papers read, I never desired a copy, nor had a sight of them. By this means it happened, that besides those many titles, which being handled at large in the history, are left untouched in the following tract, even on those occasions, where the learned doctor and I happen to treat of the same subjects, our trials are but very few of them coincident; upon which score the reader will meet with more variety betwixt us, than probably he would have expected to find on such an occasion.

HAVING drawn up this advertisement about the doctor's papers, as supposing them the very same he presented to the Royal Society; upon a sight of the following sheets, (as they were some hours since brought me from the press) the additions I there find, make it appear necessary to say something further to the reader. I must inform him then, that about the middle of this winter,

* That learned gentleman *Mr. H. Oldenburg*, secretary to the Royal Society.

† This is pointed at in the 2d page of the following account, where mention is made of an honourable person, &c.

winter, and about the end of *December* 1664, I presented to the Royal Society several books, containing each of them eighteen or nineteen of the twenty-one titles, whereof my history consists; that the Virtuosi might have the opportunity of the cold (which then began to be so strong, as to keep the press from dispatching the rest of the book *) to examine my experiments, and add to them: and one of these being delivered to the doctor, as the likeliest person to make use of it, together with an order to the stationer, to let him have the remaining sheets of the book, as fast as they should from time to time be printed; he had the curiosity, as to enlarge some of the things he had already tried, and brought in himself, (as is intimated in page 389) so to make trial of some particulars, that I had proposed and performed, which either their importance, (as the way of freezing from the bottom upwards, by me suggested, and the weight of bodies frozen and unfrozen) or his opportunity invited him to make choice of; and has been pleased to afford them place among his own experiments †; by which means, though the coincidence of what we deliver will appear to happen more frequently, than the advertisement will make one expect; yet to such readers, as do not prefer variety before certainty, the coincident passages will not, in

likelihood, be unacceptable. For, in those cases, where the events of our trials are the same, it is like the truth will be the more confirmed ‖; and in cases where the successes are very differing, the reader will be excited to make farther trials himself, and will be thereby enabled to judge, which trials have been the most carefully made, and the most warily delivered. And, though I think it but a necessary profession for me, to say on this occasion, that I am pretty confident of my having performed my duty, as to the historical part; yet this need not hinder, but that most of the differing successes, we are speaking of, may prove but instances of the truth of what I long since admonished the Reader (in my preface) that there are among the experiments of cold, divers, that are liable to contingencies; so that, as I would not have the papers of this learned man comprehended in what I said of the jejune-ness of the writers I had met with, who treat of cold, in a preface written, when I was not sure the following papers would not be made publick; so I hope the reception of these papers of this ingenious person will be such, as may invite him to hasten the publication of those fruits of his learning and industry on another subject, which divers of the Virtuosi do not more expect, than desire, to have communicated to them.

The Art of Pottery.

A N

ACCOUNT of FREEZING,

Made in *December* and *January*, 1662.

SINCE the business of freezing is obnoxious to many various contingencies, I must necessarily premise these following circumstances. That these experiments were made in very hard weather, yet with some alternate relaxations, the frost continuing above six weeks. And the place I chose was in stone windows, exposed to the North, and North-east winds, and some upon the ground. The vessels were glass-canes of several bores; earthen and pewter, small pans and porringers; spoons of pewter and silver; glasses of various figures, as phials, cylindrical, round and square; flasks, recipients, bolt-heads, and some conical ones. Most whereof, by the diversity of their figure, their openness or closeness, produce various effects in freezing, as the following observations will shew. The quantity also of the liquor exposed is to be considered; for what will shew a small thin plate of ice in a small parcel of some liquors, will shew none in a greater.

THE method I shall follow in delivering my observations shall be, first, to run over the va-

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rious liquors or bodies, whether fluid or consistent, simple or compound, &c. used in this work. Secondly, what figures observable in those ices. Thirdly, some effects arising thence. Fourthly, some properties and qualities. Fifthly, some lets or helps both to freezing and thawing. Sixthly, some uses of ice.

IN pursuance of which particulars, I had recourse to those ingenious queries of Mr. *Henshaw*, registered in your *Cimelia*, and then to *Bartholinus*, in his late book *de Nive*, and to my own collected notes from various authors, adding whatsoever trials I thought meet. And in all these I have barely set down matter of fact, neither mentioning the authors, nor their errors, which would have been both nauseous and tedious; nor shall I endeavour to render a reason of the various *Φαινόμενα*, (which cannot be done without a volume) but shall leave that province to an honourable person of this society, who hath had much experience and reflections on this subject. And now to my task.

5 E

As

* See the publisher's advertisement to the reader.

† Among which I am since informed, that he had tried divers, before he saw my papers.

‖ So one of the chief passages of the *Examen* of Antiperistasis is much confirmed by page 389, following; which contains an account of a trial made by the command of the Royal Society, to whom it was proposed by the Author of the *Examen*, with a request, that they would please to order it to be made.

As to my first head of things used, I shall begin with common water, which I exposed in a triple state, in like quantities, and in open pans, *viz.* first, cold; secondly, boiling hot; thirdly, an equal mixture of both the former. The effect was this; the cold was frozen in one hour, the boiling hot in two hours, and the mixt in an hour and a half; but with this difference, that the cold did freeze first at the top, and sides, and had a large thick crust before there was any shew of ice in the boiling hot; but the mixt and boiling hot began to freeze first at the bottom of the vessels, and when the top was cold, then it froze there also, leaving betwixt the bottom and top of the vessel a cavity for the water, which in time was wholly converted to ice. The same succeeded most manifestly on these waters poured on a smooth table, where the cold water was presently frozen, before the boiling hot water could become cold at the bottom.

WATER exhausted of air in Mr. Boyle's engine was frozen almost as soon as a like quantity exposed in an open pan; the ice whereof appeared white, and to consist purely of bubbles. The glass used was a four-ounce round phial, and a small tube one foot long half filled with water.

FAIR water, wherein arsenick had been infused eight months, congealed much sooner than a like quantity of water, into a very white ice.

SOLUTIONS of all the sorts of vitriols froze sooner in pans and tubes, than water, or any solution of the other salts by much, though that of allum came very little short of it. The ice kept both colour and taste upon the least touch of the tongue, in all of them.

A SOLUTION of allum did freeze into an ice whiter than milk, and stuck so close to the sides of the pan, that it could hardly be separated from it: this was the firmest ice offered to me in all my trials; next to which, in both these qualities, were the vitriols, especially the Roman.

SANDEVER quickly freezeeth, fritz sooner than it, and kelp than them both; all of them into lumps very white, and consequently not diaphanous.

SAL ARMONIAC shewed some variety in point of time; for in the same pan, quantity, and place with the other salted waters, it would, for the most part, freeze long after the former, though once it did freeze before them.

COMMON salt two drachms dissolved in four ounces of common water (for that proportion I observed in all my solutions) did, in 30 hours space, in the hardest season, turn to pretty hard and white ice; whereas the former solutions became so in two or three hours at the most.

A BEER-GLASS was filled with stinking sea-water full of salt, which within 26 hours acquired at the top a plate of ice of the thickness of half a crown-piece, with few bubbles in it. This tasted salt and stinking as before, but being dissolved at the fire, or thawed of itself, the stinking taste was gone, but the salt-

ish continued. The residue in the glass within four days (the season continuing) and plates taken off (once in twenty-four hours) was frozen throughout, but that at the bottom of the glass seemed to have a much brisker taste than that at the top, neither was it so firm and friable as that. I tried another beer-glass with the same water, which froze most part of it, but the season continued not so constantly sharp so long together, as in the former experiment, and therefore I could conclude nothing therefrom. But in small broad earthen pans set in ice, in 36 hours the same water became ice throughout, and with the addition of a parcel of ice or snow much sooner.

SOME water is impregnated with as much bay-salt, some with as much salt-petre, some with as much sal armoniac as the water was capable to receive, and neither of these did congeal with the highest degree of cold, continued six days together.

A SOLUTION of salt of tartar soon converted into ice, but in much longer time than common water. I observed, that it began to freeze in a tube at the top, bottom, and sides first, leaving the liquor in the middle unfrozen; whereas other solutions and liquors congealed uniformly, by descending, or ascending, or both at the same time, from side to side through the middle. Of this I made but one trial.

SALT-PETRE required 28 hours in a very cold season, and in that time became in the open pan a most pure white ice perfectly like sal prunellæ, which an apothecary mistook it for. This ice thrown into the fire (after the aqueous humidity was evaporated) did sparkle as that salt useth to do. A strong lixivium made hereof with an addition of copperas or allum singly, or mixt, set in snow and salt, or snow alone, was frozen in one night.

SAL GEM alone of all the salts, though snow and ice were mixed with it in great proportion, and though the pan was set in salt and snow, could not all that time be brought to congelation; an odd experiment. Phlegm of vitriol did freeze sooner than the solutions before-mentioned.

OIL of vitriol begins congelation (or coagulation rather) near as soon as fair water. A pretty large tube was filled $\frac{3}{4}$ full with this oil, and about $\frac{1}{4}$ thereof was frozen, the rest remaining at the bottom uncongealed. This tube was broken in the presence, and by the command of this honourable society, the coagulated part whereof was tasted by many then present, and concluded by all those, that it was a strong vitriolate taste. This coagulated part was of a paler colour than the other, and both these mixed and poured into a phial-glass heated it so hot, that none there could hold it. This coagulated part kept so in the air a week after all my other liquors had been thawed, and would, in probability, have continued so much longer, had not the glass been broken. I exposed another lesser tube with the same oil, which became frozen throughout, and required very much relaxation in the air to return its former fluidity.

I HAD set a mark on these tubes (as on all the rest, to observe their several risings) and the oil of vitriol, when coagulated, sunk more than half an inch below it, and being dissolved at the fire, returned to its first station, as you also saw. And this *Φζινόμενον* is peculiar to this oil alone, all other liquors rising higher than the mark.

I NOW come to my stronger liquors of beer, ale, and wines.

I EXPOSED at the same time a flask of small beer, and another of strong ale; the former whereof was frozen throughout in 38 hours, but three pints of the ale continued unfrozen after six days continuance of very hard weather. And the air then disposed to thawing, I broke the flask, and with the unfrozen liquor made an excellent morning's draught at four in the morning. This ale in colour, strength and quickness seemed to me and the other three tasters that sat up with me, much better than when it was first put into the flask, and by comparing it with some other in the house of the same barrel, we plainly found the said difference. After this I took the icy part of the ale, and thawed it at a fire, which was in all a pint of liquor (though the flaggon contained three pints of liquor, was filled with the ice) was very pale, and of a quick and alish taste, very much resembling that drink, which the brewers call *Blue John*. This ice was not so firm as that of water, but fuller of bubbles.

I ASSAYED the same a second time, but could not, by reason of the changeableness of the weather, attain so great a thickness of ice as in the former. And in this also I found the same changes as before.

A BEER-GLASS of *Hull-ale* in twenty-four hours contracted a crust of ice as thick as an half-crown, and proceeding, as in sea-salt water, the *Φζινόμενα* were the same, all the laminæ taken off appeared of the same colour and taste, and the lowest ice was the most tender. Another glass of the same ale exposed did not freeze throughout (no crust being taken off) in five days, when my own ale did in a like glass, both being set out together. Now the taste and colour appeared the same, or at least had no sensible difference, when they had been thawed of themselves, and when first exposed. *Hull-ale* hath a brackish taste.

CLARET very strong exposed in a spoon, in 35 hours hard freezing became an ice all of it; it was soft, kept its former colour and taste, soon discovering to the tongue of one who knew not whence it was, its nature, quality, and kind.

CANARY at the same time in a spoon exposed, in 38 hours acquired on its surface an exceeding thin plate of ice, as thin as the finest paper, and proceeded no farther in four days following.

NEITHER claret nor canary would shew the least sign of congelation in tubes, much less in bottles.

Two ounces of the best spirit of wine exposed in an earthen pan did all evaporate in less than twelve hours, but the same quantity of brandy left near a spoonful of insipid ice with-

out any taste of the spirit, which cast into the fire flamed not at all. I could discern no bubbles in this phlegmatick ice, but having interposed it betwixt mine eye and a candle, it manifested many bubbles by its shadows. Query, whether this may not turn to profit in colder countries in rectifying spirits of wine?

WE now come to consistent bodies, and shall begin with animals, and their parts.

Two eyes, the one of an ox, the other of a sheep, in one night were both totally frozen; the three humours were very hard, not separable one from another, neither of them diaphanous, as naturally they are; and the crystalline was as white as that of a whiting boiled. The tunicles, fat, and muscles were also frozen, as appeared by their stiffness, and by putting them into cold water. The ice of the waterish and glassy humours seemed to be made of flakes.

A PINT of sheep's blood did freeze at the top, and all the sides of the dish, wherein it was put, and was nothing else but the serum of the blood. This ice being separated from the blood, and thawed at the fire, and then again exposed, congealed into a seeming membranous substance, and was taken for such by some that saw it, and so continued in a warm season, and appeared in all respects a membrane. This also was seen and registered in the journal. The blood remaining gave me no signs, that frost had taken it.

I DISSECTED a dog and a cat, having lain dead in the open air, and found their entrails, nay, the very heart stiff, and some little ice in the ventricles of their hearts, and their *vena cava*.

MILK soon freezeeth into moist white flakes of ice, retaining the proper taste of milk; these flakes are soft, and manifest not many bubbles.

SEVERAL eggs were exposed, and both yolk and white in one night were hard frozen. They require a longer time to freeze than apples do. The best way to thaw them both, is to lay them on *Newcastle-coal*, or in a deep cellar. Whether eggs once frozen will produce chickens or no, I cannot say, but have been told by good house-wives they will. Some affirm, that eggs and apples put into water, the ice will be thawed within them, and the ice appear on the shell and skin. It is true, if you hold either of them near the surface of the water, they will soon gather a very thick crust upon their outsides; but if you then break the one, or cut the other, you shall see them full of ice, and the eggs then poached will taste very tough. So that this ice seems to be gathered from without, and not come from within. And besides if it did so, they must needs lose their weight, the contrary whereof will anon appear. But for the more surety, I proceeded to this farther experiment. I immersed in my cistern an egg, and an apple, two foot deep into water, and there suspended them with strings tied about them, to keep them from sinking for the space of twenty-four hours, and then took them out, and opened them. I could never observe in that time, though I often looked at them, any ice on their outsides, and

and the one being broken, and the other cut, were found both of them full within of ice.

THE next order shall be vegetables, and of them a few instances, especially those which are of a biting or sour taste. Now for the first, I employed the roots of horse-radish and onions, (for other edible roots and plants every one knows will freeze) which shewed the frost had taken them by their taste, and ice was found betwixt each of the skins of the onions, retaining the taste of the root; yet I have observed beer, wherein horse-radish and garden-scurvigrafs have been infused, will not freeze so soon as other stronger beer without them.

ORANGES and lemons frozen have a tough and hard rind, their icy juices lose much of their genuine taste; they were both frozen hard in 26 hours, or a little more, having a thick rind. They, as other fruits, when thawed, soon become rotten, and therefore the fruiterers keep them under-ground in low cellars, and cover them with straw, as they do their apples.

WHICH did, exposed in one night, freeze throughout. If you cut one of them through the middle, it will have on both the plains a most pure thin ice, hardly discernible by the eye, but easily by the touch, or by scraping it off with a knife. The cores of these apples soon turn brown, and begin their corruption there.

OIL exposed did acquire the consistency of butter melted, and cooled again; but in caves and cellars I could never see it more than candy.

STRONG white-wine vinegar did all soon freeze in a tube, and without any apparent bubbles.

AND to conclude, without mentioning nuts, bread, butter, cheese, soap, and many other things, which came under my trial, it is most certain, that whatsoever hath any waterish humidity in it, is capable of congelation: what are not, you have in the next paragraph.

HAVING now done with what will freeze, I shall briefly recount some things, whereon the cold hath no such effect.

WE mentioned before spirit of wine: add to it such strong waters as are made of it, viz. aqua Mariæ, cœlestis, &c. and canary wines in larger vessels. Secondly, the strong lees of soap-boilers, and others made of other salts, to which refer the spirits extracted from salt; vitriol, salt-petre, aqua fortis, and spirit of sulphur, which last precipitated to the bottom of the tube a small quantity of powder, very like in colour to *sulphur vivum*, which being separated from the spirit (for nothing of that evaporated) cracked between my teeth, and tasted like brimstone, and being put into water, made it as white as lac sulphuris doth, but it would not flame, perhaps because too much of its strong acid spirit was mixed with it. Spirit of foot afforded also a precipitation or sediment (the spirit not congealing) at the bottom of the tube of a yellowish colour, but much bitterer than the spirit itself, and inflammable also.

BUT here it is to be observed, that the said spirits, that would not freeze alone, yet with

the mixture of about 12 parts of water, or less of ice, or snow, did freeze throughout; except the spirits of salt, of nitre, and aqua fortis, which would not freeze with those quantities of water, ice, and snow. I intended to have tried them with a greater quantity of the said ingredients, but the weather failed me.

WHETHER the salt-water freeze in the sea, I cannot experimentally determine; but I shall add what was told me by one, that said he had dissolved ice in the northern seas, and found it very salt.

THE next proposed was the figure of liquors frozen; wherein I shall observe in general, that most of the liquors differed from one another in their figures, and being permitted to freeze, and thaw often, they still returned to the same figure, most whereof were branched. Allum appeared in lumps; salt-petre, tartar, milk, ale, wine, and sal armoniac in plates; and other liquors mentioned to freeze into a very soft ice, seeming to be made up of small globuli adhering each to other. Fair water, kelp, and the frits resembled an oaken leaf, the leafy parts being taken away, and the fibres only remaining, the interstitia being filled up with smoother ice. The middle rib (if I may so say) as in plants was much bigger than the lateral ones, all which seemed but different stiria, whose points extended towards the outside of the vessel containing the water, and made acute angles with the middle rib towards the lesser end of the said leaf.

CONCERNING the figures of frozen urine I shall say nothing, the accurate description of curious Mr. *Hook* having so fully and truly performed that part of my task.

NOW as to the famous experiment of *Quercetian*, and affirmed by many other chymists, I made experiments in these following vegetables; rosemary, rue, scurvigrafs, mints, and plantane, wherein I thus proceeded: I mixed with $\frac{1}{2}$ a pint of their distilled waters $\frac{1}{2}$ or $\frac{3}{4}$ of an ounce of their own salts; the rosemary and rue were calcined, and their salts extracted with their own waters, and then were added to their salts their own distilled waters in the above mentioned proportions. The glasses, wherein the rue and plantane were put, being sealed with *Hermes's* seal, and the other glasses left open, the effect was, that neither of them shewed the least resemblance of the plants, from which they were extracted, neither figure, nor shew of roots, stalks, branches, nor leaves, (but only a lump or heap of small globuli) much less of flower or seed. Besides the kelp frozen hath many fibres, which is made the most of it of *alga marina*, whose leaf is long and smooth without fibres in it. This one thing I cannot pretermitt, that the scented waters seemed upon their thawing to have acquired, and advanced much in their scents, and especially the rosemary, whose salt hath no smell, and its water but little; yet thawed, they smelt as strong almost as fresh leaves rubbed and smelt to.

A LARGE recipient was filled with water, which being frozen throughout, and the upper crust of the ice broken, there appeared in the middle of it a multitude of thin *laminae* of ice, some

some more, some less wide, from which proceeded *striae*, or teeth pointing inwards, and set at pretty equal distances, so that the *laminae* and *striae* resembled very much so many combs placed in no order, some lying directly, others obliquely, none transversely, having intervals betwixt each of them; betwixt some of them I could put my finger without breaking the points of the *striae*: these combs were placed round about a cavity in the middle of the receiver, sufficient to receive two of my fingers.

In a flask filled competently with water, when it was frozen, there appeared throughout the ice infinite silver-coloured bubbles, very like unto tailed hail-shot of several sizes, the largest about $\frac{1}{4}$ of an inch long; where thickest, of the bigness of a great pin's-head, others much less in all dimensions. The points of them all looked outwards, and the bigger part inwards towards the centre, where also were the largest. For there they would easily admit a little pin into all their cavity, without the least resistance. The figures of them were pretty regular; first, a small thread, and then a head as big as a shot, and thence gradually ended in a point. Some of these were straight, most a little crooked. There was a cavity in the centre of this ice filled with unfrozen water, from which I could find multitudes of cavities of bubbles, not fully formed. And in the more solid parts of the ice cut, you may discern them by a black spot, where the hole enters into the cavity. All the same phænomena appeared in a second trial, but that the bubbles were shorter and larger, and not so sharp pointed. The like I also observed in a conical glass sealed up.

THE next thing to be treated of, is the effects of freezing, *viz.* the expansion of liquors frozen, and consequently thereunto the breaking of bodies, wherein they are inclosed. All the liquors tried did sensibly in glass tubes rise beyond my mark, before the liquors could sensibly be discerned to freeze, and after rose somewhat higher with freezing. The height of the rising I shall here set of a few experiments, instead of many made (having troubled your patience too long in the former paragraphs) in several processes. Vinegar and urine rose about half an inch, and lees made with salts of rosemary, kelp, the frits, about $\frac{1}{4}$ of an inch. Solutions of alum and copperas somewhat less, and in general the saline liquors less than water, which rose a full inch, and small beer in a very narrow tube four inches; but water in the small capillary tubes could not be perceived, either to expand it self, and certainly not to freeze at all. Oil of vitriol alone (as hath been said) sinks below the mark. Hot water put into a tube first sinketh till it is cold, and then riseth before it freeze.

OPEN-mouthed glasses, such as beer-glasses, &c. filled with water up to the brim, when frozen, the ice will manifestly rise above the superficies, and make a solid triangle there. But narrow-necked glasses more plainly shew this rising. In a flask filled with water four inches below the mouth, the ice rose above the mouth, and hung two inches without it. And

once in a bolt-head the ice rose five inches above the water-mark. And here I shall briefly add two things; first, that if glasses be filled about $\frac{2}{3}$ full, they seldom break; but if more, they will for the most part break. Secondly, that round-figured or spherical glasses for the most part break in an uniform manner. I filled a bolt-head full to the neck, and stopped it at the top, which was twelve inches distant from the body, with a piece of melted candle. The ice rose above three inches in the neck, and the glass broke in the thinnest part of the body; from the point of breaking, as from a pole, the cracks run as so many meridians, but unequally distant each from other, and consequently concurred not in an opposite pole on the other side; besides there was great difference in the length of those cracks, none whereof went round the glass. In a flask thus crack'd in many places, the cracks were very irregular in all the places; for some of them ran from their centers upwards, others downwards, some somewhat parallel, but most obliquely, and few of them were considerably straight. Glass-bottles, and especially stone-jugs, keep very little, and the last no method in their breaking: the same also befalls square glasses: woods follow their grain, and metals no order at all.

AND now I come to some remarks proceeding (as I said) from this expansion, *viz.* the breaking of the vessels, or force of freezing, wherein also you may take notice of that quality of cold, mentioned by the poet, *penetrabile frigus*, piercing where light comes not.

Two oval boxes, the one of box, the other of maple (both firm woods) containing each above two ounces of water, were filled full, and with screws closed very fast: both these boxes were rended from the bottom to the top in one night, with gaps big enough to receive a barley-corn into them: these woods stretch but little, and therefore break more surely, and with larger rents than softer woods will do.

SECONDLY, a pepper-box of latten made of iron, covered with tin, had the neck broken off, and holes made in the top near the neck; and the bottom, where it was soldered, was so diserver'd, that water would easily run out there.

LEADEN pipes laid above ground were broken in many places. One I saw twenty yards long broken in seven places, and another in my cellar six yards long, broken in two places. I saw likewise in many places of this city leaden pipes, above a foot deep under ground, broken in several parts.

Cocks of cisterns, and other brass cocks, and also the barrels in pumps made of brass or lead, usually break with the frost.

I EXPOSED a copper box of a pear fashion, which did bear three several freezings, by reason of the great extensibility of that metal; but at the fourth essay it cracked all along one side of it, almost to the screw.

NEXT I tried a cylindrical silver ink-horn; but that did bear five trials, and therein I could perceive neither crack, nor dilatation of its superficies. I intended to have tried it in a small bottle, but the weather failed me. I exposed

also a round silver ball of the bigness of a large nut; the silver became very sensibly extended to a larger superficies, but did not suffer any solution of its continuity.

TOBACCO-PIPES, and all earthen-ware, taking any frost in their drying, (before they are burnt,) become very brittle, and being put into a strong fire, will certainly break into many pieces. Tiles of houses, and hard stones in buildings, scale and break off upon thawing; and thence it is, that the northern sides of stone-buildings first decay, and moulder away, as it is most manifest in antient magnificent structures.

ALABASTER and marble having any chinks in them frequently break with frost; and the statuaries tell me, they never saw any solid marble break: as for flints, paving-stones, precious stones, and such as will receive a polish, the bitumens, as amber, kennel-coal, &c. I could never see any effect on them.

THE next effect shall be that of adhesion, concerning which take the following experiments.

A SMOOTH piece of ice was laid on a smooth table, and common salt thrown upon it; the effect was, that the ice stuck so firmly to it, that it could not be sever'd from the table, without breaking the ice into many small pieces: and it will continue in this close cohesion, till the salt hath corroded through the ice to the very table, (making many holes in the ice) and hath melted it to the very bottom. But if you lay salt first upon it, then the ice sticketh not, but thaweth. These following salts applied (as before common salt was) cause adhesion to the table, but not so firm as it, viz. kelp, sandever, sal Indus, gem. prunellæ, and armoniac, and pot-ashes, but not alum, or vitriol.

THE next experiment of adhesion was this; I held a nail betwixt my lips in the open air a very little space, which stuck so firmly to them, that I could not pull it thence without difficulty and pain.

ANOTHER effect is concentration of spirits and colours. Concerning the former, you have already as much as I know, especially in the paragraph of freezing beer and ale. Concerning the latter, take these following trials. Cochineal was boiled in water to a very high tincture, and frozen; and to twice four ounces of this decoction was added in one glass a little spoonful of spirit of wine, and in another as much sea salt-water: all these were frozen throughout, and every part of this ice seemed to me of an equal colour, though the edges, as thinner and nearer the light, appeared of a brighter colour (as they do unfrozen) but the glasses being broken, shewed no discernable difference in any of them, neither as to colour nor taste. The like trials were made with mad-des weed and indico, and the success was the same.

SECONDLY, I exposed a pint pottinger full of the decoction of foot, which (the air relaxing) did only freeze an inch thick: this continued above a week consistent (in a thawing season) and very solid. Some, that saw it, judged

it to be brown sugar-candy, the taste whereof was near, if not altogether as strong as the uncongealed liquor remaining at the bottom. And in another trial, when the whole was frozen, no concentration was seen. But though it was not my hap to find this effect, my trials having been made in phials, square, cylindrical or round, yet Mr. Hook, a worthy fellow of this society, happily lighted on it, as you may perceive by his relation, and schemes of his glasses hereunto annexed.

SOME affirm, as an effect of freezing, an addition of weight made in the bodies frozen; but this affirmation answers not my trials. For in four eggs, and four apples fully frozen, I found the weight of them the same, when frozen, and thawed, as they had before they were exposed; each of the eggs and apples being weighed in this triple state both severally and jointly: with the particular weights I shall not trouble you. Besides, that freezing adds no weight, it is apparent in sealed glasses, from whence nothing can expire, and by exact ponderation of them, I could not perceive any the least difference in weight in the said triple state. This I tried several times with as much exactness as possibly I could, and still found the same event.

ANOTHER property of freezing is to render many bodies more friable and brittle; as most woods, as also iron and steel, as every one knoweth, that hath used crossbows in frosty seasons, and so likewise the bones of animals; and it is commonly observed by surgeons, that more men break their legs and arms in such seasons, than at any other time of the year, especially such, who have been tainted with the *Lues Venerea*, as *Hildanus* somewhere notes.

I SHALL now conclude the effects of freezing, by ranging them into good and bad. The good, are the long preserving bodies most subject to putrefaction; healthiness, and confirming the tone of all animals; and thickening the hairs and furs of such as have them, fatten some. Besides, it exceedingly clears the air, and other bodies, as it is manifest by the stinking sea salt-water before-mentioned, as also by this that follows: namely, I took six of the most musty stone-bottles I could procure, and competently filled them with water, which, after freezing and thawing again, became as sweet as ever they were before.

BAD effects, are the killing and destroying animals and vegetables by congealing and stopping their vital and nourishing juices, rendering them totally immoveable. It is observable, that in *Greenland*, and *Nova Zembla*, nothing but grass grows; as also what was told me by Dr. *Collins*, the present physician of the emperor of *Russia*, that no thorny plant or thistles grow in that country. And this present year most of the rosemary and sage about *London* was wholly destroyed, besides most of the more tender plants.

My fourth proposal was the properties and qualities of ice, some whereof my task ingageth me to enumerate only; such as are its slipperiness, smoothness, hardness, whereby, and by its bulk and motion, it breaks down bridges, &c.

its firmness and strength to bear carriages, and burdens; its diaphaneity, which is much less than the liquor, of which it is made. For I could never discern any object, though but confusedly, a foot beyond the clearest piece of ice, by reason of the many bubbles and luminous parts within it. Which bubbles shew only shadows, but the ice itself interposed betwixt your eye and a candle appears in many round circles, from which proceeded many rays of light, four or five, or more, in the form of a star of about $\frac{1}{4}$ of an inch in diameter, which so glaze your eyes, you can scarcely see any thing but bright light and shadow.

As for its penetration and thickness something hath been said above; to which I shall add, that I have seen the *Thames* ice of the thickness of eight inches, or more, near the middle of the river, and on the sides much more. And in garden-walks the earth frozen near two foot deep; whereas on the other sides of the same walks, on a richer mould, the frost did not reach much above one foot and $\frac{1}{2}$, and pipes of lead have been broken above a foot under the surface of the ground. I shall not mention the huge mountains of ice found in the most northerly seas, but proceed to its weight.

It is generally known, that ice swims upon the water. But I have seen snow-balls, moistened only with water, and then compressed with a strong force, and afterwards frozen, to sink: besides, the congealed oil of vitriol descends in water, and common ice is frequently observed under water; whether the solutions of salts frozen will sink, was by me forgotten to observe, and whether coagulated oil will sink in unfrozen, as *Bartholine* affirms. Some affirm, that snow-balls hard pressed, without addition of water, will sink; but experience teacheth me the contrary.

As for its tactile qualities, every one knows it is colder than water, which you may increase by adding salt unto it, or rather snow.

SMELL it hath none, but it binds up that quality in all, but most spirituous bodies, which it also in some degrees refracts in them.

LASTLY, ice yields both reflection and refraction, whereof I shall speak, when I come to its uses.

MY fifth head was lets and helps in freezing, which I shall briefly dispatch. Those besides the North and North-east winds, the absence of the sun, and the highest parts of houses or mountains, are the mixture of snow and salt (than which there is nothing more painfully and insufferably cold to my feeling) as is apparent by the trick of freezing with snow and salt by the fire-side, as also by the ingenious way of making cups of ice, invented by an incomparable person.

ADD hereunto, that water falling or thrown upon ice or snow soon becomes congealed. A mixture also of ice beaten into powder, and mixed with common sea-salt (which is best) or with kelp, allum, vitriol, or nitre. And here note, that vessels filled with water, and set upon these mixtures, begin their freezing at the bottom of the liquor, and consequently are not so subject to be broken, as those are, which

are not set in these mixtures, and that the water riseth higher with, than without them. I find also, that oil of vitriol alone, mixed with snow or ice, have the same effect, though not so powerful.

ONE affirms, that salt-petre dissolved in water, and put into a bolt-head, and long agitated, not only cools the hand exceedingly (which is very true) but also converts it to ice, yea, in the very summer month, which answereth not my trial, though kept a whole hour in that agitation in the hardest season.

THIS following experiment also I add, proposed to me.

I FILLED a bolt-head, containing a quart of water, and set in an iron pan, surrounding it on every side with snow, which covered also part of the neck; and then set the kettle over the fire, and took now and then the bolt-head from the fire, whilst the snow was thawing, but not the least sign of freezing appeared in the water put into the bolt-head.

As for the helps of thawing, take this experiment. I set in the same cellar three pans full of ice, one on *Newcastle* coal, a second on sand, a third on the earthen floor; they thawed in the same order they are mentioned, which was thrice repeated, and once that placed on the coal did thaw, when the other continued their ice. Sealed glasses seem neither to promote or hinder this act of freezing. The same success I had with eggs and apples in my cellar.

THE last thing I shall speak to, is the use of ice. You may therewith make a siphon, being fashioned and applied, as usually siphons are; and this will happen, whether you make it one continued piece of ice, or two contiguous ones; for in both the water will run exceeding fast, and this siphon soon empties all the water out.

A second use is for refraction, whereof Mr. *Hook* hath given you already a learned demonstration. And I having formed some ice into various figures, like most of those mentioned by the dioptrick writers, the *Φαινόμενα* were the very same as in the like figured glasses; but how *Descartes* made dioptrick glasses of it, I know not, especially to make use of them. And lastly, you may make a speculum of it, especially if a piece of blacked paper be placed behind it, and if you hold a candle at a convenient distance, there will appear very many speculums to your eye, according to the number of the bubbles contained in the ice. But I could not observe any heat proceed from ice, though cut in the true figure for burning-glasses, and exposed in naked ice; but frozen in spherical glasses it will heat a little.

I SHALL here subjoin some propositions of the learned *Bartholinus*, taken from his book *De Nive*, being near to the former argument, who affirms,

1. THAT the more subtile distilled spirits gain a clear splendor and elegance from snow placed about them.

2. THAT the rays from snow newly fallen glitter, and excel in a kind of splendor, where-
with

with the eyes are dazed. ' Both these are true, and have but one common cause, *viz.* ' the multitude of reflections caused by the infinite globuli, whereof every flake of snow consists.

3. THAT he saw cabbage growing in his garden, putrify on that part, which was above the snow. ' It is certain, that frost alone, with or without snow, hath this effect on cabbage, being of the tribe of succulent plants; and I observed, that this year 1644, our great house-leek, or American aloes (usually hung up in houses) kept in an upper room, was totally destroyed by the cold. And that apples will rot, I have said before, and housewives, to prevent the rotting of onions, commonly hang them up in their kitchens, or keep them in their ovens, or some close place. And this present year 1662, I saw at Mr. Box's the eminent druggist's house, abundance of squills or sea-onions quite rotten: they were laid in an open, but close garret.

4. WHEN snow melts by the sun's heat, copious vapours from the earth clouded the sun. He should rather have said, vapours from the melted snow; and 'tis no wonder, that vapours cloud the sun.

5. SNOW melts and falls off from ivy. ' I have observed all the sorts of ivies, and evergreens with us, and some biting plants too, but find in them all the contrary to what is here asserted. Nay, no difference hath been observed even in hoar-frosts, which fall equally, and continue on all sorts of plants.

6. HE excludes not a small portion of earth from snow, though pure, which, saith he, is manifest from distillation. ' This experiment I have found true by evaporation, which is tantamount to distillation; and indeed all melted snow leaves an earthy and foul settling behind it.

7. VISCOSITY with softness is greater in new than in old snow, and therefore it is brought into a mass. ' Viscosity in it I understand not; its softness indeed is manifest too, by the tracks of beasts, which appear more fair, the snow not rising on the sides of the impression made by their feet (as it doth in old) but retains their perfect character.

8. WATER-CRESSES and scurvigrass grow under the snow in gardens. ' I apprehend not, that any plant whatsoever grows at all in hard seasons; my meaning is, that no plant acquires any greater bulk of quantity, but keeps at a stand only; and this countrymen affirm of grass and corn, and gardeners of other plants. It is true many plants will upon thawing shew a finer verdure, and if warm weather presently follow, all vegetables will thrive exceedingly. For how they should thus grow, when their nourishing liquor is congealed, and consequently become immoveable, I understand not.

9. AIR is included in snow; ' which this way of mine to make snow fully convinceth. I took the whites of eggs, and beat them in the open air with a spoon, into a frothy

consistence, as women do to make their snow-poffets, and then taking a little of this substance, and laying it on a trenchard, it soon became plain flakes of snow, so that none, that saw them, could judge otherwise. Another accidental experiment proves the same; for having put water into a tube, and having long and strongly agitated it, there arose many bubbles at the top, which soon freezing (my agitation ceasing) became perfect snow. And now having here set down the way of counterfeiting, at least, if not of making snow, I will add, how a pruina or hoar-frost also may be imitated. I took a pail filled with warm water, and hung over it hair, moss, and a piece of rosemary: now the atomical vapours rising from the water, fixing themselves on the moss, hair, and rosemary, became on them a perfect hoar-frost. The like is daily seen on the beards and hairs of men and horses, travelling in cold winter nights or mornings, proceeding from their breaths, steams of their bodies, or moist atoms of the air. I tried also to make hail with drops of water, but could not hit on it, for they would never become white. Whence it is manifest, that hail is not drops of rain, suffering glaciation in the falling, as the received opinion of philosophers asserts.

10. SNOW abounds with fat. ' This I understand not.

11. SNOW with ice swims on water. ' This is a clear consequence from the seventh assertion.

12. SNOW-WATER boils meat sooner, and makes the flesh whiter. ' I tried this in flesh and fish, but could find no manifest difference, either to their sooner boiling or whiteness.

13. SNOW newly fallen hath no taste, but lying long on the ground, or frozen, somewhat bites the tongue. ' My taste was not so acute, as to distinguish the biting of one from the other. It is true indeed, that snow frozen doth more affect the tongue with its coldness, than snow alone.

14. WORMS are sometimes found in snow. ' This neither my own observation, nor relation from others can make out.

15. FROM snow, by a peculiar art, a salt of wonderful strength is drawn. ' He saith not this of his own observation, nor teacheth the way to extract it.

16. AFTER much snow plenty of nuts. ' This frequently suits with the countryman's observation, but many times fails; such years also commonly produces plenty of wheat, other seasons concurring.

I shall here also insert two remarks out of the same authors concerning freezing. The one is, that the great duke of *Tuscany* distilled spirit from wine, only by putting snow upon the alembick, without help of fire. The second, that the duke of *Mantua* had a powder, which soon congealed water into ice, even in the summer.

AND to conclude, take these general observations made by the command of the Royal Society, with weather-glasses framed after the Italian

Italian mode, and filled in part with tinged spirit of wine. Which I shall deliver briefly, and in gross, and not each day's alteration apart. I took then two of the said glasses of equal dimensions, as near as might be, and filled them with the same spirit of wine; one of them I placed in my study-window, standing north-west, the other in Mr. *Pullyn's* ware-house under St. *Paul's* church, and chose there a small recess or room, which was most remote from the entrance, and the warmest in the whole ware-house. Both the glasses were settled in their stations the 15th of *October* 1662, the spirit in both having the altitude of three inches just. When the glass in my study was depressed by the cold an inch, I went and observed that in the ware-house to have received no manifest change in its station. And at a second visit the spirit was depressed $\frac{1}{4}$ of an inch below, when that above ground was depressed near two inches. And during the long continuance of all that hard winter, it never descended above $\frac{1}{4}$ of an inch, and never was higher there than three inches and $\frac{1}{4}$ in a mild season in *April* following, by which time the papers fixed to the glass, and whereon were fixed the degrees, were quite rotten, and the characters scarcely legible. And at the same time, that in my study was raised to four inches $\frac{3}{4}$. By which it appears, that the said ware-house was in the coldest season as warm as in a mild *March*, for at that station the glass in my study stood commonly betwixt two inches and 2 and $\frac{1}{2}$. And so indeed this place appeared to one, that went into it at the coldest season. And to this purpose I several times sent in at night my hardest frozen liquors, which were constantly thawed in the morning, though it froze exceedingly hard above ground.

THE glass in my study, after two days hard freezing, was sunk below my marks into the very ball; so that I could make no further observations concerning the cold above ground.

FROM the former observations, that popular error is manifestly refuted, *viz.* that cellars and subterraneous places are hotter in the winter than in the summer; which, though they appear so to us, because they warm us in the winter, and cool us in the summer, yet they are not so in themselves: for it appears by the former experiment, that in the coldest season the spirit was depressed to two inches and $\frac{1}{4}$, and rose in *April* to 3 $\frac{1}{2}$; and no doubt would have risen about $\frac{3}{4}$ of an inch higher, had it continued there, till the hottest season of the year.

ONE thing more I observed, *viz.* that the tinged spirit of wine had in this subterraneous vault totally lost its colour, whereas that in my study (two years after) still retains its former tincture.

SINCE the printing of the foregoing papers, *viz.* 1664, (there being no frosts in *England* 1663) I made these following experiments.

FINDING the 3d of *January* the season disposed to freezing, I exposed a pint bottle of claret, and a glass cane filled with canary, a solution of sal gem, train oil, and the oil of *fructus musæ*; and on the fourth of the same

month, the night being the coldest and sharpest that I ever felt, (which all I spake with the next day confirmed) the wind then blowing hard at south-west, I found in the morning all the liquors frozen, except the sal gem exposed in an earthen pan, which shewed at the bottom of the dish some seemingly crystallized salt; the oil of the same fruit became very friable, and of a milky white colour, but the train-oil only lost its fluidity, and became of the consistence of soft greafe. And the same night a bottle of the Rhenish wine, called *Back-rag*, and another of lusty white-wine, standing in a room a story high, exposed to the said wind, had most of the wine frozen in them; the ices whereof being taken out, tasted somewhat weaker than the wine itself. All the same things happened the sixth night of the same month. It is to be observed, that the pint of claret, and the sack in the tube, were both frozen throughout these two nights, and after their double freezing and thawing, they lost nothing of their spirit, colour, and taste; nay, the claret being a strong *Burgundy* wine, though it often suffered glaciation and thawing for three weeks together, yet in all that time suffered no manifest alteration, but appeared the same to sense, as when it was exposed, in colour, taste, and strength.

As to the concentration of coloured liquors, Mr. *Hook* shewed me an oval glass, having at one end a narrow cane above an inch long, almost filled with water, tinged with cochineal, frozen; throughout, the ice round about, towards the sides of the glass, shewed wholly colourless; but that in the midst was of an exceeding high dye, but the ice, that was raised to the neck of the glass, was lightly tinged with a scarlet hue. Hereupon having some flasks by me, I put into one a strong decoction of cochineal, and into another a like decoction of foot, which being exposed to the air, and incompassed in a vessel with snow and salt, they did freeze to the thickness of an inch or more; and the air then beginning to relax, I broke the flasks, and the dissolved ice yielded a water totally colourless. I made also an experiment with a very strong decoction of gentian roots, which being exposed in a four-ounce phial, the ice thereof had a far deeper colour, and bitterer taste in the middle, and towards the bottom, than towards the outsides of it.

AND whereas *Barclay* relates, that King *James* being in *Denmark* to fetch his Queen thence, in the winter season had his nose and ears in danger of gangreening; which being timely perceived by some of the King of *Denmark's* nobility, they caused the parts to be rubbed with snow, and so the danger was avoided: the same travellers affirm, that in the northern parts, where men become stiff with cold, and almost frozen to death, that they rub the frozen parts with snow, or else cast the whole body into water, by which means the whole body is crufted over with ice, as eggs and apples are, as if the freezing atoms did pass from the body frozen into the water or snow; and this way of curing gangreens from cold, *Sennertus* doth prescribe. To make

make some experiment hereof, I exposed flesh and fish, and found, that by immersing them into water, they soon became more limber and flexible, and more easily yielding to the knife, and compassed with a crust of ice of the thickness of about half a crown, manifest tokens of their thawing; and being cut, they discovered nothing of ice in them. This, for more certainty, I often reiterated, as also in eggs and apples, above a dozen times, and never failed of unthawing them by this way. It is to be noted, if you immerse the flesh, fish, eggs, or apples deep into the water, no ice will appear on their outsides, but only when you hold them near the surface of the water.

As to the Persian experiment mentioned by *Olearius*, of making huge heaps of ice to be preserved for cooling of their drinks, I observed, that by pouring water into an open pan, or into a flask gradually, some at one time, some at another, I could quickly freeze by this way a whole flask-full, when near half of a flask filled at once, though helped by art, was unfrozen. I observed also, that the ditches between *Southwark* and *Rotherhithe* had acquired an exceeding thickness of ice, caused by the flowing of the water in them at full tide; for new water being brought in by the tide, was there congealed to the thickness of some inches every ebbing and flowing. I observed also the ice on the banks of *Thames* above two yards thick; the inhabitants told me they had seen it three or four yards thick, which thus came to pass: the tide flowing in, and meeting with great flakes of ice, drove them to the banks, and lodged them on the ice there frozen; which flakes uniting there with the former ice, raised it to that excessive height or thickness. Besides, every one may observe in *London* streets, and elsewhere, in channels, where no constant current is, that water coming from the houses soon fill the channels with thick ice; for running but a little at a time, it freezeth almost as fast as it cometh thither. Nay, I have seen ice of some yards thickness in such places, where a small rill or stream of water gently falls on the side of a hill.

AMONGST those things, that will freeze, mortar and plaister of *Paris* were omitted; and thence it is, that plaisterers and bricklayers play all the winter.

My Lord *Verulam*, in his Natural History, (and some from him have affirmed to me) that apples and eggs covered with a wet cloth will not freeze, but I find no difference in those, that are thus covered, and them that are not.

ADD to those, that sink upon congelation, all oils from animals, and from vegetables, that are extracted by expression or boiling.

ADD to those, that freeze not, water and sugar boiled to the consistence of a syrup, and also other syrups, none whereof I could ever take notice, or learn by others, that they would freeze. It is true, that water having an equal quantity of sugar dissolved in it, will freeze, but with a little more mixed therewith, freezeth not.

To try the effect of cold upon loadstones, I exposed several of them in the open air, and also within rooms, in the most severe weather, the needle being kept in a very warm place. At other times I exposed the needle to the cold air, keeping the stones warm, at other times both were exposed; but in none of my experiments could I conclude any thing certain as to their attractive faculty: for the sphere of their activity was found to be sometimes greater, and sometimes less, to a considerable difference, in ten several good stones employed for this purpose.

I ESSAYED also to find out a standard of cold, whereby to fit the tinged spirit of wine for the weather-glasses, and to that end made use of conduit-water, and the distilled waters of plantane, poppies, black-cherry, nightshade, scurvigrafs, and horse-radish; all which were first placed in the same room where a fire was kept, and then removed, and measured out into spoons in equal quantities, and also a drop of them dropped on the same bench: but though this was often tried, I could not make any sure inference from them. Only I observed, that the black-cherry-water did for the most part freeze first, but the other with very great uncertainty. The horse-radish, and scurvigrafs-waters, were for the most part froze last. The best way to discover the very beginning of freezing of liquors, is to move a pin or needle through the liquors, whereby the ice will be raised, and become discernible, when the naked eye can discover none at all.

A N

A P P E N D I X,

CONTAINING SOME

Promiscuous EXPERIMENTS and OBSERVATIONS

Relating to the Preceding

HISTORY of COLD.

Particulars referable to the II^d title.

1. **T**HE 26th of December in the morning, (being an extraordinary hard frost) there appeared to be quite frozen in my window near the fire, a phial full of the solution of minium, [made in the spirit of vinegar,] so strong, that part of it was shot into saccharum Saturni: only at the top of them there was a little (less than a quarter of a spoonful) that looked yellow, and was not frozen, though, being poured out, it did not freeze like an oil.

2. A SOLUTION of gold, made with salts, and standing in the same window by the solution of minium, was also frozen.

3. There was exposed a pint phial full of the tincture of lignum nephriticum, which being frozen, there appeared no colour in the ice, when the phial was held from the light, as in the liquor before it was frozen.

4. THE often mentioned ingenious gentleman, Mr. Drummond, who was lieutenant-general of the Russian army, told me, that he had divers times seen brandy frozen in Russia, but the ice was not so hard as common ice.

5. A FRENCH surgeon, that waited upon an extraordinary ambassador to Moscow, being inquired of by me about the freezing of spirit of wine, answered me, he had good store of brandy frozen in the bottles, and that the unfrozen part, which was retired to the middle, was a spirit of wine by great odds stronger than ordinary brandy.

THE above-mentioned ambassador also told me, that it was usual in their country to have wine freeze.

Passages taken out of a letter of the Russian Emperor's physician to Mr. Boyle.

6. THE 7th of December, I put some very strong French brandy into a China cup, such as they drink coffee out of, and exposed it to the air: in three hours time it was turned into a crusty ice all about the sides of the cup, as if some cold blast had forced it abroad.

WATER and sallad-oil were exposed, the oil reduced to the firmness of tallow, the water not frozen.

Particulars referable to the III^d title.

1. **T**HE spirit of sal armoniac made with quick-lime, volatile oil of amber, a

small quantity of oil of vitriol, solution of silver in aqua fortis, some diluted with rain-water, and a phial full of weak *spiritus sanguinis humani*, was exposed two nights and a day to the cold. The event was, that the three former liquors appeared not to be at all frozen; the solution of silver was frozen, and the spirit of blood appeared almost totally turned into ice, (for something seemed to be unfrozen at the bottom, especially near the middle part of it) and the ice rose up high enough to fill the neck, and thrust out the cork, which I found lying upon the ice above the neck. (The glass was not hereby broken.)

2. UNRECTIFIED oil of turpentine, though being exposed all night in a single phial, it would not freeze; yet the same quantity (which was about two or three spoonfuls) being exposed in an open earthen pottinger, the upper part afforded ice of a pretty thickness, and figured almost like that of frozen urine.

3. A TRAVELLER, bred to be a physician, informed me, that in that part of Scotland, where his father now lives, there is a lake, out of which runs a little river, whose waters, neither in the one, nor the other, are ever frozen in the midst of winter (which in those northern parts is wont to be very sharp) and that lumps of snow and ice cast into that lake do readily dissolve there; and yet, as he answered me, this water doth not differ in taste from common water, as he divers times observed.

4. I WAS told by a colonel, that the soldiers this winter making use of sallad-oil to keep their locks from freezing, found they could not discharge; but being advised to hemp-oil, they froze not: neither will train-oil freeze, as it is told me.

Particulars referable to the VI^b title.

1. **L**ieutenant G. Drummond told me, that he had often been fishing on ponds and lakes, that had been frozen over so strongly, that men might march with cannon over the ice; and yet these lakes were stored with live fish, as they found, when they broke the ice in several places, and drew their nets under the ice from one hole to another. The fish being drawn out, and packed up in this state, would continue good for a month, or better, without being either salted or dried.

2. AND it was remarkable, that the fishes being drawn out of the water found so great a difference

difference between it and the cold air, that presently after, as soon as they had made some few leaps up and down, they were in a trice frozen as stiff as boards. He told me, that flesh and fish, if when it was frozen, it was thawed by the fire, would be quite spoiled, and the flesh would not only lose its natural taste, but would be incredibly hard and tough. But flesh and fish being kept in cold water, would there thaw, and become tender, and so grow fit to be dressed; yet he observed not, that in the thawing they acquired a coat of ice, as I told him I observed frozen eggs and apples do in *England*, when thawed in cold water.

3. HE also told me, he had frequently seen men to have the end of their noses, and the upper part of their cheeks frozen, even when themselves were not aware of it, and that they were very careful not to enter into a stove, or come near the fire, to relieve themselves; because if they did, the frozen parts would be apt to mortify, and come off, but they would rub them well with snow, by which means they were thawed, though not without some trouble, yet without danger.

4. IN *Lapland* they use another way to restore frozen limbs, *viz.* by making a certain kind of a cheese of deers milk, which they toast against the fire, and anoint the place affected with the *Caws-boby*, and that restores the frozen member immediately.

5. I HAD some *Cheshire* cheeses, of which I desired the cheesemonger to choose the fattest and firmest to resist the frost; but they were all frozen, as also a *Cheddar* cheese of a hundred pound. I threw one into cold water, and in a quarter of an hour it gathered ice about it, or rather the water extracted the icicles out of it.

6. FISH thaws sooner and kindlier in cold water, than in the warm stove; but thawing in water is not so proper to flesh, which must have a time answerable to its bulk, or else it will never roast further than it is thawed, roast it never so long, and carefully.

7. IT is their custom in *Russia*, especially at *Moscow*, to thaw their fish (before they put it to boil) by letting it lie in cold water, till it hath got a cake of ice about it, which they take off, and then put the fish into new cold water, and, when it is covered with ice, take it out again: this they continue to do, till the fish will occasion no more ice, and unless this be first done, they find it will never be well boiled.

8. AN old sea-captain told me, that they very often met with large white bears, out of which they had fat enough, when well ordered, to yield a hog'shead of oil.

THE same captain told me also, that white bears in or about *Greenland*, notwithstanding the coldness of the climate, have an excellent scent; and that sometimes, when the fishermen had dismissed the carcass of a whale, and left it floating on the waves three or four leagues from the shore, from whence it could not be seen, these animals would stand as near the water as they could, and raising themselves on their legs would loudly snuff in the air, and

with the two paws of their fore-legs, as with fans, drive it as it were against their snouts; and when they were (as my relator supposed) satisfied whence the odour came, they would cast themselves into the sea, and swim directly towards the whale, as my relator and others observe, who had the curiosity to row at a distance after them, to see whether their noses would serve them for guides, when their eyes could not. He saw no other bears in those parts but white ones.

9. AN inquisitive doctor of my acquaintance bought at *Moscow* a small quantity of *Malaga* sack, that did as it were drain out at the bottom of a pipe or hog'shead, that had not been tapped, till it was (unawares to the owner) frozen. This liquor was much stronger and better than the wine that afforded it, and the fame of its goodness making others croud to buy the remaining part of it, they found it, when the vessel was kept in a warm place, which thawed the ice, to be little else than strengthless phlegm. The same physician had likewise some strong beer frozen, whereof the part that resisted the cold (and was taken up near the top of the vessel) was stronger than wine; but the rest, which had been once ice, was worth little or nothing. And as to these and the like glaciations, the same doctor told me, that he observed not the unfrozen liquor to retire always into the middle of the vessel; but rather (especially in sack) to be intermingled with the ice, almost (as I guess by his description) as honey is dispersed into an honey-comb.

10. SOME of the men of the old sea-captain's, that had been in the frigid zone, being on shore off *Greenland*, opened a barrel of good beer standing an end, and before they had drank much of it, the wind turning suddenly fair, and being hastened aboard, they left the barrel behind them; and the next year coming again to the same place to fish for whales, some of them went ashore in a shallop, but were by extreme cold, and the interposition of some ice, kept for a day or two from being able to get to the ship; by which accident their provision falling short, one of them remembered the barrel left behind, and coming to it, found it standing where they left it, but very hard frozen; whereupon they took a spit they had with them, and made a good fire, and therein heating it red-hot, they broached the frozen barrel with it, and when the spit had reached almost the middle part of it, there came out some quarts of a turbid liquor, but so strong and heady, that it made most of them drunk, and fall asleep for divers hours: after which, waking, they did for curiosity sake stave the cask, and found, that about this spirituous liquor the waterish part of the beer had been hard frozen on every side, and the liquor had been altogether inclosed in thick ice. This relation I had from the old captain himself, who was employed in that voyage.

11. THE often mentioned governor of *Smolensco*, a famous fortress between *Russia* and *Poland*, told me, it often happened, that the French, and sometimes the Spanish wines, that are yearly brought from *Archangel* to *Moscow*,

Moscow, are so frozen by that time they come thither, that their owners are fain to break the cask, and cleave the ice with hatchets, and then they transport it from place to place in ordinary jars, (so hard it is frozen,) and when

they mean to reduce it to liquor again, they put it into another cask, and that cask into a deep hole made into the ice or snow, where it will slowly thaw, and be far less impaired, than if it had been thawed by the fire-side, or in a stove.

The Phænomena of an Experiment about Freezing, made by Mr. BOYLE, referable to the VIIth Title.

[This Paper was produced and read in the Royal Society, Nov. 23, 1671.]

WE took a bolt-glass, bigger than two turkey-eggs, with a stem, which we caused to be drawn out at a lamp, till it was as slender as a goose-quill, or thereabouts. This vessel was filled with water, till the liquor reached to a pretty height in the slender part of the stem. Then I put it into a mixture of beaten ice and salt, in which mixture a cavity had been before made to receive a good part of it. But though upon our putting the glass into this cavity, there would at the very top seem to be some little shrinking down of the water, yet that was very small, and sometimes very scarcely, if at all, discernable; nor did the water afterwards appear to subside, and exhibit the other phænomena of freezing water mentioned by the excellent Florentine virtuosi: only when the liquor began below to be turned into ice, the quick ascent of it was manifest enough.

WHEREFORE we afterward caused the stem of a round bolt-head of clear glass, whose globous part was about $3\frac{1}{2}$ inches in diameter (taken on the out-side with calliper compasses) we caused, I say, this stem to be drawn out at the flame of a lamp, till it was at least as slender as a raven's quill; and the glass being filled with water to a competent height, that the expansions and dilatations of it might be very manifest in so very slender a pipe, we observed the ensuing phænomena.

FIRST, As soon as the globous part of the glass came to be as it were immersed in the frigorifick mixture, the water in the small stem instantly ascended, sometimes the length of a barley-corn, and sometimes less, and sometimes more. And this ascension was so hastily made, that it often begun and ceased almost in the same moment; after which the water began (though more slowly) to subside again to its former station, or thereabout, which, with other circumstances, made it very probable, that as the Florentine virtuosi ingeniously labour to prove, this sudden change proceeded rather from the constriction of the glass it self upon the first contact of the frigorifick mixture, than upon the sensible condensation of the water, which is not likely to be so suddenly effected.

SECONDLY, But whereas the newly named philosophers recite, as a constant phænomenon, that after the first subsidence of the water, and a subsequent pause for a pretty while, the water will be considerably depressed once more, before it begins to rise, we could very rarely indeed and scarce ever observe such a thing to happen, though I cannot suspect my

self to have overseen it for want of attention. For my expectation of such a subsidence of the water, and its not appearing to me the first and second time, invited me to repeat the experiment several times one after another, and to look very attentively upon the water, and the marks carefully stuck on the side of the glass, to observe the motion of the liquor. And this seemed the rather strange to me, because I had often formerly observed in trials purposefully made on other occasions, that water in convenient glasses would suffer some degree of condensation by the action of a frigorifick mixture, before it would begin to discover any ice in it. But having reiterated the experiment, till I, and those that assisted me, grew weary, I was fain to abandon it, leaving the prosecution of it to farther trials. For I dare not suspect, that so many eminent virtuosi, as noble the Florentine academy, could mistake, or misrelate a matter of fact, not once, but frequently, and uniformly taken notice of by them. And besides that, as I was saying, it is consonant to my own experiments on other occasions, in one of the glasses, wherein I tried this very experiment, I observed the second subsidence to be considerable. So that I cannot but suspect, that the so differing events of their trials and mine, as to this phænomenon, may proceed either from some peculiarity in the water they employed, or in the qualities of the glass, which the vessels I used were made of, or in the length and slenderness of the stem, considered together with the grossness of our English air in snowy weather, the pressure of the air having elsewhere been shewn by me to have a great stroke in divers condensations ascribed to cold: but whether to any of these things, or any other, that, which we have related, is to be reduced, future trial must determine.

THIRDLY, I observed for the most part, that after that subsidence, that almost immediately attends the first rising of the water, there would be for some time, more or less, a resting of the surface of the water in the same place, which continued till the upper part of the water began to ascend upon the beginning of the glaciation of its lower parts; and the duration of this pause or rest of the water I found to be very uncertain, being at some times at least twice or thrice as long as at other times, according as the frigorifick mixture did more or less vigorously operate upon the neighbouring water.

FOURTHLY, Though if the experiment was

tried in glasses, whose stems were of an unusual bigness, the ascension of the water in the stem upon the glaciation of it in the globous part, was not so quick as to be very remarkable; yet when the stem was drawn out to such a slenderness, as was before described, the water, after having (as I lately noted) rested a while, would, upon its beginning to freeze beneath, ascend so hastily in the stem, as appeared strange enough, especially at the first sight: so that usually its progress upwards was very obvious, and sometimes made with such celerity, that in one minute of an hour, or much less, it would as it were shoot up several inches, and would have probably ascended much higher within half a minute more, if the slender part of the stem had been long enough to permit it.

FIFTHLY, But whereas the Florentine academians inform, that there is a considerable intumescence or rising of the water, that does immediately precede glaciation, I never could satisfy myself, that I observed such a phenomenon. But in spite of frequently repeated trials (both alone, and before others) and of such a degree of attention as perhaps is not often employed even in more nice trials, it always appeared to me, that the ascension of the water was at least accompanied, if not rather preceded, by the actual glaciation of some parts of the water, that were most contiguous to the frigorifick mixture, or exposed to those portions of that mixture which were the most operative. Nor did it seem easy to me to assign any other, or at least, better reason of the ascension of the water in the slender stem, than the expansion, that is wont to accrue to water, upon its being actually turned to ice. It is true, that in slender stems the rising of the water will be manifest upon the production of so thin and transparent films of ice at the bottom, or some of the lateral parts of the globe the water is contained in, that it has often deceived even attentive eyes, and would have deceived me too, if the newly intimated conjecture at the reason of the intumescence of the water had not made me extraordinarily suspicious, and invited me to look upon the glass taken out of the frigorific mixture (and then wiped and held against the light) in so many differing postures, that though in some of them I could not, yet in others I did discover thin portions of ice, which sometimes I could within a minute or less make visible to others; because this ice upon thawing would not unfrequently emerge to the confines of the globe and stem, and there become easily enough discernible to a heedful eye. And though when I guessed, that the water was upon the point of beginning to freeze, I took it out of the frigorifick mixture, to try if it would afterwards freeze, or make the liquor in the slender pipe ascend; yet I never was so fortunate, as to observe any ascension of the water in the stem, but when there was actually some particles of ice in the ball, which though I newly took out of the mixture, as soon as I could perceive the least beginning of rising in the slender part of the stem, yet I regularly

found more or less ice to have been already actually produced at the bottom or sides of the globe. The ascension of bubbles about the time of the water's congelation (especially if the glass were stirred) I do not here solemnly take notice of, it being an usual concomitant of the glaciation of water.

SIXTHLY, It was remarkable, and not unpleasant in our experiment, that not only if the glass were taken out of the mixture, very soon after the water began to ascend in the stem, the thaw, by reason of the extraordinary thinness of the ice, would begin so quickly, that within about half a minute, or sometimes much less, the liquor would begin to subside manifestly again. But when the water was sufficiently disposed to congelation, which it usually was, if the glass were put into the frigorifick mixture soon enough, after the total dissolutions of the little portions of ice newly mentioned, it would, upon the contact of the frigorifick mixture, though the globe were but half buried in it, begin to glaciare in a trice; in so much that making observation by a minute watch, I have had the water shoot up in the stem within half a minute, so as to discover ice in it, and within two minutes (from first to last) to exhibit ice in most parts of the cavity of the globe.

Particulars referable to the VIIIth Title.

1. TWO sealed weather-glasses, one with spirit of wine, and cochineal, the other with a blue liquor made with spirit of man's blood, copper, and spirit of wine, were immersed in water, and kept there, till the glass, that contained the water, began to discover some ice within it: then, this water being thrown out, these thermometers were removed into oil of turpentine, (substituted for the water of the same vessel) and snow and salt being applied to the outside, the oil of turpentine (whose freezing in such a quantity and vessel we were not afraid of) was made as cold as we could. Whereupon the liquor in both the weather-glasses manifestly and considerably subsided beneath the former mark, and in one of them (which had the blue liquor) though it were but a short one, the subsidence was made half an inch; which still confirms, that the air may impart a higher degree of cold than is necessary to make water freeze, and than is always communicated by ice itself.

2. THE essential oils, as Spagyrist call them, that are made of spices, and other spirituous materials by distillation in water, being, by reason of spirituousness, unapt to freeze; men could not observe, what effect a degree of cold capable of coagulating them would produce, in reference to their taking up more or less room, when congealed, than when fluid: some liquors having been found by experience to be expanded, others to be condensed, by being made to congeal or to concrete by cold. Wherefore considering, that oil of aniseed, though an essential oil, will lose its fluidity, not only sooner than hot liquors, but with a far less degree of cold than water itself; I thought this would be a fit subject to make trial upon, and accordingly

ingly having put a convenient quantity of this liquor into a round glass, about the bigness of a middle-size orange, furnished with a suitable stem, we put a mark, where the surface of the liquor rested, as about five inches above the ball. Then putting the glass into a vessel of water, made cold by powdered sal armoniack put to dissolve in it, we observed, that the oil in the stem subsiding did grow whitish, though by inclining the glass it was easy to discern, what part was yet fluid. In a short time after this the oil seemed totally coagulated into an opacous and very white body, (almost like sperma ceti) whose upper surface was near three inches beneath the mark formerly mentioned; so that the liquor appeared to have been not inconsiderably condensed by the operation of the cold. Which further appeared by this, that whereas the oil of aniseeds, whilst fluid, would swim upon water, this butter-like concretion would sink in it. And yet when I watched, I could observe, that upon the slow thawing of this thickned substance, there emerged from time to time several bubbles into the already fluid parts, divers of which bubbles might plainly be seen in the coagulated matter before their emersion; just before which several of them exhibited various and vivid colours, and very pleasant to behold.

Particulars referable to the Xth Title.

1. **A** FLAT bolt-head, sealed up with a stem about 17 inches in length above the superficies of the water, being set in the frigorifick mixture for eight or nine hours, the water ascended 15 inches and $\frac{1}{2}$, that I measured, and afterwards $\frac{1}{8}$ of $\frac{1}{4}$ of an inch, according to the measure of another; after which time neglecting it for one hour or more, while I was at supper, it blew off the sealed end of the glass quite round, and broke the bottom of it into many pieces, leaving almost all the whole body of the pipe uncracked.

2. **W**ATER freed from air, by standing a good while in the exhausted receiver, being sealed up in a round bolt-head, whose pipe above the water was five inches or a little more to the sealed apex, being set in a frigorifick mixture, exhibited an ice very prettily shaped, and without conspicuous bubbles; in less than two hours the water came to be impelled up four inches and $\frac{2}{3}$, and seemed to reach a little above the basis of the conical and sealed part; upon its breaking with a noise, the pipe was entire, and there appeared a good part of the water unfrozen under the ice, and the broken vessel seemed to smoke. Upon considering the shortness of the conical part of the glass, we guessed the air to have been compressed to about the 20th part of its former room.

3. **T**HE globulous part of a glass-egg of about three inches (for it wanted $\frac{1}{10}$ th) in diameter on the out-side, was filled with water to the bottom of the stem, and then being carefully freed and sealed, was frozen from the bottom upwards, to try, whether the absence of the formerly incumbent air would not make the ice afford larger bubbles, and consequently take up more room, than otherwise it would, when the water was frozen in the ball; and a

little way in the lower part of the stem we found, that (the remaining) water reached from the first station of the water about eight inches and $\frac{1}{2}$, the length of the whole stem being a very little more than ten inches and $\frac{1}{2}$. Being afterwards sealed up with air in it, and frozen, the ice reached not in it full four inches above the first station, though (if I mistake not), it was as well frozen this time as the former.

Particulars referable to the XIth Title.

1. **T**HERE was taken a strong cylinder of brass, whose cavity was two inches in diameter, into which was put a bladder of a convenient size, with a quantity of water in it; that the neck of the bladder (which I had taken care to have oiled) being strongly tied, the water might not get out into the cavity of the cylinder, nor be capable of expanding it self any other way than upwards. Then into this cylinder was fitted a plug of wood turned on purpose, which was somewhat less in diameter than the cylindrical cavity, that it might rise and fall easily in it. Upon the upper part of this plug was laid a conveniently shaped flat body, upon which were placed divers weights to depress the plug; and hinder its being lifted up by the expansion wont to be made in water that is made to freeze: then a frigorifick mixture being afterwards applied to the cylinder, it appeared within half an hour, or somewhat more, by a circle, that had been purposely traced on that side of the plug, where it was almost contiguous to the orifice of the cylinder, that the water in the bladder began to expand it self; and about two hours after having occasion to shew the experiment to some inquisitive persons, the circle appeared to have been heaved up, in my estimate about $\frac{2}{3}$, if not half an inch, notwithstanding all the weights, that indeavoured to hinder the ascension, though these weights amounted to 115 pound; which were all the determinate weights we could then procure, besides brick, and some other things, that were estimated at five pounds more. Nor did I doubt, that a far greater load would not have hindered its expansion.

THE day after the above mentioned experiment was made, to try the expansive force of freezing water, the same was reiterated after the manner above delivered, but with this difference, that having procured more weights, when the plug was lifted up $\frac{2}{3}$ of an inch, or somewhat better, (which plug began sensibly to rise within half, or three quarters of an hour, after the frigorifick mixture was applied,) it was loaded with a weight of two hundred pounds, and a fifteen pound piece of lead, and other bodies, as boards, &c. to lay the weights upon; which being also weighed by themselves, came to fifteen pounds more, so that the whole amounted to 230 pounds: and if the hundred pounds were both of them (as their bulk and weight invited us to guess) of that sort of weights, which are called the great, a hundred containing a hundred and twelve pounds apiece, twenty four pounds must be added to the sum, which would thereby be made up 254 pounds.

2. AN iron barrel, being about 14 inches long, and having about $\frac{3}{8}$ of an inch diameter at the bore, and where the greatest thickness of the metal was $\frac{3}{16}$, and the least $\frac{2}{16}$, or somewhat better, being exactly stopped at the breech, and having a screw of a convenient length to stop it at the other end, was filled with water, and then the screw being put in, the barrel was buried in a mixture of beaten ice and salt for about two hours or longer; at the end of which time being taken out, it appeared to have a crack running somewhat oblique, by beginning at a place about three inches distant from the breech, and reaching to somewhat above six inches from the same: the crack was much more wide and gaping towards the middle of the barrel, which appeared also distended about that part; the ice being taken out in divers pieces, and held against a candle, seemed to have smaller bubbles than it would have had, if the water had not been pent up. But the minute bubbles were so numerous, that they made the ice more than ordinarily opacous.

3. A STRONG barrel of a gun of twenty four inches long, having the touch-hole stoppt, and a plug of iron, that was fitted to the muzzle, forcibly driven in, after the barrel had been filled with water, was put into a mixture of ice and salt, where within about three minutes by my watch, the lately named plug was with noise driven out of the end it had closed before; and when the same plug was afterward so driven in, that, to make the closure more perfect, the sides of the orifice of the barrel were hammered down upon the outward end of the plug, yet, within about three minutes more, the frigorifick mixture making the water expand it self, made it again drive out the plug, and that not only with noise, but with such violence, that we found it had broken a deal-board, that made the nearest part of an oblong box, (wherein the operation was performed.) Afterwards the iron plug, being by the help of the fire and a hammer as it were incorporated into the barrel, the touch-hole came to be unstopped; and though a long iron nail was strongly driven into it, yet the plug being incapable to be driven out (as before,) the frigorifick mixture being again applied to the barrel, quickly drove out the nail; which, lastly, being again forced in, and the commissure being for farther security brazed over, there was now no room left for the included water to expand it self much, but by breaking the barrel. But being my self called away, so that I could not stay to see the issue of the experiment, I left one to prosecute it, who soon after brought me an account, that within about a quarter of an hour (by his guess) after the barrel was put into the frigorifick mixture, though of that there was scarce left enough to cover it, it burst with a noise, and blew up the cover of the box (wherein the experiment was made) and the crack, which was two inches and a half long, was wide and gaping enough to let me see, that the barrel was of a very considerable thickness at the place, where it was broken.

A NEW pewter bottle, holding (by guess) about a pint, was filled with water, and then

the top being screwed on; was put into a frigorifick mixture, wherein when it had lain (by our estimate) about $\frac{1}{4}$ of an hour, it was broken, not without noise; and being taken out, we found in it a crack almost an inch and a half long, and in one place so broad as to amount to about $\frac{1}{4}$ of an inch. The bottle seemed to be every way distended, and particularly at the bottom, which was so swelled, that the bottle would not stand upright upon it.

One particular referable to the XIII^b Title.

THE old sea-captain told me, that out at sea, when the wind blew off from the great banks and tracts of ice, they could, by the extraordinary highness of the cold, (which would sometimes make the skin of their faces peel off) perceive, which way the ice lay, not only long before they could see it, but sometimes when they were fain to sail twenty leagues, before they could come to it.

Particulars referable to the XV^b Title.

1. THREE decoctions, one of sage, another of rosemary, and the third of parsley, were exposed in three small earthen pipkins to freeze, and were totally turned into ice, without any uncongealed liquor (that I could perceive) in the midst: nor did there appear in the ice any resemblance of the decocted plants, but the ice afforded by the decoction of sage had a very uneven superficies, and far more rugged than the two other portions of ice, which were neither of them smooth; and these (especially that of the sage) were observed manifestly to be less hard or solid than common ice.

2. NEWLY expressed juice of lemons being set to freeze in a wide-mouth-glass, afforded an ice very oddly figured, especially in one part, where it finely represented trees, as they are in winter, without leaves.

3. HARD ice grossly beaten, having a great proportion of white table-salt put to it, and mingled with it, there arose from the mixture great store of whitish fumes, as thick (at least) as common smoke, which fumes played up and down all the mixture, and lasted a very considerable while; and all this, though the weather was very warm, and the experiment made in a room, where there was a very good fire.

4. SNOW-water being put to freeze in ice and salt, afforded an ice prettily figured, and had the bubbles produced in it so minute, that they hindered not the globe, which the ice constituted, from being more transparent, than would have been easily expected.

5. WE took a quantity (not inconsiderable) of ice, about two pound or more, and having partly reduced it into small lumps, and partly beaten it into small powder, we mixt with it a convenient proportion of bay-salt not powdered. This mixture, when it was suffered to lie still for a pretty while, did not appear to emit any thing from the superficial parts; but yet afterwards, when it came to be stirred here or there, there would in that part arise a smoke easy

easy enough to be discerned, if the basin or platter, that contained the mixture, were held between the eye and the light. But if the whole body were stirred, then there would be excited so visible a smoke, as that it would not only overspread the surface of the vessel like a mist, but would overflow it on all sides for a good while. I use the word, *overflow*, because indeed the fumes did not only some of them ascend a pretty way into the air like smoke, but the greatest part of them by far, as soon as they were risen above the brims of the vessel, did fall down in streams, as if it had been a liquor poured out of a basin: so that the fumes seemed ponderous, almost like those, that one may observe, if he dip a piece of linnen in aqua fortis, and hang it up to dry; in which case the emitted steams will rather fall than rise. We also took notice, that those steams of our frigorifick mixture were far more plentiful than they seemed to be; for besides those, that were manifestly spilt out of the brims of the vessel, it was easy, by looking upon the mixture in a certain position in respect of the light; it was easy, I say, to perceive, that the whole cavity of the vessel, which was pretty deep, was all covered with those fumes, that played upon it like the thick mist upon a pond, not being able to pass over the brims of the basin. And this ascension of fumes, upon the stirring to and fro of the mixture, lasted a considerable while, and probably would have lasted longer, if partly weariness, and partly business, had not called me away.

I forgot to note, that, when those steams came out the most plentifully, I applied my face to them, to observe, if I could feel them sensibly colder than the neighbouring air; but by reason of an impediment, I could not continue in a fit posture long enough to be sure, whether those effluvia would in due time feel sensibly cold or no. And though I applied a sealed weather-glass to the same fumes, and the tinted spirit seemed thereupon a little to subside, yet some circumstances make me *ἐπιπέτυ* till further trial.

6. THE old sea-captain, that failed so often into the frigid zone, answered me, that when his ship was immured with ice, so that they could not in a long time get so much as a barrel of salt water, he made wells of the thick pieces of ice, to receive the liquor of the thawed ice, and found that water (though on the main sea) to be good fresh water, potable, and fit for dressing of their meat, and other uses, so that he never feared want of fresh water in those seas.

HE also told me, that he had divers times fastened the ship to the pieces of ice, that reached under water to about 30 fathom, and that once he lay a good while by a piece of ice so thick, that it was on ground at fifty fathom, which he clearly perceived, both by sounding, and other ways of observing, that he acquainted me with. These deep pieces of ice (he said) were not very high above the water, insomuch that when I told him I had found by trial, that a cylinder of our *English* ice could have but about the tenth part of it above the water it was made of, and made to float in, he answered, that that

proportion agreed well enough with his observation; and added, that the great depth of the ice proceeded from the successful snows, which, falling from the surface of it, depress it, and often within two or three days would itself melt; so as to shrink into a third or fourth part of its former thickness, and become hard ice. He likewise told me, that he had failed to 82 degrees and a half of latitude, and answered me, that he was not mistaken in observing it, having had very good opportunity to do it by more than ordinary fit instruments, that he had carried along with him.

HE told me too, that in some parts near the coast of *Greenland*, he found the variation of the compass to be 22 degrees, and not very long after to be scarce any at all; which strange alteration he knew not what to make of.

HE told me moreover, that the last year sailing in the height of 77 degrees in the main sea, he was suddenly surrounded, and his ship locked fast up, only that it was driven by and with the ice, till the 7th of *June* following; and then, the ice opening a little, he made a shift to steer through it, and pursue his voyage; adding, that he observed, that that vast tract of ice being once broken, the fragments of it drove towards *Hudson's Straights*.

7. THE old sea-captain told me as strange a thing, which he had often, though not carefully observed, that great tracts of ice dead the wind; insomuch, that when he has been driven towards the ice by stormy weather, and feared to be in great danger, when they came near it, he unexpectedly found a kind of calm, that raised his wonder, and freed him from his fear. And at other times going out of the ice upon an almost smooth sea, when he had not yet gone far on it, he found, that there was a storm at distance from the ice: and mentioning this, as a very odd thing, to a *Dutch* navigator, who frequented those seas for the whale-fishing, he assured him, that he had several times observed this wonderful property of the ice.

One particular referable to the XVIIth Title.

IN *Siberia* (a northern province of *Russia*) the earth is thawed in summer but about two foot in depth, beneath which it continues frozen, and yet over this frozen part of the ground there groweth good corn. This I had from the *Russian* emperor's chief physician.

Particulars referable to the XVIIIth Title.

1. THE little sealed weather-glass being taken, was put into a glass broader at the top than the bottom, and greased on the inside with tallow, in which glass the ball in the inside of it was more than covered with water; and that water being frozen, notice was taken whereabouts the tinted spirit of wine rested in the stem: after which, the ice being newly taken off from the ball in the open air of an exceeding frosty morning, just upon the removal of the ice the liquor rose a little in the shank, as it useth to happen, when a glass-bubble filled with warm water is suddenly removed into cold: but presently after the tinted liquor, as I expected, subsided, not only as much as it had risen, but a pretty way (the shortness of

the instrument considered) below the former mark. Which may confirm our observation, that the free air may communicate a more intense degree of cold than ice itself.

2. THE weather having continued for some time very cold, we placed two or three days ago a trusty sealed thermoscope (that was made by the standard weather-glass at *Gresham* college, which I therefore call the standard thermoscope, having used it for some years) in a cellar, where we had observed beer not to freeze in a very extraordinary sharp winter; and having looked upon it last night, which was, as the night preceding, very frosty, the wind being at east, we found, after ten a clock, that the tinted spirit of wine stood at two divisions, and at $\frac{1}{8}$ above the freezing mark; and this morning being a hard frost, it was found to stand much at the same height. Wherefore having caused it to be removed into the free air in the garden, it now being about nine of the clock, is fallen to the freezing mark, and consequently is subsided above two full divisions or inches beneath its station in the warm cellar. But nevertheless I hence observe, that the air in the cellar, notwithstanding the cold weather, is not (or is but very little) warmer than the air in my bed-chamber is wont to be in frosty weather: for the same weather-glass being usually kept in that chamber, the spirit of wine was wont to stand about two inches above the cipher or freezing-mark, in the morning before the fire was made, in case there was a moderate frost abroad; and in summer-time, when the weather was very hot, the tinted spirit has ascended to the eighth, ninth, and sometimes almost to the tenth mark.

3. THE last night being made extraordinary cold by frost, snow and wind, the standard weather-glass (before mentioned) was removed into the garden, and left there till this morning, when the tinted spirit appeared to be subsided above two divisions beneath the cipher or freezing-mark; so much greater was the cold of the air, than was absolutely necessary for the congelation of water. And yet the coldness of this very night did not by *Αυριμεπί-στασις* so increase the heat of the cellar, but that a phial, containing about two or three ounces of chymical oil of anise-seeds, being left there till nine of the clock this morning, was taken out without being thawed into a liquor: which argues, that the heat of the cellar was inferior to that of the outward air in moderate seasons, since oftentimes, both in spring and autumn, oil of anise-seeds is by the warmth of the air kept in a fluid form: as this particular parcel of oil in the same phial, wherein it was exposed, was kept by the moderate warmth of my chamber many times this winter.

4. THIS morning (being *December* 29, 1665) a little before ten of the clock, the weather having been frosty (bating one mild, but rainy day) for near a fortnight, I took my sealed weather-glass out of my chamber-window, and having held it a while in the open air in the court, as also wetted it with water, to reduce it the sooner to the coldness of the ambient air, I caused one to pump so long, till to a younger

eye than mine, the water, that came out of the pump, seemed to begin to reek; and then I held the ball of the weather-glass for a pretty while in the stream, that came out of the pump, and observed, that it made the tinted liquor considerably rise; and the more, the longer I kept it, till it was risen to the height of the cross, which I made in the frame. Then carrying it up to my chamber, though there was a good fire there, the spirit of wine began to subside again; thereby shewing, that the air in my chamber was colder than the reeking water, that had been pumped out.

5. ANOTHER time (being *Feb.* 17, 1665) after it had continued frosty weather three or four days, (if I mistake not the number) about nine or ten of the clock in the morning, I caused the water of a considerably deep well to be pumped for a good while upon it, after it had been kept a pretty while in the air, to bring it to the temper of that; the pump-water raised it by degrees, but slowly enough, to between four or five eighths of an inch higher than the pump-water at *Oxford* had been able to do. Then I carried the weather-glass to a spring, that was wont to smoke in frosty weather, and was not far from the pump; and having laid down the weather-glass, (that my hand might have no operation upon it) so as the ball was covered with water just at the spring-head; after it had rested there a good while, I found the tinted spirit but very little raised: so that in all it scarce exceeded five eighths above the height it had been brought to at *Oxford*.

AFTERWARDS in the same place I brought the weather-glass about noon to the north side of the house, to which the pump belongs; and letting it rest against the wall in the open air for half an hour or more, I found, that though it had been that morning a small frost, and though the sun did not shine out, yet by the weather-glass the air was just at the same degree of warmth (if not a little greater) that the water had been at the spring-head in frosty weather, when there was snow upon the ground; and consequently the air was then much hotter than the water had been in the pump at *Oxford*, where yet in very cold weather it uses to smoke.

Feb. 19, being the third day of the continuance of a moderate frost, I held the sealed weather-glass under the pump, and having caused the water to be pumped for a good while upon the ball of it, I found the tinted spirit rise as high with the warmth of the water, as it had done many weeks before in the depth of winter, by the warmth of the water of the same pump.

THE next day, being the fourth day of the frost, the neighbouring spring, which (as I was informed by those I sent to see) had not, during the precedent days, smoked, did smoke this morning, as one I sent to see, informed me, that another spring likewise did. About noon (the weather being fair, and the sun shining) I employed one to keep the ball of the weather-glass for a competent time covered with water just at the head of the spring, which had smoked in the morning; and by his relation, which was confirmed by the height of the tinted

tincted liquor, when I saw it, it appeared to have risen higher now by near or a full quarter of an inch, than I could make it do at the same spring-head divers weeks ago. But note, that this day the spring-water was a pretty deal warmer than the air, notwithstanding the time and clearness of the day, as appeared by the subsiding of the tincted spirit, when brought from the spring to my chamber in a frosty morning, the ground being then covered (but not thickly) with snow.

6. HAVING inquired of an ingenious man, obliged to make some trials about cold, whether he had observed any thing to confirm or contradict the suspicion I published in the History of Cold about the coldness and temperature of the air; he gave me such an answer, that does notably confirm my conjecture. For he told me, that he had divers times observed in an exactly sealed weather-glass, that the tinged spirit of wine was higher at some times, when the weather was frosty, than at some other times, when it was not; and that having had occasion to keep his weather-glass with the ball in water, which was afterwards frozen, and continued ice for divers days, he warily brake the ice all about the ball, and removing it thence into the air, though it were in the same room, yet he found the liquor to descend from such a mark to such a mark; and having desired to see the instruments, I found the bigness of the ball to be like that of a middle-sized or somewhat large crab, and the stem to be about two foot and a half long: and having had the curiosity to measure the distance between the above mentioned marks, I found, that the liquor, by being removed out of the ice into the air, had subsided a pretty deal above three inches.

A relation given me by an ingenious gentleman, lately returned out of Poland.

7. ABOUT the 21, 22, and 23d of December 1669, old style, lying within three Polish miles of *Warsaw*, we saw every day the sun accompanied with two parhelions, the one eastward, the other westward, almost in a direct line, and distant about 8 or 10 times the diameter of the sun from it, and continued visible from near ten to twelve a clock, the weather being extreme cold, the air as clear, as possibly to be imagined, both night and day; and when the sun did shine, appeared as full of glittering spangles or particles of ice. The like hath been since, when it hath frozen very hard; which generally happens, the air being very clear, and as generally thaws, the heavens being clouded any time together.

8. THE old sea-captain, that sailed so often to *Greenland* to fish for whales, assured me yesterday, being April 8, 75. that 18 or 19 years ago, he sailed thither in the company of two Dutch ships, whereof one was a *Hollander*, but the other of *Emden*: the names of the masters he told me. When they were come together as far as the place, where the *English* used to stay in *Greenland* (as I remember) the masters of the two ships desired this captain to give them leave to fish there with him; which, he told

them, he could not possibly do, being a servant of the *Greenland* company, and employed there by them. Whereupon these masters told him, that they would then go seek their fortunes in an unknown world; and seven or eight weeks after, they came back to him, miserably distressed for want of fresh water and fuel, which they desired his leave to take upon the place; which being but an act of humanity, and intrenched not upon the rights of the company, he willingly permitted. Whereupon they fell into discourse of their voyage; one of the masters told him, that coasting along the ice, in hopes to find some new land, and some place where they might freely, as well as conveniently fish for whales, they had at length come so far, that after the foggy and dark weather was cleared up, they took the latitude, and found it to be 89 degrees, so that they were within one degree of the pole.

THE old captain doubting of this, the master brought him his journal, where the course was set down, which testified the same thing; and afterwards conferring with the master of the other ship, (for they sailed in company) he agreed in the same relation. And the captain hearing, that the steersman of one of the ships was a *Scotsman*, he got to discourse with him, and saw his journal too, which agreed with what the others had declared. And afterwards one of the masters having occasion to come to *London*, and being there met accidentally by our captain, he brought him to some of the Northern company, to whom he averred the foregoing relation, of whose truth the captain seemed to me to be convinced. I asked him several questions relating to this odd story, to divers of which he could make no answer, having not asked them of his *Dutchmen*; but to some few things he gave answers, the substance whereof was, that though there were vast regions of ice towards the shores, yet where they found themselves so near the pole, the sea was very open and free; so that if wood and water had not begun to fail them, and if they had not feared their other provisions would not hold out, they might have made a passage perhaps as far as *Japan*. That from the north-east there came a great rolling sea, which one of the masters, that had been at the bay of *Biscay*, compared to that *Spanish* sea; and that the cold there was not extreme, but such as they could well endure, and complained no more of, than they did in *Greenland*. That sailing from *Greenland* towards the pole, they found the compass to vary a point, after they had sailed some degrees northward; then the variation of it was for a great while inconsiderable, and a while after that, it came to be two points. And lastly, when they came to be so near the pole, the declination increased strangely; so that at 89 degrees of latitude they found the variation to be four, not degrees, but points of the compass, and that towards the east.

9. THE old sea-captain told me, that they are in the seas frequently pestered with thick fogs extremely cold, which last some of them 10 or 12 hours, some a whole day, and others two or three days.

HE told me, that lying at anchor in *Bell-Sound* on the coast of *Greenland*, near a mountainous rock, that was very high, he and some others made a shift to get up to the top, which he judged to have half a mile of perpendicular height; and when they came to the upper part of the mountains, they found the weather very clear, and the sky very serene; and it being then *June*, the sun shined so hot upon them, that he and others stripped themselves, and aired their shirts and naked bodies to cool themselves, seeing all the while a thick fog like clouds at the bottom of the hill; whither when they came down with store of fowl, that they had killed, they found the fog, as they left it, very dark, and exceeding cold.

A passage taken out of the Czar's doctor's letter.

10. Aug. 29, 1664. This winter we stayed at *Vologda* three months, which is north-east from *Moscow* some degrees. I expected the intense cold, which is usually felt there; but (as it happened) we had not three days of that, which we call winter-weather there, notwithstanding we were there in *December*, in which month it rained unusual and dangerous. The cold, which is so much talked of in books, hath been rare in these late years; for some *English*, which have lived there thirty years since, have observed such an alteration in the climate, that, except I had good confidence in the fidelity of their relations, being men of known worth and sobriety, I should not adventure to tell you, that in these thirty years the winters are become so mild, as the notable cold weather, which uses to freeze people in their way coming to market in several postures, as they were striking their horses, or guiding their sledges, hath been rarely felt, only to the freezing the noses and cheeks of some people, which may rather be termed a blast, than a settled intense cold.

11. THE warmer the room is made by day, the thicker is the hoar upon the glass at night, sometimes an inch thick, which I have seen. If it be a small frost, the nails only of the windows, which fasten the latten together, will be tipped with white; all the nails of insides of doors, and iron-work, will be adorned with the frost, and going out of the door you will endanger your breath.

THE falconers here say, birds creep under the snow at nights.

ASSUREDLY the bears provide themselves with a cave against the winter. I have kept a bear two days without meat or drink, he still sucking his paws, making a lather with his tongue; and, had he not smelt the meat of the house, which made him craving and clamorous, no doubt he might have been kept much longer upon his fast.

12. A wind from the sea there causes a thaw; so it does at *Archangel*, although it comes thither north.

I shall hereafter give you a catalogue of our plants, some of which are rare in *England*, but here in quantity, viz. *lilium convallium*, *pyrola*, *bifolium*, *polygonatum*, &c. I shall a little inform you concerning the vegetable lamb, which *Olearius* calls *barometts*.

13. BUT he told me they used very little physick, the air being so healthful, as that it is no rare thing to see people 80 or 100 years old; especially the poorer sort, that do not indulge themselves with strong drink.

14. THE same captain answered me, that in *Greenland* itself the north-east winds were colder than any other, which yet he ascribed in part to the situation of the country, those winds blowing over vast tracts of ice, without sea to mitigate the cold they communicated to the wind.

Particulars referable to the XIXth title.

1. LEUTENANT G. *Drummond*, who for some years was governour of *Smolensco*, told me, that he had many times barrels little less than our hogsheds of strong beer, which being left night and day in the sledges upon the snow, would be frozen all about next the cask to a considerable thickness, so that the gimlet must pierce the ice a great way, before the vessel would be set aboard; but then the liquor, which came forth, would not only be much stronger than the beer was at first, but much more pleasantly tasted.

2. LIEUTENANT G. *Drummond* confirmed what others had told me, of the great noise, like the discharge of muskets, that they hear in the wooden houses, whose walls are made of fir-trees (unsquared, and only disbarked,) upon very intense frosts; and he assured me, the great cracks or flaws, that appeared in the timber after these explosions, were barely clefts made by the bursting of the trees, without any splinters, or other parts of the wood thrown off from the body of the timber.

3. THE two Swedish Ambassadors assured me, that it is true, that in *Muscovy*, and some other northern countries also, the hares are, as in these parts, grey, (*grise*;) but snow-white in winter; and that they begin to change colour in autumn, (and to recover it in the spring.) And the elder of them, Monsieur *Coyet*, being asked of me, if he himself had observed it, he assured me, that he had. It was likewise affirmed by the Swedish Resident, who was then present, and related it to me before them, that in the borders of *Muscovy* he had seen store of partridges milk-white: when I asked, whether they changed colour in summer, or were not rather constantly white: he answered me, he could not tell, it being winter when he was there. And when I inquired, whether there were not some other besides hares, that changed colour according to the seasons, they all three told me, that squirrels, which in the summer are of the usual colour, do in the winter turn grey, and recover their colour in the following summer.

THEY were pleased also to send me word the next day by an ingenious gentleman, son to Monsieur *Coyet*, that they had forgot to tell me, that whereas the river *Duna* divides *Livonia* and *Muscovy*, on one side of the river the hares are of the ordinary colours, but on the other side white. So that when the hunters meet with any white hares on this side of the river, they say it is a *transfuga*.

4. AMONGST the odd effects of cold in *Russia*, and some other countries, where that quality

quality reigns in winter, it is none of the least admired, that if a man be abroad in the air with a cane or staff furnished with a metalline head, the cold is so intense in that compact body, that the tip of the tongue being applied to the metal, they will stick, and be (as it were) glewed together, so that a man cannot sever them without great pain, and sometimes without leaving some of the skin of his tongue behind upon the handle of the staff; as it has been affirmed to me by eye-witnesses of unquestionable credit. The reason of this odd phenomenon, as far as I can conjecture, may be the great and sudden loss of agitation occasioned in the spittle and part of the tongue, by the great want of agitation in the parts of the metal that they touch. For if a bowl (for instance) of ivory meet in a direct line with another of the same bigness, that is already moving upon a billiard-table, it will communicate to it but a part of its own motion, and so retain the rest for itself: but if the impelled bowl were at rest, the impelling bowl will communicate to it all, or almost all its motion, and lose as much itself, as may appear by its remaining quiescent in the place of the other. I must not enlarge upon this subject of motion among bodies, that hit against others. But to apply the observation to my present purpose, it seems the metalline handle of the stick, by the intenseness of the cold, has its parts so deprived of motion, that when those of spittle and the tongue have communicated to them as much of their agitation as they can, there will not be between those three bodies agitation enough to keep the spittle fluid, which consequently being turned into ice, will stick to the two consistent bodies it adhered to, namely, the tongue and the metal, and by this means will fasten them together.

In confirmation of this conjecture I shall add some other phenomena, which may be explicated by the help of it. And first we see, that in very frosty mornings the ice, that sticks to glass-windows, often appears in the form of trees, or otherwise oddly and prettily figured. This is vulgarly so explained, as if the cold produced those icy bodies on the outside of the glass, through which, some fancy, that the vapours of the warm room penetrate: but it is plain, that this ice uses to be formed within the room, as I have divers times observed, either by the thawing of it, or by scraping it off; so that it appears to be formed of vapours, which being carried to and fro by the air, when they chance to pass along the glass-panes of the windows, which by the cold, that reigns in the external air in frosty weather, have lost the wonted agitation of their parts, these vapours transfer so much of their motion to the glass, that they retain not enough to keep them fluid; the consequence of which is their being turned into ice, which in very cold countries may be far thicker than it uses to be here: inasmuch that a learned acquaintance of mine assured me, that he had in *Russia* observed in some stoves, (where it is like the heat produced store of vapours,) that the ice on the inside of the windows was near an inch thick.

A note out of Martinius, in his account of China.

5. *In Peking elevatione Poli 42. gr. per integros quatuor menses, facto circa Novembris medium initio, flumina omnia aded duro concresecunt gelu, ut currus, equosque, ac gravissima quæque onera glacies tuto ferat. Hæc plerumque concretio uno fit die; cum non nisi pluribus, & quidem ab inferiori superficie prius, fuit liquefactio.* p. 27. 'Martinius in his account of Peking' p. 27. tells us, that although the pole be not elevated above 42 degrees, yet for four whole months, from the middle of *November*, all the rivers are so bitterly frozen over, that the ice will safely bear coaches, and horses, and all the heaviest burdens. This congelation is for the most part made in one day; but the melting of the ice requires many, and begins from the lower surface.'

A note taken out of Martinius Cromerus his Polonia, lib. 1. p. 53, 54.

6. *Tanta est enim vis frigoris in his regionibus interdum, ut radicitus arefcant arbores, & aqua ex editiori loco effusa, priusquam terram contigerit, in glaciem concresecat. Lacus quidem, & paludes, & flumina duobus tribusve mensibus hibernis, nonnunquam autem vel in quintum vel sextum usque concreta glacie, non modo peditibus, verum etiam equitibus, & curribus ac plaustris, quamvis oneratis, multis simul longo spatio pervia & secura præbent itinera. Equidem quodam tempore ultimo die mensis Martii Vistulam in Masovia per firmam adhuc glaciem, cum curru & quadrigis, & aliquot equitum comitatu transivi. Hæc etiam præteritâ hyeme in Prussia glacialis piscatio in lacubus post initium Novembris cæpta, duravit per totum Martium, gelu autem per totum Aprilem.* 'So great is the violence of cold sometimes in these countries, that trees wither at the roots; and water poured out from an high place, turns into ice before it comes to the ground. And truly the lakes, and marshes, and rivers are so frozen for two or three months in winter, and sometimes for five or six, that not only footmen, but also horsemen, and coaches, and waggons, though loaded, may for a long space freely and securely pass over them. Truly once I passed over the *Weissel* in *Masovia* upon the firm ice the last day of *March*, with a coach and four horses, and a retinue of some horsemen; and this last winter in *Prussia* the fishing in the ice began in the lakes after the beginning of *November*, and continued all *March*, but frost lasted all *April*.

A note taken out of Cromerus's Polonia, lib. 1. p. 68.

In cæteris lacubus, atque etiam in majoribus piscinis & fluminibus tempore hyberno commodiores ferè sunt piscationes, quàm æstate, pertusâ certis intervallis glacie, retique per majus foramen in aquam immisso: quod longis funibus ad pericas alligatis hominum equorumve operâ longo spatio in diversum tractum, coëuntibus rursus piscatoribus, alio foramine refertum extrahitur. 'In other lakes, and in the larger fish-ponds, and rivers, fishing is more commodious in

• winter than in summer, the ice being broken
• in some places, and a net cast into the water
• through a great hole, which by long ropes
• tied to poles, men and horses draw different
• ways for a considerable space; and then the
• fishermen meeting together, take it up well
• filled at another hole.

7. AN ingenious physician confirmed to me upon trial, that the pommel of a sword, that was exposed to the winter-air in *Moscow*, would stick to his tongue, that touches it therewith, and fetch off the skin, if he forcibly and suddenly pulled it away.

8. A GENTLEMAN, that came lately from *Warsaw*, told me, that in one night, or rather twelve hours, he observed this winter the ice next the surface of the water to reach four inches directly downwards.

9. THE old sea-captain told me, that when he was in *Greenland*, and in those artick regions, his appetite was so great, that he could well eat more in one day, than he could in a week or ten days here; and that accordingly he and others found themselves stronger there than here, and more prone to venereal pleasures.

HE told me also, that sailing with intention to make some discovery into the artick circle, that after having sailed a great while through a sea exceeding blue and deep, they were as much surprized to find themselves on a sudden upon a sea black almost like ink, which much frightened them, none of all their wanderers having met with a sea of that colour. This made them, after many disputes and doubts, resolve to sound both from their ship and shallop, but they could find no ground at seventy fathom.

10. A BOTTLE of strong sack, about two thirds filled, cracked, and the wine was frozen, viz. the phlegm, but no ice on the top, as in water; nor does the phlegm ever ascend to the top, to be frozen in an entire body.

THIS sack being presently thawed, lost its vigour, and so will any thing else.

11. THE frost in these parts pierces the ground five foot, which the undertakers for digging a cellar for a friend of mine found by woful experience, being forced to make their way by fire, and sometimes by cleaving the earth with wedges like a rock.

THE ice in *Siberia* in the river *Ob* is said to be a fathom and a half thick, where they have in the whole year but twelve weeks of degelation.

THE rivers, that I have travelled over, have breathing-places for a mile, sometimes half a mile, and a quarter, out of which comes a fume like that of the *Cross-Bath* or *King's Bath* at the *Bath*. The like out of a cellar upon the opening of the door, enough to suffocate a man, if taken unawares.

DEATH by cold is not painful, especially if the cold be very intense; as a friend of mine told me, who waiting upon his uncle here (a colonel) in quality of a page, he fate upon the side of the sledge, as servants do, and it being very cold, he ran to get himself some

heat in his feet, and afterwards returned to sit upon the sledge, and found himself surprized with the cold, but had not the power to prevent the danger of suffocation by calling for help; yea, rather he seemed to be pleased with falling into a pleasing sleep, and so tumbled back upon his uncle's legs, which raised a suspicion in him, that his cousin was frozen: and so making haste to the next village, he rubbed him all over with snow strenuously enough, and afterwards brought him into a warm room, which by degrees revived him, he feeling himself afflicted and pained in all his limbs with such a tingling numbness, as they use to have who leaned too hard upon their elbows, but much more painful and amazing.

12. That cold dries excessively, appears by the story of the cheeses, and stock-fish, which is dried in the wind, some of which is sprinkled with salt. The earth will cleave with it, but I never observed it cracked with such monstrous hiatus, as *Olearius* reports; yet that may be true also. Where there is frost long before the snow comes, the ice in rivers will have cracks.

ABOUT the middle of *December* being at *Yewslave* in my lodging in a morning before day, the house being new, and exposed to the north-east wind, it gave a crack like a musket.

Particulars referable to the XXth Title.

1. A Sealed glass-bubble with quicksilver in it weighed in the air, and being carefully counterpoised in water, that to my hand, whilst I was sitting by the fire-side, felt luke-warm, did, after snow and salt were applied on the out-side of the glass, that held the water, weigh $\frac{3}{4}$ of a grain, or somewhat better, before or just when there appeared a little film of ice on the inside of the glass, containing the water, less than it did when the bubble was first put in.

2. A GLOBE of snow, rammed into the mould of just one inch diameter, weighed 112 grains.

3. A BULLET of ice of an inch diameter, made in the same mould, amounted to 2 drachms, 5 grains.

4. AFTER a long frost and snow, a great deal of new snow being fallen last night, the liquor in the gaged weather-glass stands beneath the first mark, argues a more than ordinary frost: and yet the mercury in the baroscope stands at near $\frac{2}{3}$ beneath 29 inches, to which perhaps the high wind may contribute.

5. FOUR ounces of snow made up in a lump, were counterpoised in a pair of good scales, and exposed in a frosty night after eleven o'clock without being taken out of the balance; the next morning between 9 and 10, there appeared a decrement of 29 or 30 grains, which seemed to have evaporated from the snow it self: for though a small portion of it (probably late in the morning) were melted in the scale, yet that liquor was but little, and amounted not to 8 grains, which was not a third of the weight, which the snow-ball had lost; but supposing the decrement would be greater, if the snow had

quaintance; and the thing being by him looked upon as remarkable, he was desirous to have it very circumstantially from the said physician himself, before he would say more of it. The next month may bring us in this account.

THE other particular mentioned in the title of this head, came in a letter sent also by Mr. Boyle, in these words:

I shall acquaint you, that two very ingenious men, Dr. Clarke and Dr. Lower, were pleased to give me an account of a pretty odd kind of observation: one of them assuring me, that he had several times, in the lungs of sheep, found a considerable quantity of grafs in the very branches of the aspera arteria:

and the other relating to me, that a few weeks since, he, and a couple of physicians, were invited to look upon an ox, that had for two or three days almost continually held his neck streight up, and was dead of a disease, the owner could not conjecture at; whereupon, the parts belonging to the neck and throat, being opened, they found, to their wonder, the aspera arteria in its very trunk all stuffed with grafs, as if it had been thrust there by main force: which gives a just cause of marvelling and inquiring, both how such a quantity of grafs should get in there; and how, being there, such an animal could live with it so long.

Of a Place in England, where, without petrifying Water, WOOD is turned into STONE.

First Printed in the *Philosophical Transactions*, N^o VI. as above.

THE same searcher of nature, that was alledged in the immediately precedent observations, did impart also the following, in another letter from Oxford, where he saith,

I was a while since visited by a gentleman, who tells me, that he met with a place in these parts of England, where, though there be no petrifying spring (for that I particularly asked) wood is turned into stone in the sandy earth itself, after a better manner than by any water I have yet seen: for I had the curiosity to go to look upon pieces of wood he brought thence, and hope for the opportunity of making some trials to examine the matter a little further, than I have been yet able to do. *Thus far that letter.*

SINCE which time, he was pleased to give this further information of the same matter,

with a mantissa of some other particulars, belonging to this subject, in these words:

I was lately making some trials with the petrified wood I told you of, which I find to be a very odd substance, wonderfully hard and fixed. If I had opportunity to reprint the *History of Fluidity and Firmness*, I could add divers things about stones, that perhaps would not be disliked; and I hope, if God vouchsafe me a little leisure, to insert several of them in fit places of that history, against the next edition. Here is a certain stone, that is thought to be petrified bone, being shaped like a bone, with the marrow taken out; but with a fit menstruum, I found that I could easily dissolve it, like other soft stones: and possibly it may prove as fit as osteocolla, for the same medicinal uses.

A Farther ACCOUNT of an OBSERVATION about WHITE BLOOD.

First Printed in the *Philosophical Transactions*, N^o VI. p. 117.

SINCE the printing of the former sheet, there is this farther account from the same hand, Mr. Boyle.

I have at length, according to your desire, received from the ingenious Dr. Lower an account in writing of the observation about chyle found in the blood; which though you may think strange, agrees well with some experiments of his and mine, not now to be mentioned. The relation, though short, comprizing the main particulars of what he had more fully told me in discourse, I shall give it you with little or no variation from his own words.

A maid, after eating a good breakfast, about seven in the morning, was let blood about eleven the same day in her foot; the first

blood was received in a porringer, and within a little while it turned very white; the last blood was received in a saucer, which turned white immediately, like the white of a custard. Within five or six hours after, he (the physician) chanced to see both, and that in the porringer was half blood and half chyle, swimming upon it like a serum as white as milk, and that in the saucer all chyle, without the least appearance of a drop of blood; and when he heated them distinctly over a gentle fire, they both hardened: as the white of an egg when it is heated, or just as the serum of blood doth with heating, but far more white. This maid was then in good health, and only let blood because she never had her courses, yet of a very florid clear complexion.

HYDROSTATICAL PARADOXES,

Made out by

NEW EXPERIMENTS,

For the most part PHYSICAL and EASY.

The PUBLISHER'S ADVERTISEMENT to the READER.

WHEN the author writ the following treatise, he had a design, as appears by some passages in the preface, to publish together with it some things, which he had divers years before provided for an Appendix to his Physico-mechanical treatise about the Air: but part of the Appendix consisting of experiments, which the author has several times made, but trusting to his memory, did not think it necessary to record, when he came to recollect particulars, he found, that some years, which had passed, since divers of them were tried, and variety of intervening occurrences, had made it unsafe for him to rely absolutely upon his memory for all the circumstances fit to be set down in the historical part of the design'd Appendix. And therefore he resolv'd to repeat divers experiments and observations, that he might set down their phænomena, whilst they were fresh in his memory, if not objects of his sense. But though, when he writ the following Preface he did it upon a probable supposition, that he should seasonably be able to repeat the in-

tended trials; yet his expectation was sadly disappointed by that heavy, as well as just visitation of the plague, which happened at *London*, whilst the author was in the country; and which, much earlier than was apprehended, began to make havock of the people at so sad a rate, that not only the glassmen there were scattered, and had, as they themselves advertised him, put out their fires, but also carriers, and other ways of commerce (save by the post) were strictly prohibited betwixt the parts he resided in, and *London*; which yet was the only place in *England*, whence he could furnish himself with peculiarly shaped glasses, and other mechanical implements requisite to his purposes: and the same calamity continuing still, without yet affording us any certain ground of determining, when it will end, the author chuses rather to suffer the following Paradoxes to come abroad without the Appendix, (which is no way necessary to them, whatever they may be to it,) than any longer put off those ingenious persons, that sollicit the publication of them.

The P R E F A C E.

THE rise of the following treatise being a command imposed on me by the Royal Society, the reader will, I hope, need no more, than this intimation, to keep him from wondering to find some passages worded as parts of a discourse pronounced before an assembly; it being not unusual (though not necessary) to present either in writing, or by word of mouth, together with the experiments made before that illustrious company, an historical account of them.

BUT, because it is probable, that some reader will desire to be satisfied about other particulars relating to the publication of this treatise, I presume it will not be amiss, both to say something of the reasons, why I publish it as the first part of the present Appendix to my *Physico-mechanical Experiments*, and to give some account of the manner of writing it.

V O L. II.

I HAD quickly both an opportunity, and an invitation to enlarge the papers, I was to read, beyond the limits of a bare description of the phænomena, and matters of fact, by my having been, through some intervening accidents, so hindered from exhibiting them altogether, that I was desir'd to bring in an account in writing, that might be register'd (how little soever worthy of such company) in the Society's collection of philosophical papers, for the sake of those members, who could not be present at all the experiments; so that, finding some enlargements expected from me, I was easily induced to add the explications of the phænomena I described, whilst I perceiv'd, that by a small addition of pains I might much gratify divers ingenious friends, that were not so well versed in Hydrostaticks; as in the other parts of real learning.

HAVING thus been induced to enlarge the account of my experiments, till it had at-

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tained the bulk it is now arrived at, I confess I was, without much difficulty, persuaded, that to suffer it to pass abroad * in the company of the Appendix, wherewith it is published, would not prove unacceptable to the curious, no more than an improper introduction to the rest of my Appendix, and that for several reasons.

FOR, first, the Hydrostaticks is a part of philosophy, which, I confess, I look upon as one of the ingeniousest doctrines, that belong to it; theorems and problems of this art being most of them pure and handsome productions of reason, duly exercised on attentively considered subjects, and making in them such discoveries as are not only pleasing, but divers of them surprising, and such as would make one at first wonder, by what kind of ratiocination men came to attain the knowledge of such unobvious truths. Nor are the delightfulness and the subtilty of the Hydrostaticks the only things, for which we may commend them: for there are many, as well of the more familiar, as of the more abstruse phenomena of nature, that will never be thoroughly understood, nor clearly explicated by those, that are strangers to the Hydrostaticks; upon whose principles depend, besides many other things, the explications of most of the physico-mechanical experiments, we have ventured to present the publick, and the decision of those many controversies, which they and the phenomena of the Torricellian experiment have occasioned among the modern inquirers into nature.

BUT the use of this art is not alone speculative, but practical, since not only the propositions it teaches, may be of great importance to navigation, and to those that inquire into the magnitudes and gravities of bodies, as also to them that deal in salt-works; but that the Hydrostaticks may be made divers ways serviceable to the chymists themselves, to whose art that doctrine seems to be so little of kin, I might here manifest, if I could think it fit to transcribe, what I have † elsewhere delivered to that purpose.

BUT that, which invited me to write something of this part of philosophy, is, not only that I think it considerable, but that, notwithstanding its being so, I find it but very little, and not very happily cultivated. For, being nor looked upon as a discipline purely mathematical, the generality of mathematicians have not in their writings so much as taken notice of it, much less improv'd it. And since the admirable *Archimedes*, who, in his little tract *De Insidentibus Humido*, has left us three or four very excellent propositions, (but proved by no very easy demonstrations) among divers others, that have more of geometrical subtilty than usefulness; those mathematicians, that (like *Marinus Ghetaldus*, *Stevinus*, and *Galileo*) have added any thing considerable to the Hydrostaticks, have been (that I know of) very few; and those too have been wont to handle them rather as geo-

metricians, than as philosophers, and without referring them to the explication of the phenomena of nature. And as for the Peripateticks and other school-philosophers, though on some occasions, as when they tell us, that water weighs not in water, nor air in air, they deliver assertions about matters belonging to the Hydrostaticks, (which term, in this treatise, I often take in a large sense, because most of the things delivered about the weight of bodies, may, by easy variations, be made applicable to other fluids;) yet they are so far from having illustrated, or improved them, that they have but broached, or credited, divers of the most erroneous conceits, that are entertained about them. So that, there being but few treatises written about the Hydrostaticks, and those commonly bound up among other mathematical works, and so written, as to require mathematical readers, this useful part of philosophy has been scarce known any farther, than by name, to the generality even of those learned men, that have been inquisitive into the other parts of it, and are deservedly reckoned among the ingenious cultivators of the modern philosophy. But this is not all; for some eminent men, that have of late years treated of matters hydrostatical, having been prepossessed with some erroneous opinions of the peripatetick school, and finding it difficult to consult experience about the truth of their conclusions, have interwoven divers erroneous doctrines among the sounder propositions, which they either borrowed from *Archimedes*, and other circum-spect mathematicians, or devised themselves; and these mistakes being deliver'd in a mathematical dress, and mingled with propositions demonstrably true, the reputation of such learned men, (from which I am far from desiring to detract,) and the unqualifiedness of most readers to examine mathematical things, has procured so general an entertainment for those errors, that now the Hydrostaticks is grown a part of learning, which it is not only difficult to attain, but dangerous to study.

WHEREFORE, though neither the occasion and design of this treatise exacted, nor my want of skill and leisure qualified me to write either a body, or elements of Hydrostaticks; yet I hoped I might do something, both towards the illustrating, and towards the rescue of so valuable a discipline, by publishing the ensuing tract; where I endeavour to disprove the received errors, by establishing paradoxes contrary to them, and to make the truths the better understood and received, partly by a way of explicating them unemploy'd in hydrostatical books, and partly by confirming the things I deliver, by physical and sensible experiments. And over and above this, the more to recommend Hydrostaticks themselves to the reader, I have, besides the paradoxes oppos'd to the errors I would disprove, taken occasion by the same way to make out some of the usefullest of those hydrostatical truths, that

* About this passage, see the Publisher to the Reader.

† Chiefly in several places of the unpublished part of the *Treatise of the Usefulness of Experimental Philosophy*.

that are wont to seem strange to beginners.

If it be here demanded, why I have made some of my explications so prolix, and have on several occasions inculcated some things; I answer, That those, who are not used to read mathematical books, are wont to be so indisposed to apprehend things, that must be explicated by schemes; and I have found the generality of learned men, and even of those new philosophers, that are not skilled in mathematicks, so much more unacquainted, than I before imagined, both with the principles and theorems of Hydrostaticks, and with the ways of explicating and proving them, that I feared, that neither the paradoxes themselves, that I maintain, nor the hypotheses about the weight and pressure of the air, upon which little less than my whole pneumatical book depends, would be thoroughly understood without such a clear explication of some hydrostatical theorems, as, to a person not versed in mathematical writings, could scarce be satisfactorily delivered in few words. And therefore, though I do not doubt, that those, who are good at the most compendious ways of demonstrating, will think, I might in divers places have spared many words without injury to my proofs; and though I am myself of the same mind I expect to find them of; yet I confess, that it was out of choice, that I declin'd that close and concise way of writing, that in other cases I am wont most to esteem. For writing now not to credit myself, but to instruct others, I had rather geometricians should not commend the shortness of my proofs, than that those other readers, whom I chiefly designed to gratify, should not thoroughly apprehend the meaning of them.

But this is not all, for which I am to excuse myself to mathematical readers. For some of them, I fear, will not like, that I should offer for proofs such physical experiments, as do not always demonstrate the things, they would evince, with a mathematical certainty and accurateness; and much less will they approve, that I should annex such experiments to confirm the explications, as if suppositions and schemes, well reasoned on, were not sufficient to convince any rational man about matters hydrostatical.

In answer to this, I must represent, that in physical enquiries it is often sufficient, that our determinations come very near the matter, though they fall short of a mathematical exactness. And I chuse rather to presume upon the equity of the reader, than to trouble him and myself with tedious circumlocutions, to avoid the possibility of being misunderstood, or of needing his candour. And we see, that even mathematicians are wont, without finding any inconvenience thereby, to suppose all perpendicular lines, made by pendulous bodies, to be parallel to one another: though indeed they are not; since, being produced, they would meet at the centre of the earth. And to presume, that the surface of every calm water, in a vessel, is parallel to

the horizon, and consequently a plane; though, in strictness, themselves think it the portion of a sphere; and though also I have usually observed it to be higher, where it is almost contiguous to the sides of the vessel, than it is in other places.

MOREOVER, since we find, that though water will be uniformly raised in pumps to several heights, but not to thirty-five foot; and will, in ordinary open pipes, be almost of the same level within and without, but not if the pipe be extraordinary slender; upon these, and divers other such considerations, I may have sometimes made use of expressions that seemed not positive and determinate enough to be employed about matters, to which mathematical demonstrations are thought applicable. But I elsewhere give an account of the scruples I have about such demonstrations, as they are wont to be applied to physical matters. And, in the present paradoxes, I think I have not done nothing, if in my hydrostatical explications I have made it appear, that in experiments made with such liquors and glasses, as I employed, the rules will hold without any sensible, or at least any considerable error; for thereby we may learn the truth of many things, for the main, though in some we should not have attained to the exactness of measures, and proportions, which yet our endeavours may assist others to arrive at.

AND as for my confirmation of hydrostatical propositions by physical experiments, if some readers dislike that way, I make no doubt, but that the most will not only approve it, but thank me for it. For though, in pure mathematicks, he, that can demonstrate well, may be sure of the truth of a conclusion, without consulting experience about it; yet because demonstrations are wont to be built upon suppositions or postulates; and some things, though not in arithmetick or geometry, yet in physical matters, are wont to be taken for granted, about which men are liable to slip into mistakes; even when we doubt not of the ratiocination, we may doubt of the conclusion, because we may of the truth of some of the things it supposes. And this consideration, if there were no other, will, I hope excuse me to mathematicians, for venturing to confute some reasonings, that are given out for mathematical demonstrations. For I suppose it will be considered, that those, whose presumed demonstrations I examine, though they were some of them professors of mathematicks, yet did not write merely as mathematicians, but partly as naturalists; so that to question their tenets ought not to disparage those, as well certain, as excellent and most useful sciences, pure mathematicks, any more than that the mathematicians, that follow the Ptolemaick, the Copernican, the Tyconian, or other systems of the world, write books to manifest one another's paralogisms in astronomical matters: and therefore (to proceed to what I was about to say) it cannot but be a satisfaction to a wary man to consult sense about those things, that fall under the cognisance

fance of it, and to examine by experiences, whether men have not been mistaken in their hypotheses and reasonings; and therefore the learned *Stevinus* himself (the chief of the modern writers of Hydrostaticks) thought fit, after the end of his Hydrostatical Elements, to add in an appendix some pragmatistical examples, (as he calls them) that is, mechanical experiments (how cogent I now inquire not) to confirm the truth of his tenth proposition, to which he had, not far from the beginning of his book, annexed what he thinks a mathematical demonstration. And, about the very subjects we are now upon, the following paradoxes will discover so many mistakes of eminent writers, that pretend to have mathematically demonstrated what they teach, that it cannot but make wary naturalists (and it is chiefly to gratify such, that I publish this) be somewhat diffident of conclusions, whose proofs they do not well understand. And it cannot but, to such, be of great satisfaction to find the things, that are taught them, verified by the visible testimony of nature herself. The importance of this subject, and the frequent occasion I have to make use of this kind of apology, will, I hope, procure me the reader's pardon, if I have insisted somewhat long upon it.

AFTER what has been hitherto discoursed, it will be easy for me to give an account, why I premise these hydrostatical paradoxes to the rest of the Appendix, wherewith they are * now publish'd: for since a great part of my work, in that Appendix, was to be a further explication of some things delivered in the book it is subjoin'd to, and the vindication of them from invalid objections; and since I have generally observed, that the objections, that have been, either publicly or privately, made against the explications and reasonings contained in that book, were wont to proceed from unacquaintedness, either with the true notion of the weight and spring of the air, as I maintain them, or with the principles and theorems of Hydrostaticks, or else from erroneous conceits about them; I thought it would much conduce to both the forementioned ends of my Appendix, if I cleared up that doctrine, to which my experiments and reasonings have been all along consonant; and whose being either not known, or misunderstood, seems to have occasioned the objections, that have been hitherto made against the hypotheses I have proposed, or the explications I have thence given. And however, since the proofs, I offer for my opinions, are for the most part drawn from experiments new and easy, and that my aim is but to discover truths, or make them out by clearer explications, without supposing, like those I dissent from, any thing, that is either precarious, or scarce, if at all, intelligible; I hope, that if I should not prove happy enough to reach my ends, yet the ingenious and equitable reader will approve my design, and be advantaged by my experiments. Of which some of the chiefest, and some of the most

difficult, having been seen (divers of them more than once) by the Royal Society itself, or by inquisitive members of it; it will, I presume, be but a reasonable request, if the reader, that shall have the curiosity to try them over again, be desired not to be hasty in distrusting the matters of fact, in case he should not be able at first to make every thing succeed according to expectation. For, as easy as I have endeavoured to make these experiments, yet I dare not promise myself, that they will all of them be privileged from the fate, whereto I have observ'd other physico-mathematical ones to be not seldom obnoxious, from some unheeded physical circumstance, by which those, that are not acquainted with the subtleties of nature, or, at least for the time, do not sufficiently consider them, are apt to be imposed upon.

THIS advertisement will, perhaps, be best illustrated and recommended by an instance; and therefore I shall subjoin one, that will possibly seem somewhat odd.

IT has been taken notice of by two or three ingenious modern mathematicians, and I have had occasion to make it out by particular experiments, that warm water is lighter *in specie*, than cold; whence it has been deduced, that wax, and other bodies, very near equiponderant with common water, will swim in that which is cold, and sink in that which is hot, or luke-warm. Which experiment, though as it may be (and perhaps it has been) tried, I readily allow to be agreeable to the known laws of the Hydrostaticks, yet I have sometimes undertaken, that the trial should have a quite contrary effect. To that purpose, having taken some yellow bees-wax, which was formed into a pellet of the bigness of a cherry, and, by the help of a little lead, was made so near equiponderate to cold water, that, being but a very little heavier, a very small diminution of its weight would make it emerge, I removed it out of the very cold water into some, that had been purposely made luke-warm (or a little more than so,) where it quickly, somewhat to the wonder of the lookers on, appeared to swim on the top of the water. And that it might not be suspected, that it was supported by any visible bubbles, which I have observed, in some cases, to buoy up even heavy bodies, and deceive the unskilful, or unattentive; I briskly enough ducked the bullet two or three times under water to throw them off, notwithstanding which it constantly return'd to float; and yet, being removed again into the same cold water it had been taken out of, and ducked as before, to free it from adherent bubbles, it lay quietly at the bottom, and, though raised several times to the upper part of the water, would immediately subside to the very lowest. Now that, which invited me to promise an experiment, which seems to contradict the principles of the Hydrostaticks, was not any distrust of those principles themselves, but a conjecture, that as by warmth the water would be made a little lighter *in specie* than it was before;

• An account of this passage also may be had from the Publisher's Advertisement to the Reader.

before ; so, by the same warmth, the spirituous and more agitable parts of the wax, whose texture is loose enough, would be somewhat (though not visibly) expanded, and would by that expansion gain a greater advantage towards floating, than the increased lightness of the water would give it disposition to sink. And I confirm'd this conjecture by a farther experiment, which at first was itself somewhat surprising to the beholders. For when the wax was first taken out of the cold water, and immediately immersed in the warm, it would readily enough sink ; and being (with a quill or a knife) raised to the top of the water, it would again fall down, but more slowly than at the beginning ; and after some few minutes, if it were rais'd to the upper parts of the water, it would remain afloat. (And I have known it, when it had remained a while longer at the bottom, so to emerge, that if I were sure no unheeded bubbles had been newly generated, and held it up, it might be said to emerge of its own accord ;) as on the other side, being put into the cold water, as soon as ever it was taken out of the warm, it would at the very first float, and being then knocked downwards, it would, readily enough, regain the upper part of the water : but if I continued to send it downwards about six or seven times (more or fewer) successively, it would emerge every time more slowly than other, and at length not emerge at all, even when I tried it in water made heavy, by being highly infri- ginated with salt and snow placed about the glass. Which phenomena I had thought it reasonable to expect, because I presumed, that the wax, being removed immediately out of the warm water into the cold, must require some time to lose the adventitious expansion, which the warmth had given it, and must be deprived of it by degrees, by the coldness of the water, into which the wax was transferred. As, on the other side, there must be some time necessary for so little a warmth, as that of the tepid (or little more than tepid) water, to give the wax that addition of dimensions, (which also it must receive by degrees) that was necessary, in spite of the rarefaction of the water, to make it float. I might add, that these trials were repeated, for the main, with more

bullets of wax than one, and that they succeeded far otherwise, when, instead of a piece of wax, we employed a poised glass-bubble, in which the temperature could make either no change at all, or no considerable change of dimensions. And to these I might add other circumstances, if I did not remember, that I mention these trials but occasionally, and to make the caution, formerly recommended to the reader, appear not to be impertinent ; since a hydrostatical experiment, true in itself, may easily miscarry by overlooking such circumstances, as it is not easy to be aware of.

But, by this advertisement, I would by no means divert men from being diffident of hydrostatical traditions and experiments. For, besides the many erroneous opinions, there are matters of fact, whose truth, though not question'd, but built upon, I think ought to be brought to trial. For, even whilst I was concluding this preface, I found, that divers, even of the moderns, and particularly a very learned man, that has lately written of Hydrostaticks, have much troubled themselves to render a reason, why, since, according to their doctrine, water weighs not in water, wooden vessels, though of a substance lighter than water, being by leaks, or otherwise, fill'd with water, should sink and remain at the bottom of the water : whereas, judging this phenomenon disagreeable to what I look upon as the laws of the Hydrostaticks, I was confirm'd in that opinion, by having had the curiosity to make some trials of it, with four or five vessels of differing shapes and sizes, whereof two were of wax ; which, though a matter but very little lighter than water, I could not sink, or keep sunk by pouring water into them, or suffering them to fill themselves at leaks made near the bottom : and if they were depressed by force or weights, they, as also the wooden vessels, would, upon the removal of the impediment, (and sometimes with the cavity upwards) emerge. . And I am the more solicitous to have things in the Hydrostaticks duly ascertained, because the weighing of bodies in liquors may hereafter appear to be one of the general ways I have employed, and would recommend, for the examining of almost all sorts of tangible bodies.

HYDROSTATICAL PARADOXES,

Made out by

NEW EXPERIMENTS,

Presented to the ROYAL SOCIETY, (the Lord Viscount
BROUNCKER being then President) *May 1664.*

MY LORD,

TO obey the orders of the Society; that forbid the making of prefaces and apologies, in accounts of the nature of that, which you expect from me; I shall, without any further preamble, begin with taking notice, that upon perusal of Monsieur *Pascal's* small French book, which was put into my hands, I find it to consist of two distinct treatises; the one, of the *Æquilibrium* of liquors, as he calls it; and the other, of the *weight of the mass of the Air*.

As for this latter, (which I shall mention first, because I can in very few words dispatch the little I have to say of it;) though it be an ingenious discourse, and contains things, which, if they had been published at the time, when it is said to have been written, would probably have been very welcome to the curious; yet I have very little else to say of it in this place, in regard that, since that time, such kind of experiments have been so prosecuted, that I presume it is needless, and would not be acceptable to repeat, what Monsieur *Pascal* has written, in this Society, which has seen the same truths, and divers others of the like nature, more clearly made out by experiments, which could not be made by Monsieur *Pascal*, and those other learned men, that wanted the advantage of such engines and instruments, as have in this place been frequently made use of.

WHEREFORE, having already at a former meeting given you, by word of mouth, an account of Monsieur *Pascal's* ingenious invention, of a pair of bellows without vent, to measure the various pressure of the atmosphere; I remember nothing else, that needs hinder me from proceeding to the other part of his book, *The Treatise of the Æquilibrium of Liquors*.

THIS I find so short, and so worthy of the author, that to give you all, that I judge worth taking notice of in it, would oblige me to transcribe almost the whole tract; and therefore I shall rather invite you to read the whole, than divert you from the design by culling out any part of it; yet, if you will not be satisfied without something of more particular, I shall be obliged to tell you, that the discourse consisting partly of conclusions, and partly of experiments, the former seemed to me to be almost all of them (there being but few that I doubt of) consonant to the principles and laws of the Hydrostaticks. But as

for the latter, the experimental proofs he offers of his opinions are such, that, I confess, I have no mind to make use of them.

AND the reasons, why, notwithstanding that I like most of Monsieur *Pascal's* assertions, I decline employing his way of proving them, are principally these:

FIRST, Because though the experiments he mentions be delivered in such a manner, as is usual in mentioning matters of fact; yet I remember not, that he expressly says, that he actually tried them, and therefore he might possibly have set them down, as things, that *must* happen, upon a just confidence, that he was not mistaken in his ratiocinations. And of the reasonableness of this doubt of mine, I shall ere long have occasion to give an instance.

SECONDLY, Whether or no Monsieur *Pascal* ever made these experiments himself, he does not seem to have been very desirous, that others should make them after him. For he supposes the phenomena he builds upon to be produced fifteen or twenty foot under water. And one of them requires, that a man should sit there with the end of a tube leaning upon his thigh; but he neither teaches us, how a man shall be enabled to continue under water, nor how, in a great cistern full of water, twenty foot deep, the experimenter shall be able to discern the alterations, that happen to mercury, and other bodies at the bottom.

AND thirdly, These experiments require not only tubes twenty foot long, and a great vessel of, at least, as many feet in depth, which will not in this country be easily procured; but they require brass cylinders, or plugs, made with an exactness, that, though easily supposed by a mathematician, will scarce be found obtainable from a tradesman.

THESE difficulties making the experiments proposed by Monsieur *Pascal* more ingenious than practicable, I was induced, on this occasion, to bethink myself of a far more expeditious way to make out, not only most of the conclusions, wherein we agree, but others, that he mentions not; and this with so much more ease and clearness, that not only this illustrious assembly, but persons, no more than moderately versed in the vulgar principles of the Hydrostaticks, may easily enough apprehend, what is designed to be delivered, if they will but bring with them a due attention, and minds disposed to prefer reason and
experience

experience to vulgar opinions and authors: which last clause I annex, because the following discourse, pretending to confute several of those, challenges a right to except against their authority.

It not being my present task to deliver the elements, or a body of Hydrostaticks, but only ten or twelve paradoxes, which I conceive to be proveable by this new way of making them out; I shall, to avoid confusion, deliver them in as many distinct propositions: after each of which, I shall endeavour in a proof, or an explication, to shew, both that it is true, and why it ought to be so. To all these I shall, to avoid needless repetitions, premise a word or two by way of postulatam, or lemma.

AND because I remember, to what assembly I address this discourse, I shall make use of no other, than an easy supposition I met with, in a short paper (about a mercurial phenomenon) brought in a year or two since to this learned Society, by a deservedly famous member of it*: for though his supposal be made upon occasion of an experiment of another nature, than any of the ensuing, it may be easily accommodated to my present purpose.

THIS postulatam, or lemma, consists of three parts; the first of them more, and the two last less principal.

SUPPOSE we then, first, that if a pipe open at both ends, and held perpendicular to the horizon, have the lower of them under water, there passes an imaginary plane or surface, which touching that orifice, is parallel to the horizon, and consequently parallel, as to sense, to the upper surface of the water; and this being but a help to the imagination, will readily be granted.

SECONDLY, To this it will be consonant, that each part of this designable surface will be as much, and no more pressed, as any other equal part of it, by the water that is perpendicularly incumbent on it. For the water, or other fluid, being supposed to be of an homogeneous substance, as to gravity, and being of an equal height upon all the parts of the imaginary surface; there is no reason, why one part should be more pressed by a perpendicular pillar of that incumbent fluid, than any other equal part of the same surface by another perpendicularly incumbent pillar of the same, or equal basis and height, as well as of the same liquor.

BUT thirdly, Though whilst our imaginary surface is equally pressed upon in all parts of it, the liquor must retain its former position; yet, if any one part comes to have a greater weight incumbent on it, than there is upon the rest, that part must be displaced, or depressed, as it happens, when a stone, or other body heavier than water, sinks in water. For wherever such a body happens to be underneath the water, that part of the imaginary plane, that is contiguous to the lower part of the stone, having on it a greater

weight, than other parts of the same surface, must needs give way; and this will be done successively, till the stone arrive at the bottom. And if, on the other side, any part of the imaginary surface be less pressed upon than all the rest, it will, by the greater pressure on the other parts of the surface, be impelled upwards, till it have attained a height, at which the pressure (of the raised water, and the lighter or floating body, if any there be, that leans upon it, and gravitates together with it upon the subjacent part of the imaginary surface) will be equal to that, which bears upon the other parts of the same surface.

AND because this seems to be the likeliest thing to be questioned in our † assumption, though he, that considers it attentively, will easily enough be induced to grant it; yet I shall here endeavour to evince it experimentally, and that by no other way of proof, than the same I employ all along this present discourse.

TAKE then a cylindrical glass pipe, of a convenient bore, open at both ends; let the tube be steadily held perpendicular to the horizon, the lower end of it being two or three inches beneath the surface of a convenient quantity of water, which ought not to fill the glass vessel, that contains it. The pipe being held in this posture, it is manifest, that the water within the pipe will be almost in a level with the surface of the water without the pipe, because the external and internal water (as I am wont for brevity's sake to call them) have free intercourse with one another, by the open orifice of the immersed end of the pipe; yet I thought fit to insert the word *almost*, because, if the pipe be any thing slender, the surface of the water in it will always be somewhat higher than that of the water without it, for reasons, that it is not so necessary we should now inquire after, as it is, that we should here desire to have this taken notice of once for all; that mistakes may be avoided without a troublesome repetition of the difference in heights of the surface of liquors within pipes and without them, in case they be any thing slender.

THE pipe being held in the newly-mentioned posture, if you gently pour a convenient quantity of oil upon the external water, you shall see, that as the oil grows higher and higher above the surface of that water, the water within it will rise higher and higher, and continue to do so, as long as you continue to pour on oil; of which the reason seems manifestly to be this; that in the imaginary plane, that passes by the orifice of the immersed end of the pipe, all that is not within the compass of the orifice, is exposed to an additional pressure from the weight of the oil which swims upon the water, and that pressure must still be increased, as there is more and more oil poured on: whereas a circular part of the imaginary plane, equal to the orifice of the glass, is by the sides of the pipe fenced from the immediate pressure of the oil;

* That excellent mathematician, the learned Dr. Wallis, Savilian Professor of Geometry.

† This Experiment, and the Explication of it, if to some they should here seem somewhat obscure, will be easily understood by the Figures and Explications belonging to the first ensuing paradox.

oil; so that all those other parts of the water, being far more pressed, than that part, which is comprehended within the cavity of the tube, and consequently the pressed parts of the external water are, by the equal gravitation of the oil upon the parts of the external water, impelled up into the cavity of the pipe, where they find less resistance than any where else, till they arrive at such a height, that the cylinder of water within the pipe does as much gravitate upon the subjacent part of the imaginary surface, as the water and oil together do upon every other equal part of the same surface or plane.

But as well the former lemma, as this experiment, will be sufficiently both cleared and confirmed by the following explications; to which I should for that reason forthwith proceed, were it not, that, since divers passages of the following treatise suppose the air to be a body not devoid of weight, which yet divers learned adherents to the Peripatetick philosophy do resolutely deny, it seems requisite to premise something for the proof of this truth.

AND though I think the arguments we have employed to that purpose already, do strongly evince it; yet, if I may be allowed to anticipate one of my own experiments of the Appendix, I shall give an instance of the weight of the air, not liable so much as to those invalid objections, which some of the Aristotelians have made against those proofs, wherewith we have been so happy, as to satisfy the learnedest even of our professed adversaries.

WE caused then to be blown at the flame of a lamp a bubble of glass, (of about the bigness of a small hen-egg) which, that it might be light enough to be weighed in exact scales, ought to be of no greater thickness than is judged necessary to keep it from being (when sealed up with none but very much expanded air in it) broken by the pressure of the ambient atmosphere. This bubble was (like a pear with its stem) furnished with a very slender pipe of glass, at which it was blown, that it might be readily sealed up; and then, (the air within it being by the flame of the lamp gradually rarified, as much as conveniently could be) whilst the body of the bubble was exceeding hot, the newly-mentioned stem was nimbly put into the middle of the flame; where, by reason of its slenderness, the glass, which was exceeding thin, was immediately melted, whereby the bubble was hermetically sealed up. This glass being permitted leisurely to cool, I could afterwards keep it by me an hour, or a day, or a week, or longer, if I thought fit; and when I had a mind to shew the experiment, I put it in one of the scales of an exact balance, that would turn, perhaps, with the thirtieth, or fiftieth, or a less part of a grain; and having carefully counterpoised it, I then warily broke off the sealed end, placing a sheet of paper just under the scale, to receive the fragments of the glass; and putting in again those fragments, that scale, wherein the glass was, would considerably preponderate; which it must do upon the

account of the weight of air, there being no other cause, either needful, or justly assignable, but the weight of the air that rushed into the cavity of the glass, as finding less resistance there than elsewhere, by reason that the included air had its spring much weakened by its great expansion.

THIS experiment I many times tried, sometimes before some Virtuosi, and sometimes before others; who all allowed it to be conclusive. For here it could not be objected, as against the weighing of air in a bladder, (which objections yet I could easily answer, if it were now proper) that the air, which ponderates, is stuffed with the effluvia of him, that blows the bladder, and (besides that) is not air in its natural state, but violently compressed. For here it is the free air, and in its wonted laxity, that makes the glass preponderate.

AND that there is a great ingress of the external air, is evident by these three phenomena. The one, that if you lend an attentive ear, you shall plainly hear a kind of whistling noise to be made by the external air, as it rushes violently in upon the breaking of the glass; the other, that the rarefaction of the air sealed up in the bubble being very great, there is a great deal of space left for the ambient air to fill upon its admission; and the greatness of this rarefaction may be guessed at, both by the breaking of such bubbles now and then by the pressure of the external air, which is not competently assisted by the internal to resist; and also by the third phenomenon I intended to take notice of, namely, That, if, instead of breaking off the sealed end of the glass in the air, you break it under water, that liquor will, by the pressure of the atmosphere, be forced to spring up like an artificial fountain into the cavity of the bubble, and fill about three quarters of it. By which last circumstance I gather, that the weight of the air is more considerable, than even many, who admit the air to have weight, seem to imagine. For we must not suppose, that all the air contained in the bubble, when broken, weighs no more, than the weight requisite, in the opposite scale, to reduce the balance to an equilibrium; since this additional weight is only that of the air, that intrudes on the breaking of the glass; which air, by the observations newly mentioned to have been made with water, appears to be but about three quarters of the whole air contained in the broken bubble; and yet, according both to our estimate, and that of divers Virtuosi, and some of them eminent mathematicians, when the capacity of the bubble was short of two cubical inches, (and so proportionably in other glasses) the nice balance we used, manifested the newly-admitted air to amount to, sometimes, near half a grain, and sometimes beyond it.

AND because one of the last experiments that I made to this purpose, with sealed bubbles, was none of the least accurate, I shall conclude this subject with the following account of it:

A THIN glass bubble, blown at the flame of a lamp, and hermetically sealed, when the contained air was exceedingly rarified, was counterpoised in a nice pair of scales; and then the sealed *apex* being broken off, and put again into the same scale, the weight appeared to be increased by the re-admitted air, a pretty deal above $\frac{1}{16}$ ths, and consequently very near, if not full $\frac{1}{4}$ of a grain. Lastly, having by some slight (for it is no very easy matter) filled it with common water, we weighed the glass and water together, and found the latter, besides the former, to amount to nine hundred and six grains. So that supposing, according to our former estimate, countenanced by some trials, that the re-admitted air, which amounted to $\frac{1}{4}$ of a grain, filled but $\frac{1}{4}$ of the whole cavity of the bubble, the air that was in it, when sealed, possessing one quarter of that cavity, the whole air contained in the bubble may be reasonably presumed to weigh a whole grain; in which case we might conclude (abstracting from some little niceties, not fit to be taken notice of here, as elsewhere) that the water in our experiment weighed very little more, than nine hundred times as much as an equal quantity of air. And therefore, though we allow, that in an experiment so diligently made as this was, the air pre-existent in the bubble did not adequately possess so much as a fourth part, but about a fifth, or a sixth of its cavity, the air will yet appear so heavy, that this experiment will agree well with those others, recorded in another treatise, wherein we assigned (*numero rotundo*) a thousand to one, for the proportion wherein the specifick gravity of water exceeds that of air.

P A R A D O X I.

That in water, and other fluids, the lower parts are pressed by the upper.

PROVIDE a glass-veffel of a convenient height and breadth, A, B, C, D. filled with water almost to the top; then take a glass-pipe, open at both ends, cylindrical, and of a small bore, (as about the eighth, or sixth part of an inch in diameter.) Put the lower end of this pipe into clear oil, or spirit of turpentine; and having, by suction, raised the liquor to what part of the pipe you think fit, as soon as it is there, you must, very nimbly removing your lips, stop the upper orifice with the pulp of your finger, that the raised liquor may not fall back again: then, taking the pipe, and that liquor out of the oil of turpentine, place it perpendicularly in the glass of water, so as that the surface of the oil in the pipe be somewhat higher than that of the water without the pipe; and having so done, though you take off your finger from the upper orifice of the pipe, the oil will not fall down at the lower orifice, though that be open, but will remain suspended at the same height, or near thereabouts, that it rested at before.

Now oil of turpentine, being a heavy fluid, does, as such, tend downwards; and

not being stopped by the glass itself, whose lower orifice is left open, it would certainly fall down through the pipe, if it were not kept suspended by the pressure (upwards) of the water beneath it; there appearing no other cause, to which the effect can reasonably be ascribed, and this being sufficient to give an account of it, as we shall presently see. For that it is not any contrariety in nature, betwixt the oil and the water, as liquors, that will not mingle, is evident from hence; that if you had removed your finger, when the pipe was not so deeply immersed in the glass, but that the surface of the oil in the pipe was an inch or two more elevated above that of the water in the glass, than in our present case we suppose it to be; the oil, notwithstanding its presumed contrariety to water, would have freely subsided in the pipe, till it had attained an equipollency of pressure with the external water.

THE reason, therefore, of the phenomenon seems to be plainly this: Supposing the imaginary surface, on which the extremity Q of the pipe PQ leans, to be GH. If that part of the surface, on which the oil leans at Q, be as much, and no more charged, or pressed upon by the weight of the incumbent cylinder of oil QX, than the other parts of the same imaginary surface GH are by the water incumbent on them, there is no reason, why that part at Q should be displaced, either by being depressed by the weight of the cylinder of oil XQ, or raised by the equal pressure of water upon the other parts of the superficies GH.

AND that this equilibrium, betwixt the oil and the water, is the true cause of the phenomenon, may be confirmed by observing what happens, if the altitude of either of the two liquors be altered in relation to the other.

AND, first, we have already taken notice, that if the cylinder of oil reach, in the pipe, much higher than that of the surface of the water, the oil will descend: of which the reason is, because, the designable surface GH being more charged at Q than any where else, the part Q, being unable to resist so great a pressure, must necessarily be thrust out of place by the descending oil.

SECONDLY, This subsiding will continue but till the surface of the oil in the pipe be fallen almost as low, as that of the water without the pipe; because then, and not before, the parts at Q are but as much pressed by the oil, as the other parts of the surface GH are by the water, that leans upon them.

THIRDLY, It is a concluding circumstance to our present purpose, that if, the oil and water being in an equilibrium, you gently lift up the pipe, as from Q to S, the depth of the water being lessened, the oil in the pipe will grow preponderant, and therefore will fall out in drops or globules; which, by the greater specifick gravity of the water, will be buoyed up to the top of the liquor, and there float: and still, as you lift up the pipe higher and higher towards the surface LM, more and more of the oil will run out. But if you stop

the pipe any where in its ascent, as at S, the effluxion of the oil will likewise be stopped. And at the imaginary superficies JK, as by reason of the shallowness of the water from L to J, or M to K, the pressure of the water upon the other parts of the surface is not near so great, as it was upon the surface GH, where the water had a greater depth; so, by reason of the proportionate effluxion of the oil, whilst the pipe was lifted up from Q to S, the remaining cylinder of oil, incumbent on S, is not able to press that part of the superficies JK more strongly, than the other parts of the same superficies are pressed by the water incumbent on them. And if the pipe be lifted up, till the lower orifice be almost raised to V, that is, almost as high as the uppermost surface of the water LM, so much of the oil will, for the reason already given, run out, that there will scarce be any left in the pipe TV.

FOURTHLY, But if, when the pipe rests at the surface GH, where the oil is in an æquilibrium with the water, you should, instead of lifting it from Q to S, thrust it down from Q to O; then the external water would not only sustain the oil, but make it ascend in the pipe to a height equal to the distance EG; and so the pipe will contain, besides a longer cylinder of oil ÆW, a shorter one of water ÆO. For the pipe being transferred from the position PQ, to the position ON, there is a new imaginary surface EF, that passes by the lower orifice of the pipe. Now the part of this surface at O will not, by the incumbent oil alone, be pressed as much as the other parts of the same surface are by the incumbent water. For the oil alone was but in æquilibrium with the water, when it was no deeper than LG, or HM; so that the other parts of the superficies EF being more pressed upon by the water, than the part at O by the oil, the oil must give place, and be buoyed up by the water, (which, if it were not for the weight of the oil, would be impelled up into the pipe full as high as the surface of the external water) till the pressure of the admitted water OÆ, and the cylinder of oil ÆW, do both together gravitate as much upon the part O, as the rest of the incumbent water does upon the other parts of the same superficies EF.

FIFTHLY, and lastly, It is very agreeable to what has been delivered, touching the æquilibrium of the oil and water in the pipe PQ, that the surface X, of the oil in the pipe, will not be of the same level with LM, that of the external water, but a little higher than it. For though the slenderness of the pipe do somewhat contribute to this effect, yet there would be an inequality, though not so great, betwixt these surfaces, upon this account; that oil of turpentine being *in specie*, (as they speak in the schools) that is, bulk for bulk, a lighter liquor than water, it is requisite, that the height of it, incumbent on the part Q, be greater than that of the water on the other parts of the same surface GH, to make the pressure of the oil, on the part it leans

upon, equal to the pressure of the water on the other parts of the surface. And if the inequality were greater betwixt the specific gravities of these two liquors, the inequalities betwixt the surface X and the surface LM would be also greater; as may be tried by substituting, for common water, oil of tartar *per deliquium*, which is a saline liquor much heavier than it. And that, in case the pipe contain not a lighter liquor than the external fluid, the surface of the liquor in the pipe will not be higher, than that of the liquor without it, we shall by and by have opportunity to manifest by experience.

FROM what has been hitherto shewn, we may safely infer the proposition, upon whose occasion all this has been delivered. For since the oil, in a pipe open at both ends, may be kept suspended in any part under water, as at Q, because it is there in an æquilibrium with the external water; and since, being lifted up in the water, as from Q to S, the oil can no longer be kept suspended, but, by its own gravity, will run out: and since, in a word, the deeper the water is, the greater weight and pressure is required in the cylinder of oil, to be able to countervail the pressure of the water, and keep itself from being lifted up thereby; there seems no cause to doubt, but that the parts of the water incumbent on the superficies GH do more press that superficies, than the parts of the water contiguous to the superficies JK do press that; and consequently, that the parts of the water, that are under the uppermost surface of it, are pressed by those of the same fluid, that are directly over them. As we saw also, that the upper parts of the oil, whilst the pipe was in raising from Q to S, depressed the lower so much, as to force them quite out of the pipe; there being, in these cases, no reason, why the lowermost parts of a liquor should press more, or have a stronger endeavour against any other liquor (or any other body) the higher the liquor incumbent reaches, if these inferior parts derived their pressure only from their own particular gravity, (which is no greater, than that of the other homogeneous parts of the liquor :) and therefore they must derive the great force, wherewith they press, from the weight of the incumbent parts, which, consequently, must be allowed to press upon them.

BUT, before I proceed to the following propositions, it will not be amiss to mention here, once for all, a few advertisements, to avoid the necessity of repeating the same things in the sequel of the discourse.

AND first, What is here said of the pressure of the parts of water upon one another, and the other affections, that we shall attribute to it, in the following paper, are to be applied to heavy fluids in general, unless there shall appear some particular cause of excepting some of them in particular cases.

SECONDLY, Whereas I lately intimated, that the inequality betwixt the surfaces of the oil in the pipe, and of the external water, was in part to be ascribed to the slenderness of the

the

the pipe to be employed in these experiments; I did it for this cause, that, whatever the reason of it be, (which we need not here inquire after,) we are assured by experience, as we have elsewhere shewn, that, when glass-pipes come to be slender, water, and many other liquors (though not quicksilver) will have within them a higher surface, than that of the same liquor without them; and this inequality of surfaces (as far as we have yet tried) increases with the slenderness of the pipe. But this, as to our present experiment, is a matter of so little moment, that it may suffice to have intimated, that we did not oversee it.

THIRDLY, Wherefore, notwithstanding this little inconvenience of slender glasses, we think it expedient to employ such in the following experiments, because we found, that in those of a wide bore, upon such little inequalities of pressure, as are not easily to be avoided, the oil and water will pass by one another in the cavity of the pipe, and so spoil the experiment, which requires, that the oil within the pipe be kept in an intire and distinct body.

FOURTHLY, Common oil and water, or any other two liquors, that will not mingle, may serve the turn in most of these experiments; but we rather chuse oil of turpentine, because it is light and thin, clear and colourless, and may be easily had in quantities, and is not so apt to spot one's clothes, or obstinately to adhere to the porous bodies it chances to fall on, as common, and other expressed oils. And for their sakes, to whom the odour is offensive, we presently correct it, by mingling with it a convenient quantity of oil of rhodium, or some other chymical oil, that is odoriferous.

FIFTHLY, Oil of turpentine, though it be not reckoned among the saline menstruums, will yet (as we elsewhere note) work upon copper, and so by digesting it upon crude filings of that metal, we obtain a deep green liquor, which may be made use of instead of the limpid oil, to make the distinction of the liquors more conspicuous.

SIXTHLY, And for the same purpose we often use, instead of clear water, a strong decoction of brazil, or log-wood, or else red ink itself: I say, a strong decoction, because unless the liquor be so deeply tinged, as to appear opacous in the glass, when it comes into the slender pipe, its colour will be so diluted, as to be scarce discernible.

SEVENTHLY, In the shape of the glass-vessel, we need not be curious; though that of a wide-mouthed jar, expressed in the scheme, be for some uses more convenient than other shapes. The depth of these glasses, and the length of the pipes, must be determined by the experiments, about which one means to employ them. To make out the first paradox already proved, a glass of about five or six inches deep, and a pipe about as many inches long, will serve the turn: but

for some others of the following experiments, tall cylindrical glasses will be requisite; and for some, broad ones likewise will be expedient.

EIGHTHLY, One must not be discouraged by not being able, at the first or second time, to suck up oil of turpentine to the due height, and stop it with one's finger from relapsing; but one must try again, and again; especially since many trials of this kind may be made in a few minutes: and for beginners it is a safe and good, though not the shortest way, to suck up rather more liquor than one judges will be needful; because having filled the pipe to that height, you may, by letting in the air warily and slowly between the orifice of the glass and the pulp of your finger, suffer so much liquor to run out of the pipe, as will reduce it to the height you desire; and there, by close stopping the orifice with your finger, you may keep it suspended as long as you please, and immerse it into any heterogeneous liquor, and take it out again at pleasure without spilling any of it. By which slight expedient alone, I can decline several difficulties, and do many things, which, according to Monsieur *Pascal's* way, require a great deal of trouble and apparatus to be performed,

LASTLY, In such experiments, where it may be of use, that there be a considerable disparity betwixt the two unmingled liquors, we may (as is above intimated) instead of fair water, employ *oleum tartari per deliquium*, and tinge it with brazil or cochineel; from either of which, but especially from the latter, it will obtain an exceeding deep redness. And where one would avoid strong scents and oiliness, he may, if he will be at the charge, employ oil of tartar *per deliquium*, instead of fair water; and highly rectified spirit of wine, instead of oil of turpentine. For these two liquors, though they will both readily mingle with water, will not with one another; and if a great quantity of some other liquor be to be substituted for simple water, when these chymical liquors are not to be had in plenty, one may employ (as we have done) a very strong solution made of sea-salt, and filtered through cap-paper: this brine being near about as limpid as common water, and far heavier than it. And for a curiosity, we have added to the two lately mentioned liquors (oil of tartar, and spirit of wine) some oil of turpentine, and thereby had three liquors of different gravities, which will not by shaking be brought so to mingle, as not quickly to part again, and retire each within its own surface; and by thrusting a pipe with water in the bottom of it (placing also one's finger upon the upper orifice) beneath the surface of the lowermost of these liquors, and by opportunely raising or depressing it, one may somewhat vary the experiment in a way not unpleasant, but explicable upon the same grounds with the rest of the phenomena mentioned in this discourse.

PARADOX II.

That a lighter fluid may gravitate or weigh upon a heavier.

I KNOW that this is contrary to the common opinion, not only of the schools, but even of divers hodiern mathematicians, and writers of Hydrostaticks, some of whom have absolutely rejected this paradox, though they do but doubt of the truth of the former.

BUT when I consider, that whether the cause of gravity be the pulsion of any superiour substance, or the magnetical attraction of the earth, or whatever else it be, there is in all heavy bodies, as such, a constant tendency towards the center, or lowermost parts of the earth; I do not see, why that tendency or endeavour should be destroyed by the interposition of any other heavy body; though what would otherwise be the effect of that endeavour, namely, an approach towards the center, may be hindered by another body, which being heavier than it, obtains by its greater gravity a lower place; but then the lighter body tending downwards, must needs press upon the heavier, that stands in its way, and must, together with that heavier, press upon whatever body it is, that supports them both, with a weight consisting of the united gravities of the more, and the less heavy body.

BUT that, which keeps learned men from acknowledging this truth, seems to be this, that a lighter liquor (or other body) being environed with a heavier, will not fall down, but emerge to the top: whence they conclude, that, in such cases it is not to be considered as a heavy, but as a light body.

BUT to this I answer, that though in respect of the heavier liquor, the less heavy may, in some sense, be said to be light; yet notwithstanding that relative or comparative levity, it retains all its absolute gravity, tending downwards as strongly as before; though, by a contrary and more potent endeavour upwards of the contiguous liquor (whose lower parts, if less resisted, are pressed upwards by the higher, elsewhere incumbent; according to the doctrine partly delivered already, and partly to be cleared by the proof of the next proposition,) its endeavour downward is so surmounted, that it is forcibly carried up. Thus when a piece of some light wood being held under water, is let go, and suffered to emerge, though it be buoyed up by the water, whose specific gravity is greater, yet even whilst it ascends it remains a heavy body; so that the aggregate of the water, and the ascending wood, weighs more than the water alone would do; and when it floats upon the upper part of the water, as part of it is extant above the surface, so part of it is immersed beneath it, which confirms what we were saying, that a lighter body may gravitate upon a heavier.

And thus there is little doubt to be made, but that if a man stand in one of the scales of a balance with a heavy stone tied to his hand,

and hanging freely by his side, if then he lift that weight as high above his head as he can, notwithstanding that the stone's motion upwards makes it seem a light body, in respect of the man, whose body it leaves beneath it, yet it does not, either during its ascent or after, lose any thing of its connatural weight. For the man, that lifts it up, shall feel its tendency downwards to continue, though his force, being greater than that tendency, be able, notwithstanding that tendency, to carry it up: and when it is aloft, it will so press against his hand, as to offend, if not also to bruise it; and the stone, and the man, that supports it, will weigh no less in the scale he stands in, than if he did not at all support it, and they were both of them weighed apart.

LIKEWISE, if you put into one scale a wide-mouthed glass full of water, and a good quantity of powdered common salt; and into the other scale a counterpoise to them both; you may observe, that, though at the beginning the salt will manifestly lie at the bottom, and afterwards by degrees be so taken up into the body of the liquor, that not a grain will appear there; yet nevertheless (as far as I can judge by my experiments) the weight in that scale will not be diminished by the weight of as much salt as is incessantly either carried up, or supported by the restless motion of the dissolving corpuscles of the water; but both the one and the other, (allowing for what may evaporate) will concurrently gravitate upon the scale, that the glass containing them leans on.

BUT of this more elsewhere. Now to prove the proposition, by the new method, we have proposed to ourself, in this discourse:

TAKE a slender glass-pipe, and having sucked up into it fair water, to the height of three or four inches, stop nimbly the upper orifice with your finger, and immerse the lower into a glass full of oil of turpentine, till the surface of the oil in the vessel be somewhat higher than that of the water in the pipe: then removing your finger, though the pipe do thereby become open at both ends, the water will not fall down, being hindered by the pressure of the oil of turpentine. As will be obvious to them, that have attentively considered the explication of the former paradox; there being but this difference between this experiment and that there explained, that here the water is in the pipe, and the oil in the vessel, whereas there the oil was in the pipe, and the water in the vessel. And if you either pour more oil into the glass, or thrust the pipe deeper into the oil, you shall see that the water will be buoyed up towards the top of the pipe; that is, a heavier liquor will be lifted up by a lighter. And since, by the explication of the first proposition, it appears, that the reason, why the liquor is in this case raised in the pipe, is the gravity of the liquor that raises it, we must allow, that a lighter liquor *in specie* may by its gravity press against a heavier.

AND it agrees very well with our explication, both of this, and of the first experiment;

See the second figure.

periment; that as there, the surface of the oil in the pipe was always higher than that of the water without it, because the oil being the lighter liquor, a greater height of it was required to make an æquilibrium; so in our present experiment the surface of the liquor in the pipe will always be lower than that of the oil without it. For in the imaginary plain E F, the cylinder of water J G, contained in the pipe J H, will, by reason of its greater gravity, press as much upon the part J, as the distilled oil (K E, J L,) being a lighter liquor, can do upon the other parts of the same supposed plain E F, though the oil reached to a greater height above it.

THIS second paradox, we have hitherto been discoursing of, may be also proved by what we formerly delivered, to make out the truth of the third part of the lemma premised to these propositions.

BUT because this and the former paradox are of importance, not only in themselves, but to the rest of this treatise, and are likely, in most readers, to meet with indisposition enough to be received, I will subjoin in this place a couple of such experiments, as will not, I hope, be unacceptable; that I devised, the one to confirm this second paradox, and the other to prove the first.

SOME of the gentlemen now present may possibly remember, that about the end of the year, that preceded the two last, I brought into this place a certain new instrument of glass, whereby I made it appear, that the upper parts of water gravitate upon the lower; which I did, by sinking a body, that was already under water, by pouring more water upon it.

BUT that experiment belonging to other papers, I shall here substitute another performed by an instrument, which, though it makes not so fine a shew, may be more easily provided, and will as well as that other (though you were pleased to command that from me) serve to make out the same truth; which I shall apply myself to do, as soon as I have, by an improvement of the expedient I am to propose, made good my late promise of confirming the second paradox.

AND before I can well draw an argument from these experiments, for either of the propositions to be proved by them, I must briefly repeat what I have elsewhere delivered * already (on another occasion) touching the cause of the sinking of such bubbles; namely, that the bubble X consisting of glass, which is heavier *in specie* than water; and air, which is lighter *in specie* than water; and, if you please, also of water itself, which is of the same specifick gravity with water; as long as this whole aggregate of several bodies is lighter than an equal bulk of water, it will float; but in case it grows heavier than so much water, it must, according to the known laws of the hydrostaticks, necessarily sink, (being not otherwise supported.) Now when there is any competent pressure (whether produced by weight or otherwise,) upon the wa-

ter, in which this bubble is for the most part immersed, because the glass is a firm body, and the water, though a liquor, either suffers no compression, or but an inconsiderable one; the air included in the bubble, being a springy and very compressible body, will be compelled to shrink, and thereby possessing less room than it did before, the contiguous water will succeed in its place; which being a body above a thousand times heavier than air, the bubble will thereby become heavier than an equal bulk of water, and consequently will sink: but if that force or pressure be removed, the imprisoned air will, by its own spring, free itself from the intruding water; and the aggregate of bodies, that makes up the bubble, being thereby grown lighter than an equal bulk of water, the subsided bubble will presently emerge to the top.

THIS explication of the causes of the sinking of bubbles agrees in some things with the doctrine of the learned Jesuits *Kircher* and *Schottus*; and some other writers, in the account they give of those two experiments, that are commonly known by the name, the one of the Roman, the other of the Florentine experiments. But there are also particulars, wherein I (who have never a recourse to a *fuga vacui*;) dissent from their doctrine: the principles, I go upon, having invited and assisted me to make that experiment, afford me some new phænomena, which agree not with their opinions, but do with mine: but I forbear to mention them here, because they belong to other papers; and for the same reason I omit some accession of ludicrous phænomena (as they call them) which I remember I have sometimes added to those, which our industrious authors have already deduced from those experiments.

THESE things being premised, I proceed to the confirmation of the second paradox, by the following experiment:

TAKE a long glass-pipe, sealed, or otherwise exactly stopped at one end, and open at the other; (whose orifice, if it be no wider than that it may be conveniently stopped with a man's thumb, the tube will be the fitter to exhibit some other phænomena.) Into this pipe pour such a quantity of common water, as that there may be a foot, or half a yard, or some other competent part left unfilled, for the use to be by and by mentioned. Then having poised a glass-bubble with a slender neck, in such a manner, as that, though it will keep at the top of the water, yet a very little addition of weight will suffice to sink it, put this bubble thus poised into the tube; where it will swim in the upper part of the water, as long as it is let alone; but if you gently pour oil of turpentine upon it, (I say gently, to avoid confounding the liquors) you will perceive, that, for a while, the bubble will continue where it was: but if you continue pouring on oil, till it have attained a sufficient height above the water, (which it will be easy to perceive, because those two liquors will keep themselves distinct)

Fig. III.

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* In certain notes upon some of the Physico-mechanical Experiments touching the air.

you shall see the bubble subside, till it fall to the bottom, and continue there as long as the oil remains at the height above the water.

THE reason of this phænomenon, according to our doctrine, is this, that the oil of turpentine, though a lighter liquor than water, yet gravitates upon the subjacent water, and by its pressure forces some of it into the cavity of the bubble at the open orifice of its neck, whereby the bubble, which was before but very little less heavy than an equal bulk of water, being by this accession made a little more heavy, must necessarily sink; and the cause of its submersion, namely the pressure of the oil, continuing, it must remain at the bottom.

AND to confirm this explication, I shall add, that in case, by inclining the tube or otherwise, you remove the cylinder of oil, or a competent part of it, (in case it were longer than was necessary) the bubble will again emerge to the top of the water (for, as for the oil, that is too light a liquor to buoy it up;) which happens only, because the pressure of the oil upon the water being taken off, the air, by virtue of its own spring, is able to recover its former expansion, and reduce the bubble to be as light, as it was before.

AND now we may proceed to that other experiment, by which we lately promised to confirm the first paradox. And, in some regard, this following experiment has been preferred, as more strange, to that I have been reciting; for it seemed much less improbable, that, of two heterogeneous liquors, the inferior should be pressed upon by the incumbent, which, though lighter, kept in an intire body above it; than that, in water, which is a homogeneous liquor, and whose parts mingle most freely and exquisitely with one another, the upper part should press upon the lower; and that they will do so, may appear by the experiment it is now time to subjoin.

PROVIDE a long tube, and a poised bubble, as in the former experiment; then, having poured water into the tube, till it reach above five or six inches (for a determinate height is no way necessary) above the bottom, cast in the bubble, which will not only swim, but, if you thrust it down into the water, it will of itself emerge to the upper part of it. Wherefore take a slender wand, or a wire, or a slender glass-pipe, or any such body, that is long enough for your purpose, and, with it, having thrust the bubble beneath the surface of the water, pour water slowly into the tube, (whose cavity will not be near filled by the rod, or wire,) till it have attained a competent height, (which, in my last trials, was about a foot, or half a yard above the bubble;) and you shall see, that the bubble, which before endeavoured to emerge, will, by the additional weight of the incumbent water, be depressed to the bottom of the tube. After which you may safely remove the wire, or other body, that kept it from rising. For, as the weight of the incumbent water was that, which made it sink, so, that weight continu-

ing on it, the bubble will continue at the bottom.

BUT yet it is not without cause, that we employ a wire, or some such thing, in this experiment, though we affirm it to be only the weight of the incumbent water, that makes the bubble sink. For if you should pour water into the tube to the height lately mentioned, or even to a greater, if you did not make use of the wire, it would not serve the turn; because that, as fast as you pour in the water, the bubble, being left to itself, will rise together with it; and so, keeping always near the upper part of the water, it will never suffer the liquor to be so high above it, as it must be, before it can depress it. But to confirm, that it is the weight of the superiour water, that sinks the bubble, and keeps it at the bottom; if you take out of the tube a competent quantity of that liquor, and so take off the pressure of it from the bubble, this will presently, without any other help, begin to swim, and regain the upper part of the water; whence it may at pleasure be precipitated, by pouring back into the tube the water, that was taken out of it. And these confirmations, added to the former proofs of the first and second paradoxes, being, we conceive, sufficient to satisfy impartial readers of the truth of them, we should presently advance to the next proposition, if we did not think fit to interpose here a scholium.

SCHOLIUM.

IT may, perchance, be wondered at, why, since we lately mentioned our having made some trials with oil of tartar *per deliquium*, we did not, in the present experiment, instead of fair water, make use of that, it being a very much heavier liquor, and (though it may be incorporated with expressed oils) unminglable, in such trials, with oil of turpentine. But to this I answer; that, even in such slender pipes, as those made use of about the first experiment, I found, that oil of tartar was ponderous enough to flow down, though slowly, into the oil of turpentine at one side of the immersed orifice, whilst the oil passed upwards by it along the other side of the pipe. And my knowledge of this could not but make me a little wonder, that so curious a person, as Monsieur *Pascal*, should somewhere teach, that, if a tube of above fourteen foot long, and having its orifice placed fourteen foot under water, be full of quicksilver, the fluid metal will not all run out at the bottom of the pipe, though the top of it be left open to the air, but will be stopped at a foot high in the pipe. For the impetus, that its fall will give it, must probably make it flow quite out of the pipe: and, not here to mention those trials of ours with quicksilver and slender tubes, that made me think this very improbable, if we consider, that the experiment will not succeed, with much more favourable circumstances, betwixt oil of turpentine and oil of tartar, though the heavier of these two liquors be many times lighter than quicksilver; it tempts me much to suspect,

suspect, that Monsieur *Pascal* never actually made the experiment, at least with a tube as big as his scheme would make one guess; but yet thought he might safely set it down, it being very consequent to those principles, of whose truth he was fully persuaded. And indeed, were it not for the impetus, the quicksilver would acquire in falling from such a height, the ratiocination were no way unworthy of him.

BUT experiments, that are but speculatively true, should be proposed as such, and may oftentimes fail in practice; because there may intervene divers other things capable of making them miscarry, which are overlooked by the speculator, that is wont to compute only the consequences of that particular thing, which he principally considers; as, in this case, our author seems not to have considered, that in such tubes, as the Torricellian experiment is wont to be made in, the largeness of them would make them unfit for this trial.

AND I have known ingenious men, that are very well exercised in making such experiments, complain, that they could never make this of Monsieur *Pascal's* to succeed. In which attempts, that the size of the tubes much contributed to the unsuccessfulness of the trials, I shall, without repeating what has been already intimated to that purpose, in the following part of this discourse have opportunity to manifest; and, withall, to add as illustrious a proof of this our second paradox, as almost any we have yet given.

P A R A D O X III.

That if a body contiguous to the water be altogether, or in part, lower than the highest level of the said water, the lower part of the body will be pressed upward by the water, that touches it beneath.

THIS may be proved by what has been already delivered in the explication of the first experiment: for, where-ever we conceive the lowest part of the body, which is either totally, or in part, immersed in water, to be, there the imaginary superficies being beneath the true superficies, every part of that imaginary superficies must be pressed upwards, by virtue of the weight of the water incumbent on all the other parts of the same superficies; and so that part of it, on which the immersed body chances to lean, must, for the same reason, have an endeavour upwards. And if that endeavour be stronger than that, wherewith the weight of the body tends downwards, then (supposing there be no accidental impediment) the body will be buoyed, or lifted up. And though the body be heavier than so much water, and consequently will subside, yet that endeavour upwards of the water, that touches its lower part, is only rendered ineffectual to the raising, or supporting the body, but not destroyed; the force of the heavy body being from time to time resisted, and retarded by the water, as much as it would be, if that body were put into one scale, and

the weight of as much water, as is equal to it in bulk, were put into the other.

To confirm this, we may have recourse to *Fig. I. II.* what we said in the explication of the second experiment. For in case the slender pipe, wherein the water is kept suspended, be thrust deeper into the oil; or in case there be more oil poured into the vessel, the water will be impelled up higher into the pipe; which it would not be, if the oil, though bulk for bulk a lighter body, did not press against the lower surface of the water, (where alone the two liquors are contiguous) more forcibly than the water, by its gravity, tends downwards. And, even when the liquors rest in an æquilibrium, the oil continually presses upwards against the lower surface of the water; since in that continual endeavour upwards consists its constant resistance to the continual endeavour, that the gravity of the water gives it to descend. And since the same phenomenon happens, whether we suspend water in oil, as in the second experiment, or oil in water, as in the first; it appears, that the proposition is as well applicable to those cases, where the sustained body is specifically heavier, as to those, where it is specifically lighter, than the subjacent fluid.

BUT a further and clearer proof of this doctrine will appear in the explication of the next proposition. In the mean time, to confirm that part of our discourse, where we mentioned the resistance made by the water to bodies that sink in it, let us suppose, in the annexed figure, that the pipe *E F* contains an *Fig. IV.* oil specifically heavier than water, (as are the oils of guaiacum, of cinnamon, or cloves, and some others;) and then, that the oil in the pipe, and the water without, being at rest in an æquilibrium, the pipe be slowly raised towards the top of the vessel: it is evident, from our former doctrine, and from experience too, that there will run out drops of oil, which will fall from the bottom of the pipe to that of the vessel; but far more slowly, than if they fell out of the same pipe in the air.

Now, to compute, how much the pressure of the water against the lower parts of the drop amounts to, let us suppose the drop to be *G*, to whose lowermost part there is contiguous, in any assignable place, where it falls, the imaginary superficies *H J*. It is evident, that, if the drop of oil were not there, its place would be supplied by an equal bulk of water; which being of the same specific gravity with the rest of the water in the vessel, the surface *H J* would be laden every where alike; and consequently no part of it would be displaced. But now, the drop of oil being heavier than so much water, that part of the imaginary superficies, on which that drop leans, has more weight upon it, than any other equal part of the same superficies; and consequently will give place to the descending drop. And since the case of every other supposed surface, at which the drop can be conceived to arrive in its descent, will be the same with that of the superficies *H J*; it will, for the reason newly given, continue falling, till

till it comes to the bottom of the vessel, which will suffer it to fall no further. And in case the drop G were not, as we suppose it, of a substance heavier *in specie* than water, but just equal to it, the contiguous part of the superficies H J would be neither more nor less charged, than the other parts of the same superficies; and the part leaned on would be neither depressed nor raised, but the drop G would continue in the same place. And so we may prove, (what is affirmed by *Archimedes*, and other hydrostatical writers) that a body, equiponderant *in specie* to water, will rest in any assignable place of the water, where it is put.

AND (to proceed further) since, if the drop G were of a matter but equiponderant to water, it would not sink lower at all, no more than emerge; it follows, that though, being heavier *in specie* than water, yet the gravity, upon whose account it falls, is no more than that, by which it surmounts an equal bulk of water; (since, if it were not for that overplus, the resistance of the water would hinder it from falling at all:) and consequently, it loses in the water just as much of the weight it would have in the air, as so much water, weighed likewise in the same air, would amount to.

WHICH is a physical account of that grand theorem of the Hydrostaticks, which I do not remember that I have seen made out in any printed book, both solidly and clearly; the learned *Stevinus* himself, to whom the later writers are wont to refer, having but an obscure, and not physical, demonstration of it.

AND, because this theorem is not only very noble, but, as we elsewhere manifest, very useful, it will not be amiss to add, that it may easily be confirmed by experiment.

FOR, if you take (for instance) a piece of lead, and hang it by a horse-hair (that being supposed very near equiponderant to water) from one of the scales of an exact balance; and, when you have put a just counterpoise in the other scale, suffer the lead to sink in a vessel of water, till it be perfectly covered with it, but hangs freely in it, the counterpoise will very much preponderate. And, part of the counterpoise being taken out, till the balance be again reduced to an æquilibrium, you may easily, by subducting what you have taken out, and comparing it with the whole weight of the lead in the air, find what part of its weight it loses in the water. And then, if you weigh any other piece of the same lead, suppose a lump of twelve ounces, and hang it by a horse-hair at one scale, you may be sure, that, by putting into the other scale a weight less by a twelfth part, (supposing lead to water to be, as twelve to one) that is, eleven ounces, though the weights be far from an æquilibrium in the air, they will be reduced to it, when the lead is covered with water.

THE pressure of water against the lower part of the body immersed in it may be confirmed by adding, that we may thence deduce the cause of the emergency of wood, and other bodies lighter than water; which

though a familiar effect, I have not found its cause to have been so much as inquired into by many, nor, perhaps, to have been well rendered by any. If we suppose then, that the pipe be almost filled, not with a sinking, but a swimming oil, as oil of turpentine, if, as in the first experiment, the lower orifice be thrust under water, (to a far less depth, than that of the oil in the pipe) and the upper be slowly unstopped, the oil will, as we formerly declared, get out in drops at the bottom of the pipe. But to determine, why these drops, being quite covered and surrounded with water, and pressed by it as well downwards as upwards, should rather emerge than descend, I shall not content myself to say, that water *in specie* is heavier than this kind of oil: for, besides that, in some cases, ere long to be mentioned, I have made the water to depress even this kind of oil, and besides that, it is not every piece of wood, lighter *in specie* than water, that will float upon water, how shallow soever it be; the question is, how this prepollent gravity of the water comes to raise up the oil, though there be, perchance, much more water, for it to break its way thorough, above it, than beneath it.

THE reason then of the emersion of lighter bodies in heavier fluids seems to be this, that the endeavour upwards of the water, contiguous to the lower part of the body, is stronger than the endeavour downwards of the same body, and the water incumbent on it. As, in the former scheme, supposing the drop G to be the oil of turpentine, and to touch the two imaginary and parallel plains H J, K L; it is evident, that upon the lower part of the drop N, there is a greater pressure of water, than upon the upper part of the same drop, M: because, that upon all the surface K L, there is but an uniform pressure of water A K B L, and upon all the parts of the surface H I, there is a greater weight of water A H B I, except at the part N; for there the oil G, being not so heavy as so much water, the oil being exposed to a greater pressure from beneath, than its own gravity (and that of the water incumbent on it) will enable it to resist, must necessarily give way, and be impelled upward. And the case being the same between that and any other parallel plain, wheresoever we suppose it to be in its ascent, it must consequently be impelled further and further upwards, till it arrive at the top; and there it will float upon the water. Or, (to explicate the matter without figures) when a specifically lighter body is immersed under water, it is pressed against by two pillars of water; the one bearing against the upper, and the other against the lower part: and because the lengths of both these pillars must be computed from the top of the water, the lower part of the immersed body must be pressed upon by a pillar longer than the upper part by the thickness of the immersed body; and consequently must be pressed more upwards than downwards. And by how much the greater disparity of specific gravity there is betwixt the

the

the water and the emerging body, by so much the swifter (*ceteris paribus*) it will ascend: because so much the more will there be of pressure upon all the other imaginary surface, than upon that part, that happens to be contiguous to the bottom of the ascending body.

AND upon the same grounds we may give (what we have not yet met with) a good solution of that problem, proposed by hydrostatical writers, Why, if a cylindrical stick be cut in two parts, the one as long again as the other, and both of them, having been detained under water at the same depth, be let go at the same time, and permitted to emerge, the greater will rise faster than the lesser. For suppose one of these bodies, as O P, to be two foot high, and the other, Q R, to be half so much, and that the lowermost surfaces of both be in the same imaginary plain, parallel to the uppermost surface of the water, and three foot distant from it; in this case there will be against the lower part of each of the wooden bodies a pressure, (from the laterally superiour water) equal to that upon all the other parts of the imaginary plain, whereto those bodies are contiguous. But whereas upon the upper surface of the shorter body, Q R, there will lean a pillar of water two foot high, the pillar of the same liquor, that will lean upon the top of the taller body, P O, will be but one foot high; as the attentive considerer will easily perceive. So that the wooden bodies being lighter *in specie* than water, both of them will be impelled upwards; but that compounded pillar (if I may so call it) which consists of one foot of wood, and two foot of water, will, by its gravity, more resist the being raised, than that which consists of two foot of wood, and but one foot of water: so that the cause of the unequal celerity in the ascension of these bodies consists chiefly, (for I would neither overvalue nor exclude concomitant causes) that the difference of the pressure against the upper and lower part of each body respectively is greater in one than in the other.

AND hence we may probably deduce a reason of what we often observe in the distillation of the oils of aniseeds, cloves, and divers aromatick vegetables, in lembecks, by the intervention of water: for oftentimes when the fire has not been well regulated, there will come over, besides the floating oil, a whitish water, which will not in a long time become clear. And as we have elsewhere taught that whiteness to proceed from the numerous reflections from the oily substance of the concrete, by the heat of the fire broken into innumerable little globules, and dispersed through the body of the water; so the reason, why this whiteness continues so long, seems to be chiefly (for I mention not such things, as, the great surfaces, that these little globules have in respect of their bulk) that, because of the exceeding minuteness of these drops, the height of the water, that presses upon the upper part, is almost equal to that of the water, that presses against the lower part. So that the difference between

these two pressures being inconsiderable, it has power to raise the drops but very slowly, (inasmuch, that upon this ground I devised a menstruum, wherewith I could mingle oil in drops so exceedingly minute, that even when there were but a few spoonfuls of the mixture, it would continue whitish for divers whole days together) though at length they will emerge: and the sooner, because, whilst they swim up and down, as they frequently chance to meet and run into one another, they compose greater drops; which are (for the reason already given) less slowly impelled up by the water; at the top of which, the chymist, after a due time, is wont to find new oil floating. But whether this be any way applicable to the swimming of the insensible particles of corroded metals in aquafortis, and other saline menstruums, I must not now stay to inquire.

ONE thing more there is, that I would point at, before I dismiss this paradox; namely, that, for the same reason we have all this while deduced, when the emergent drop, or any other body, floats upon the top of the water, it will sink just so far, (and no farther) till the immersed part of the floating body be equal in bulk to as much water as is equal in weight to the whole body. For suppose, in the annexed figure, Y to be a cube of wood three foot high, and six pound in weight; this wood, being much heavier than air, will sink into the water, till it come to an imaginary superficies, X W, where, having the position newly described, it will necessarily acquiesce. For all the other equal parts of the superficies, X, W, Q, being leaned upon by pillars of water equal in height to the part X A, or W B, if the whole weight of the wooden cube be greater than that of as much water, as is equal to the immersed part, it must necessarily sink lower, because the subjacent part of the surface (at V) will be more charged than any of the rest. And, on the other side, if the cube were lighter than as much water as that, whose place the immersed part takes up; it must, by the greater pressure of the water upon the other parts of the imaginary superficies, X W, than upon that contiguous to the wood, (as at V) be impelled upward, till the pressure of the whole wood upon the part it leans on, be of the same degree with that of the rest of the water, upon the rest of the superficies; and consequently be the same with the water, whose place the immersed part of it takes up; the lightness of that immersed part, in respect of so much water, being recompensed by the weight of the unimmersed part, which is extant above the superficies of the water. And we see, that when a piece of wood falls into water, though, by the impetus it acquires in falling, it passes through divers imaginary plains, that lie beneath its due station; yet the greater pressure, to which each of those plains is exposed in all its other parts, than in that, which is contiguous to the bottom of the wood, does quickly impel it up again, till, after some emersions and subsidings, it

rests at length in such a position, as the newly explicated hydrostatical theorem assigns it.

S C H O L I U M.

THIS ingenious proposition (about floating bodies) is taught and proved, after the manner of mathematicians, by the most subtle *Archimedes*, and his commentators; and we have newly been endeavouring to manifest the physical reason, why it must be true. But partly because the proposition ought to hold, not only in such intire and homogeneous bodies as men exemplify it in, (such as a piece of wood, or a lump of wax) but in all bodies, though of a concave figure, and made up of many bodies of never so differing natures; (and perhaps some of them joined together only by their superincumbency upon one another;) and partly, because that a truth, which is one of the main and usefulest of the Hydrostaticks, and may be of so much importance to navigation, has not yet (that I know of) been attempted to be demonstrated, otherwise than upon paper; it will not be amiss, for the satisfaction of such of those, whom it may concern, as are not versed in mathematical demonstrations, to add an experiment, which I made to prove it mechanically, as exactly as is necessary for the satisfaction of such persons.

AFTER, then, having employed several vessels, some of wood, some of latten, and some of other materials, to compass what I desired; we found glasses to be the most commodious we could procure. And therefore, filling a large and deep glass to a convenient height with fair water, we placed in it another deeper glass, shaped like a goblet or tumbler, that it might be the fitter for swimming; and having furnished it first with ballast, and then, for merriment sake, with a wooden deck, by which a tall mast, with a sail fastned to it, was kept upright; we freighted with wood, and by degrees poured sand into it, till we had made it sink just to the tops of certain conspicuous marks, that we had fastned on the outside of the glass, to opposite parts thereof. Then observing, how high the water reached in the larger glass, (which, by reason of the vessel's transparency, was to be seen) we carefully placed two or three marks in the same level with the horizontal surface of the water; and taking out the floating vessel as it was, with all that belonged to it, and wiping the outside dry, we put it into a good pair of scales, and having found what it amounted to, we weighed in a competently large phial (first counterpoised apart) so much water, (to a grain, or thereabouts,) and pouring this water into the large glass above mentioned, we found it to reach to the marks, that we had fastned to the outside of the glass, and consequently to reach to the same height, to which the weight of the floating glass, and all that was added to make it resemble a ship, had made it arise to. By which experiment (which we tried, as to the essential parts of it, with vessels of differing sizes, shapés, and ladings too; as

wood, stone, quicksilver, &c.) it appears, that the floating vessel itself, with all that was in it, or supported by it, was equal in weight to as much water as was equal in bulk to that part of the vessel, which was under water, supposed to be cut off from the extant part of the same vessel, by a plain continuing the horizontal surface of the water: since the weight of the floating vessel; which raised up the water in the larger vessel to the greatest height it attained, was the same with the weight of the water, which being poured into the larger vessel (when the other was taken out) raised the water therein to the same height. We may also obtain the same end, by a somewhat differing way, (which is the best way, in case the vessels be too great,) viz. to observe, first, by pouring in water out of a bowl or pail, or other vessel of known capacity, as often as is necessary to fill the great vessel, or cistern, or pond, to the top, (or to any determinate height required;) and, next, letting out, or otherwise removing all that water, to put in its place the vessel, whose weight is to be found out. Thirdly, to let, or pour in water, till the vessel be afloat, and by its weight raise the external water to the height it had before. And lastly, to examine, how much this water, that was last poured in, falls short in weight of the water, that was in it at first, and afterwards removed. For this difference will give us the weight of as much water, as is equiponderate to the whole floating vessel, whether small or great, with all that it either carries or sustains. The hydrostatical theorem we have been considering, and the experiments, whereby we have endeavoured to confirm or illustrate it, may (*mutatis mutandis*) be applied to a ship with all her ballast, lading, guns, and company; it holding generally true, *That* (to express the sense of the proposition more briefly) *the weight of a floating body is equal to as much water, as its immersed part takes up the room of*. Whence we might draw some arguments in favour of the learned *Stevinus*, (for whose sake it partly was, that I annexed this scholium) who, if I misremember not, does somewhere deduce as a corollary from certain hydrostatical propositions, that a whole ship, and all that belongs to it, and leans upon it, presses no more nor less upon the bottom it swims over, than as much water, as is equal in bulk to that part of the ship, which is beneath the surface of the water.

P A R A D O X I V.

That in the ascension of water in pumps, &c. there needs nothing to raise the water, but a competent weight of an external fluid.

THIS proposition may be easily enough deduced from the already mentioned experiments. But yet, for further illustration and proof, we will add that, which follows.

TAKE a slender glass-pipe, (such as was used about the first experiment) and suck into it about the height of an inch of deeply tinted water; and, nimbly stopping the upper

See paradox the first.

per orifice, immerse the lower part of the pipe into a glass half filled with such tinted water, till the surface of the liquor in the pipe be an inch (or as low as you would have it) beneath that of the external water. Then pouring on oil of turpentine, till it swim three or four inches, or as high as you please above the water; loosen gently your finger from the upper orifice of the pipe, to give the inclosed air a little intercourse with the external; and you shall see the tinted water in the pipe to be impelled up, not only higher than the surface of the external water, but almost as high as that of the external oil, through which (it being transparent and colourless) the red liquor may be easily discerned.

Now in this case it cannot be pretended, that the ascent of the water in the pipe proceeds from nature's abhorrency of a vacuum; since the pipe being full of air, and its orifice unstopped, though the water should not ascend, no danger of a vacuum would ensue; the air and the water remaining contiguous as before.

THE true reason, then, of the ascent of the water, in our case, is but this; that upon all the other parts of the imaginary superficies, that passes by the immersed orifice of the pipe, there is a pressure partly of water, and partly of the oil swimming upon that water, amounting to the pressure of four or five inches of water; whereas upon that part of the same superficies, whereon the liquor contained in the pipe leans, there is but the pressure of one inch of water: so that the parts near the immersed orifice must necessarily be thrust out of place by the other parts of water, that are more pressed; till so much liquor be impelled up into the pipe, as makes the pressure on that part of the imaginary superficies as great, as that of the oil and water on any other equal part of it. And then, by virtue of the æquilibrium, (often mentioned) the water will rise no further; and, by virtue of the same æquilibrium, it will rest a little beneath the surface of the external oil, because this last named liquor is less heavy, bulk for bulk, than water.

AND by this we may be assisted to give a reason of the ascension of water in ordinary sucking pumps. For as the oil of turpentine, though a lighter liquor than water, and not mingleable with it, does, by leaning upon the surface of the external water, press up the water within the pipe, to a far greater height than that of the external water itself; so the air, which, though a far lighter liquor than oil of turpentine, reaches I know not how many miles high, leaning upon the surface of the water in a well, would press it up into the cylindrical cavity of the pump, much higher than the external water itself reaches in the well, if it were not hindered.

Now that, which hinders it in the pump, is either the sucker, which fences the water in the pump from the pressure of the external air, or that pressure itself. And therefore, all that the drawing up of the sucker needs to do, is, to free the water in the pipe from the

impediment to its ascent, which was given it by the sucker's leaning on it, or the pillar of the atmosphere's being incumbent on it; as in our experiment, the sides of the pipe do sufficiently protect the water in the pipe from any pressure of the external oil, that may oppose its ascent.

AND lastly, as the water in our pipe was impelled up so high, and no higher, that the cylinder of water in the pipe was just able to balance the pressure of the water and oil without the pipe; so in pumps, the water does rise about thirty three or thirty four foot: and though you pump never so long, it will be raised no higher; because at that height the pressure of the water in the pump, upon that part of the imaginary superficies, that passes by the lower orifice of it, is the same with the pressure, which other parts of that imaginary superficies sustain from as much of the external water, and of the atmosphere, as come to lean upon it.

THAT there may be cases, wherein water may be raised by suction, not upon the account of the weight of the air, but of its spring, I have elsewhere shown; and having likewise in other places endeavoured to explicate more particularly the ascension of water in pumps; what has been said already may suffice to be said in this place, where it is sufficient for me to have shewn, that, whether or no the ascension of water *may have* other causes, yet, in the cases proposed, it *needs* no more than the competent weight of an external fluid, as is the air; whose not being devoid of gravity, the cogency of our experiments has brought even our adversaries to grant us.

FOR confirmation of this, I will here add, because it now comes into my mind, (what might, perhaps, be elsewhere somewhat more properly mentioned) an experiment, that I did but lightly glance at in the explication of the first, and the scholium of the second paradox.

IN order to this, I must advertise, that, whereas I there took notice, that some ingenious men had complained, that, contrary to the experiment proposed by Monsieur *Pascal*, they were not at all able to keep mercury suspended in tubes, however very slender, though the lower end were deeply immersed in water, if both their ends were open; the reasons of my doubting, whether our ingenious author had ever made, or seen the experiment, were not only, that it had been unsuccessfully tried, and seemed to me unlikely to succeed in tubes more slender, than his appeared; but, because the impetus, which falling quicksilver gains by the acceleration of motion it acquires in its descent, must, in all probability, be great enough to make it all run out at the bottom of a tube open at both ends, and filled with so ponderous a liquor, though the tube were very much shorter, than that proposed by Monsieur *Pascal*.

THIS advertisement I premise, to intimate, that, notwithstanding the hopelessness of the experiment, as it had been proposed and tried,

tried, I might have reason not to think it impossible to perform, by another way, the main thing desired; which was, to keep quicksilver suspended in a tube, open at both ends, by the resistance of the subjacent water. For, by the expedient I am going to propose, I have been able to do it, even with a liquor much lighter than water.

FINDING then, that even a very short cylinder of so ponderous a fluid as mercury, would, if it were once in falling, descend with an impetus not easy to be resisted by the subjacent liquor, I thought upon the following expedient to prevent this inconvenience. I took a slender pipe, the diameter of whose cavity was little above the sixth part of an inch; and having sucked in, at the lower end of it, somewhat less than half an inch of quicksilver, and nimbly stopped the upper orifice with my finger, I thrust the quicksilver into a deep glass of oil of turpentine, with a care not to unstop the upper orifice, till the small cylinder of quicksilver was eighteen or twenty times its depth beneath the surface of the oil. For by this means, when I unstopped the pipe, the quicksilver needed not (as otherwise it would) begin to fall, as having a longer cylinder, than was requisite to make an æquilibrium with the other fluid. For, by our expedient, the pressure of the oil was already full as great, if not greater, against the lower part of the mercurial cylinder, as that, which the weight of so short a cylinder could exercise upon the contiguous and subjacent oil. And accordingly, upon the removal of my finger, the quicksilver did not run out, but remain suspended in the lower part of the pipe. And as, if I raised it towards the superficies of the oil, the mercury would drop out for want of its wonted counterpoise; so, if I thrust the pipe deeper into the oil, the increased pressure of the oil would proportionably impel up the mercury towards the higher parts of the pipe; which being again a little, and but a little, raised, the quicksilver would fall down a little nearer the bottom of the pipe: and so, with a not unpleasant spectacle, the ponderous body of quicksilver was made sometimes to rise, and sometimes to fall; but still to float upon the surface of a liquor lighter than common spirit of wine itself.

BUT, besides that the experiment, if the maker of it be not very careful, may easily enough miscarry, the divertisement it gives seldom proves lasting; the oil of turpentine, after a while, insinuating itself betwixt the sides of the pipe and those of so short a cylinder of mercury, and thereby disordering all. And therefore, though I here mention this experiment, as I tried it in oil of turpentine, because that is the liquor I make use of all along these paradoxes; and because also I would shew, that a lighter fluid than water (and therefore why not air, if its height be greatly enough increased?) may, by its weight and pressure, either keep the mercury suspended in pipes, or even raise it in them: yet I found water, wherewith I filled tall glasses, a fitter liquor than oil for the exper-

iment, in which though I sought, and found some other phænomena; yet, because they more properly belong to another place, I shall leave them unmentioned in this.

AND since experience shews us, that a cylinder of mercury, of about thirty inches high, is equiponderant to a cylinder of water of about thirty-three, or thirty-four foot high; it is very easy to conclude, that the weight of the external air, which is able to raise and keep suspended thirty-three, or thirty-four foot of water in a pump, may do the like to twenty-nine, or thirty inches of quicksilver in the Torricellian experiment.

P A R A D O X V.

That the pressure of an external fluid is able to keep an heterogeneous liquor suspended at the same height in several pipes, though those pipes be of very different diameters.

THE contrary of this proposition is so confidently asserted and believed by those mathematicians and others, that favour the doctrine of the schools, that this persuasion of theirs seems to be the chief thing, that has hindered men from acknowledging, that the quicksilver, in the Torricellian experiment, may be kept suspended by the counterpoise of the external air. And a famous writer, that has lately treated, as well of the Hydrostatics, as of the phænomena of the Torricellian experiment, does rely so much upon the falshood of our paradox, that, laying aside all other arguments, he contents himself to confute his adversaries with one demonstration (as he calls it) grounded on the quite contrary of what we here assert. For his objection runs to this sense; That, if it were the pressure of the external air, that kept the quicksilver suspended in the newly-mentioned experiment, the height would not (as experience shews it is) be the same in all cylindrical pipes, though of very differing bores. For, supposing the height of the mercurial cylinder, in a tube of half an inch diameter, to be twenty-nine inches; it is plain, that a mercurial cylinder of the same height, and three inches in diameter, must weigh divers times as much as the former: and therefore the pressure of the external air being but one and the same, if it be a just counterpoise to the greater cylinder, it cannot be so to the less; and if it be able to keep the one suspended at twenty-nine inches, it must be able to keep the other suspended at a far greater height; which yet is contrary to experience. And indeed this objection is so specious, that, though I elsewhere have already answered it, both by reason and experience, as far forth as it concerns the Torricellian experiment; yet, to shew the mistake, on which it is grounded, it may be very well worth while to make out our proposed paradox, (as that, whose truth will sufficiently disprove that error) by shewing, both *that* the assertion is true, and *why* it must be so.

PROVIDE, then, a more than ordinarily wide-mouthed glass, clear, and of a convenient depth;

depth; into which having put a convenient quantity of water, deeply tinged with brazil, or some other pigment, fit to the orifice a broad but thin cork, in which, by burning or cutting, make divers round holes of very differing wideesses; into each of which you may thrust a glass cylinder, open at both ends, and of a size fit for the hole, that is to receive it, that so the several pipes may be embraced by these several holes; and, as near as you can, make them parallel to one another, and perpendicular to the superficies of the water, into which they are to be immersed. But we must not forget, that, besides these holes, there is an aperture to be made in the same cork (it matters not much of what figure, or whereabouts) to receive the slender end of a glass funnel; by which oil may be conveyed into the vessel, when it is stopped with the cork. And in the slender part of this funnel we use to put some cotton-wick, to break the violence of the oil, that is to be poured in, which might else disorder the experiment. All this being thus provided, and the cork (furnished with its pipes) being fitted to the orifice of the vessel; if at the funnel you pour in oil of turpentine, and place the glass betwixt your eye and the light, you may, through that transparent liquor, perceive the tinted water to be impelled up into all the pipes, and to rise uniformly in them. And, when this tinted liquor has attained to the height of two or three, or more inches, above the lowermost surface of the external oil, if you remove the funnel, (which yet you need not do, unless there be yet oil in it) you may plainly perceive the water to reach as high in one of the smaller pipes, as in another three or four times as great; and yet the water in the several pipes, as it is evident, is sustained at that height above the level of the other water, by the pressure or counterpoise of the external oil; which therefore, being lighter *in specie* than water, will have its surface somewhat higher without the pipes, than that of the tinted water within them. And if by the aperture, that receives the funnel, you immerse, almost to the bottom of the oil, the shorter leg of a slender glass siphon, at whose longer leg you procure by suction the oil to run out; you shall perceive, that, according as the depth and pressure of the external fluid decreases, so the water in the pipe will subside; and that uniformly, as well in the lesser, as in the greater pipes.

THE reason of this is not difficult to be rendered by the doctrine already delivered. For, suppose *EF* to be the surface of the water, both within and without the pipes, before any oil was poured on it: if we then suppose the oil to be poured in through the funnel, its lightness in respect of water, wherewith it will not mingle, will keep it from getting into the cavity of the pipes *L, M, N*; and therefore, spreading itself on the outside of them above, it must necessarily, by its gravity, press down the superficies of the external water, and impel up that liquor into the cavities of the pipes. And if we suppose the pouring on of the oil

to be continued, till the uppermost surface of the oil be raised to *GH*, and that of the external water depressed to *IK*, (or thereabouts) an imaginary plane passing along the lower orifices of the pipes; I say, the tinted waters in the pipes ought to have their uppermost surfaces in the same level, notwithstanding the great inequality of their bores. For that part of the surface *IK*, which is comprehended within the circular orifice of the greatest pipe *L*, is no more charged by the incumbent water, than any other part, equal to that circle of the same imaginary superficies, is by the water or oil incumbent on it; (and consequently, no more than the part, comprehended within the circle of the small pipe *N*, is by the water contained in that small pipe;) the external oil having as much a greater height upon the superficies *IK*, than the water within the pipe, as is requisite to make the two liquors counterbalance each other, notwithstanding the difference of their specific gravities. And though the pipe *L* were twice as big, it would charge the subjacent plane *IK* no more, than the pressure of the oil on the other parts of the same imaginary surface is able to resist. And yet this pressure of the external oil ought not to be able to raise the water in the slender pipe *N* higher, than the surface *Q* in the same level with the surface *O*. For, if the water were higher in the small pipe, being a heavier liquor than oil, it must press upon that part of the surface *IK*, it leans on, with greater force, than the external oil upon the other parts of the same plane *IK*; and therefore with greater force, than the weight of the external oil could resist. And, consequently, the water in the slender pipe must subside, till its surface be inferior to that of the external oil; since, till then, the difference of their specific gravities cannot permit them to rest in an æquilibrium. To be short; it is all one to the resistance of the external oil, how wide the cylinder is, that it supports in the pipe; provided the height of it be not greater, in respect of the height of the oil, than the difference of the respective gravities of those two liquors requires. For, so long the pressure of the cylinder of water will be no greater on that part of the imaginary superficies, which it leans upon, than the pressure of the external oil will be on all the other parts of the same superficies; and consequently, neither the one, nor the other of those liquors will subside, but they will both rest in an æquilibrium.

BUT here it will not be amiss to note, first, that it is not necessary, that the glass cylinders *L, M, N*, should be all of the same length; since, the lower orifice being open, the water will rise to the same height within them, whether the parts immersed under the water be exactly of the same length, or no.

AND secondly, That throughout all this discourse, and particularly in the explication of this paradox, we suppose, either that the slenderest pipes, that are employed about these experiments, are of a moderate size, and not exceeding small; or that, in case they be

very small, allowance be made in such pipes for this property, that water will rise in them to a greater height, than can be attributed to the bare counterpoise of either the water, or the oil, that impels it upwards, and keeps it suspended. But this difference is of so little moment in our present inquiries, that we may safely neglect it, (as hereafter we mean to do) now we have taken this notice of it for prevention of mistakes.

P A R A D O X VI.

If a body be placed under water, with its uppermost surface parallel to the horizon; how much water soever there may be on this, or that side above the body, the direct pressure, sustained by the body, (for we now consider not the lateral, nor the recoiling pressure, to which the body may be exposed, if quite environed with water,) is no more, than that of a column of water, having the horizontal superficies of the body for its basis, and the perpendicular depth of the water for its height.

And so likewise,

If the water, that leans upon the body, be contained in pipes open at both ends, the pressure of the water is to be estimated by the weight of a pillar of water, whose basis is equal to the lower orifice of the pipe, (which we suppose to be parallel to the horizon,) and its height equal to a perpendicular reaching thence to the top of the water; though the pipe be much inclined towards the horizon, or though it be irregularly shaped, and much broader in some parts, than the said orifice.

STEVINUS, in the tenth proposition of his Hydrostatical Elements, having proposed in more general terms the former part of our paradox, annexes to it a demonstration to this purpose:

HAVING first supposed ABCD to be a solid rectangular figure of water, whose basis EF is parallel to the horizon, and whose height GE is a perpendicular let fall from the uppermost surface of the water to the lowermost; his demonstration is this:

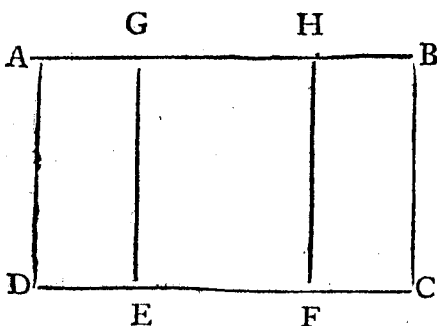


Fig. VII.

If the bottom EF be charged with a greater weight, than that of the water GHFE, that surplufage must come from the adjoining water: therefore, if it be possible, let it be from the water AGED, and HBCF; which granted, the bottom DE will likewise have a greater weight incumbent on it, upon the score of the neighbouring water GHFE, than that of the water AGED.

And, the reason being the same in all the three cases, the basis FC must sustain a greater weight, than that of the water HBCF: and therefore the whole bottom DC will have a greater weight incumbent on it, than that of the whole water ABCD; which yet (ABCD being a rectangular body) would be absurd. And by the same way of reasoning you may evince, that the bottom EF sustains no less a weight, than that of the water GHFE. And so, since it sustains neither a greater weight, nor a less, it must sustain just as much weight, as the column of water GHFE.

THIS demonstration of the learned Stevinus may well enough be admitted by a naturalist, (though, according to some hypotheses touching the cause and nature of gravity, it may fail of mathematical exactness;) and by it may be confirmed the first part of our proposed paradox. And some things, annexed by Stevinus to this demonstration, may be also applied to countenance the second. But, because this is one of the noblest and usefulest subjects of the Hydrostatics, we think it worth while to illustrate, after our manner, each of the two parts of our paradox by a sensible experiment.

FIRST then, take a slender glass pipe, of an even bore, turned up at one end like the annexed siphon. Into this siphon suck oil of turpentine, till the liquor have filled the shorter leg, and be raised two or three inches in the longer. Then, nimbly stopping the upper orifice with your finger, thrust the lower part of the siphon so far into a deep glass full of water, that the surface of the oil in the longer leg of the pipe may be but a little higher than that of the external water; and, upon the removal of your finger, you will find the surface of the oil to vary but little, or not at all, its former station. And as, if you then thrust the pipe a little deeper, you will see the oil in the shorter leg to begin to be depressed; so, if afterwards you gently raise the pipe toward the top of the water, you shall see the oil not only regain its former station, but flow out by degrees in drops, that will emerge to the top of the water. Now, since the water was able, at first, to keep the oil in the longer leg of the pipe suspended no higher, than it would have been kept by a cylinder of water equal to the orifice of the shorter leg of the pipe, and reaching directly thence to the top of the water; (as may be easily tried, by making a siphon, where the shorter leg may be long enough to contain such a cylinder of water to counterpoise the oil in the longer;) and since, when once, by the raising of the pipe, the height of the incumbent water was lessened, the oil did more than counterbalance it, (as appears by its flowing out of the siphon;) we may well conclude, that, though there were in the vessel a great deal of water, higher than the immersed orifice of the siphon, (and it would be all one, though the siphon were placed at the same depth in a pond or lake;) yet, of all that water, no more did gravitate upon the orifice, than that, which was placed directly over it; which was such

such a pillar of water, as the paradox describes.

AND, by the way, we may hence learn, that though water be not included in pipes, yet it may press as regularly upon a subjacent body, as if it were. And therefore we may well enough conceive a pillar of water, in the free water itself, where there is nothing on any side, but the contiguous water, to bound the imaginary pillar.

BUT I had forgot to add, that the first part of our paradox will hold, not only when the water, superior to the body it presses upon, is free; but also, when it is included in vessels of never so (seemingly) disadvantageous a shape. For, if you so frame the shorter leg of a siphon, that it may expand itself into a funnel, like that of *fig. 6.* employed about the proof of the foregoing (fifth) paradox; (for which purpose the legs must be at a pretty distance from each other :) though you fill that funnel with water, the oil in the longer and slender leg of the siphon will be able to resist the pressure of all the water, notwithstanding the breadth of the upper part of the funnel. So that, even in this case also, the surface of the oil in the longer leg will be but a little higher than that of the water in the funnel.

FOR further confirmation of this, we caused to be made a siphon, so shaped, that one of the legs (which were parallel, and of the same bore,) had in the midst of it a sphere of glass, save that it communicated with the upper and lower parts of the same leg.

IN the uniform leg of the siphon, we put a convenient quantity of oil of turpentine, and into the other as much water, as filled not only the lower part of it, but the globular part too. And yet we did not find, that all this water was able to keep up the oil in the uniform leg, at a greater height, than if the leg, that contained the water, had been uniform too; as much of the water in the globe, as was not directly over the lower orifice of it, being supported by the lateral parts (if I may so call them) of the same globe. And if that leg were, instead of water, filled with oil, and the uniform leg with water; notwithstanding the far greater quantity of oil, that was necessary to fill that leg, whereof the hollow sphere was but a part; the water in the uniform leg would not be kept up, so much as to the same height with the oil in the mishapen leg.

Fig. IX.

BUT to make this matter yet the more clear, we caused a siphon to be made of the figure expressed in the adjoining scheme; into which having poured a convenient quantity of mercury, till it reached in the shorter leg *C D*, almost to the bottom of the globular part *E*, and in the longer leg *A B*, to an equal height: we afterwards poured a sufficient quantity of water into the said longer leg *A B*, which drove away the quicksilver, and impelled it up in the shorter leg till it had half, or more than half, filled the cavity of the globular part *E*; (which yet we did not wholly fill with quicksilver, because the tube

A B was not long enough for that purpose :) and then we observed, that, notwithstanding the great weight of (that body, which is of all bodies, save one, the most ponderous) quicksilver, which was contained in the lower part of the same leg of the siphon, the surface of the quicksilver *H G*, was impelled up as high by the water in the leg *A B*, as the disparity of the specific weights of those two liquors (whereof one is about fourteen times as heavy as the other) did require: so that it appeared not, that, for all the great weight of quicksilver, contained in the globular cavity *E*, there pressed any more upon the slender and subjacent part *E C* of that leg, than as much as was placed directly over the lower orifice of the said cavity *E*. So that the other, and lateral parts of that mercury being supported by the concave sides of the glass, whereunto they were contiguous, the water in the leg *A B* appeared not any more pressed by the quicksilver, than if the leg *C D* had been, as well as the other, of an uniform bigness; and, by this means, if we had made the hollow globe of a large diameter, a small quantity of water, poured into the leg *A B*, might have been able to raise a quantity of quicksilver exceedingly much heavier than itself. But then so little water can raise the quicksilver, in so broad a pipe, but to an inconsiderable height.

To make out the second part of our paradox by an experiment, we took three glass-pipes; the one made like a bolt-head, with a round ball, and two opposite items; the other was an irregular pipe, blown with an elbow, wherewith it made an angle; and the third was as irregularly shaped, as I could get it blown; being in some places much broader, and in some much narrower than the lower orifice of it. And these two last named pipes had their upper ends so inserted into holes, made fit for them in a broad piece of cork; that, when they were immersed, they made not right angles, but very oblique ones, with the horizontal surface of the liquor. The other glass likewise, which consisted of a great bubble, and two opposite pipes, was fastned to the same cork, which having beforehand been made fit for a wide-mouthed glass of a good depth, and half filled with water, was thrust as a stopple into the mouth of the said glass, so that the water ascended a pretty way into each of the three pipes by their lower orifices, which, as well as the upper, we left open; then a good quantity of oil of turpentine being poured into the same vessel through a funnel, the water was by the incumbent oil impelled up to the height of two or three inches in each of the three pipes. Which argues, that, notwithstanding their being so unequal in bigness, and so irregular in shape, (inasmuch that we guessed one of them was ten or twelve times greater in one part, than in another, or than it was even at the orifice) the water, contained in each of them, pressed upon its lower orifice no more (I do not add, nor no less) than it would have done, if it had been

a cylinder, having the orifice for its basis, and the perpendicular depth of the water and oil above, for its height. For in case each of the pipes had contained but such a cylinder of water, that water would nevertheless have had its uppermost superficies at the same height: and, on the other side, it would have been impelled up beyond it, if its weight did not as strongly endeavour to depress the immediately subjacent water, as the pressure of the external fluids endeavoured to impel it up.

AND since the height of the water was about the same in the several pipes, though two of them, being very much inclined, contained much more water than if they were erected; yet by the same way of reasoning we may gather, that the imaginary plain, passing by the immersed orifice of either of these inclining pipes, sustained no more of pressure, than it would have done from a shorter cylinder of water, if erected. And indeed, in all these cases, where a pipe either is broader in other places than at its lower orifice, or inclined any way towards the horizon, the weight of the contained liquor is not all supported by the liquor, or the body contiguous to the lower orifice, but partly by the sides of the pipe itself. And therefore if, when in a slender pipe you have brought a parcel of oil of turpentine to be in an æquilibrium with the external water, as in the experiment belonging to the first paradox; if, I say, when this is done, you incline the pipe towards the sides of the glass, you may indeed observe the surface of the oil in the pipe to be, as before, a little higher than that of the water without it: but you shall likewise see, that though the orifice of the pipe were not thrust deeper into the water, yet there will be a pretty deal of water got up into the pipe; because the oil not leaning now upon the water only, as it did before, but partly upon the water, and partly upon the pipe, its pressure upon the subjacent water is considerably lessened; and thereby the external water, whose pressure is not diminished too, is able to impel up the oil, and intrude for a little way into the pipe. But if you re-erect the pipe, the pressure of the oil being then again exerted upon the subjacent water, it will be able to depress, and drive it again out of the cavity of the pipe.

AND to this agrees very well what we further tried as follows: We caused three pipes to be blown (shaped as the adjoining figures;) one having in it divers acute angles; the other being of a winding form, like a skrew or worm of the limbeck; and the third very irregularly crooked; and yet each of these pipes having all its crooked parts, and some of its streight and erected parts, filled with oil of turpentine; being thrust to a convenient depth under water and unstopped there, (after the manner already often declared) we found, that, according to our paradox, the surface of the oil in the pipe was higher than that of the water without it, as much as it

would have been in case the pipe had been streight, (as we tried, by placing by the crookedest of them a streight pipe with oil in it) though the quantity of the oil, in one of these pipes, were perhaps three times as much as would have sufficed, if the pipe had been strait: so that this surplussage of oil did not press upon the subjacent water, (for if it had done so, the oil would have run out of the pipe.) And I remember, that lifting up as much of one of these crooked pipes, as I thought fit, somewhat above the surface of the water; when the superficies of the oil in the pipe was not above half an inch higher than that of the water without it, I estimated, that the crooked pillar of oil, contained in that part of the pipe, which was above the surface of the water, was about seven or eight inches long. So true it is, that the pressure of liquors, contained in pipes, must be computed by the perpendicular that measures their height, whatever be their length or bigness.

SCHOLIUM.

THE learned *Stevinus*, having demonstrated the proposition we lately mentioned out of him, subjoins divers consecutaries, of which the truth hath been thought more questionable, than that of the theorem itself. And therefore he thought fit to add a kind of appendix to make good a paradox, which seems to amount to this; that if, in the cover of a large cylindrical box, exactly closed, there be perpendicularly erected a cylindrical pipe open at both ends, and reaching to the cavity of the box; this instrument being filled with water, the circular basis of it will sustain a pressure, equal to that of the breadth of the basis and height of the pipe.

I CHOSE thus to express this theorem, (which might be, according to *Stevinus*, proposed in more general terms) because this way of expressing it will best suit with the subsequent experiment, and may consequently facilitate the understanding of the paradox. But though the learned *Stevinus's* aims were to be commended; who finding this proposition doubted, seems to have had a great mind to give an experimental demonstration of it, and therefore proposes no less than five pragmatikal examples (as he calls them) to make out the truth of what he asserts; yet in this he hath been somewhat unhappy, that that experiment, which alone (for ought I can find) has been tried of all the five, is rejected as incompetent by those, that profess to have purposely made trial of it. And indeed, by reason of the difficulty of bringing them to a practical examen, I have somewhat doubted, whether or no this useful writer did ever make all those trials himself; rather than set down the events, he supposed they must needs have, as presuming his conjectures rightly deduced from a demonstrative truth. Wherefore though another of the experiments, he proposes, be not free from difficulty, yet having, by the help of an expedient, made it practicable, we are induced by its plainness and clear-

clearness to prefer it to what else he proposes to the same purpose.

We provided then a vessel of latten, of the figure expressed in the scheme, and furnished it with a loose bottom CD, made of a flat piece of wood covered with a soft bladder, and greased on the lower side near the edges, that leaning on the rim of wood GH, contiguous every where to the inside of the latten, it might be easily lifted from off this rim; and yet lie so close upon it, that the water should not be able to get out between them: and to the midst of this loose bottom was fastned a long string, of a good strength, for the use hereafter to be declared. The instrument thus fitted, the water was poured in apace at the top AB, which, by its weight pressing the false bottom CD against the subjacent rim GH, contributed to make the vessel the more tight, and to hinder its own passing. The vessel being filled with water, we took the forementioned string, one of whose ends was fastned to I, the middle part of the loose bottom, and, tying the other end K to the extremity of the beam of a good pair of scales, we put weights one after another into the opposite scale, till at length those weights lifted up the false bottom CD from the rim GH; and consequently lifted up the incumbent water; which presently after ran down between them. And having formerly, before we poured in any water, tried what water would suffice to raise the bottom CD, when there was nothing but its own proper weight, that was to be surmounted; we found, by deducting that weight from the weight in the scale, and comparing the residue with the weight of as much water as the cavity of the broad, but very shallow cylinder, BECHGDF, would have alone (if there had been no water in the pipe AI) amounted to; we found, I say, by comparing these particulars, that the pressure upon CD was by so very great odds more, than could have been attributed to the weight of so little water, as the instrument pipe and all contained, in case the water had been in an uniform cylinder, and consequently a very shallow one, of a basis as large as that of our instrument; that we could not but look upon the success, as that, which, though it did not answer what the reading of *Stevinus* might make a man expect; yet may deserve to be further prosecuted, that whether or no the paradox of *Stevinus* (which not only some others, but the learned Dr. *Wallis* himself question) will hold, the inquiry he has started, may be so pursued, as to occasion some improvement of this part of Hydrostaticks: where, to define things with certainty, will perhaps be found a difficulter task than at first glance one would think; both because divers speculative things must be taken into consideration, whose theory has not perhaps yet been cleared, and because of the difficulty, that will be found in practice by them, that shall go about to make *Stevinus's* experiments, or others of that sort, with all requisite accurateness. As indeed, it is far easier to pro-

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pose experiments, which would in likelihood prove what we intend, in case they could be made, than to propose practicable expedients, how they may be made.

PARADOX VII.

That a body immersed in a fluid sustains a lateral pressure from the fluid; and that increased, as the depth of the immersed body, beneath the surface of the fluid, increaseth.

THOUGH I shall not wonder, if this proposition seems strange enough to most readers; yet I think I could make it out by several ways, and particularly by one, that is plain and easy, being but that which follows:

TAKE then a slender glass-pipe (like that employed about the first experiment;) and cause it to be bent within two or three inches of one end, so that the longer and the shorter legs, EF and FG, may make, as near as can be, a right angle at F; then dipping the orifice of the shorter leg FG in oil of turpentine, suck into the siphon (if I may so call it) as much of the liquor as will fill the shorter leg, and reach two or three inches high in the longer: then nimbly stopping the upper orifice with your finger, immerse the lower part of the glass under water, in such manner, as that the longer leg EF may make, as to sense, right angles with (AB) the horizontal surface of the water; and the shorter leg FG may be so far depressed under that surface, that IK, the superficies of the oil in the longer leg, be but a little higher than AB, that of the external water. Then, removing your finger, you may observe, that the oil in the siphon will continue (with little or no change) in its former station. By which it appears, that there is a lateral pressure of the water against the oil contiguous to G, the orifice of the shorter leg of the pipe; since it is only that pressure, that hinders the efflux of the oil at that orifice, notwithstanding the pressure of the perpendicular cylinder of oil, that would drive it out.

AND that this pressure of the perpendicular cylinder doth really urge the oil in the shorter leg to flow out, you may learn, by slowly lifting the siphon (without changing its former posture) towards the surface of the water. For as the lower leg comes nearer and nearer to that surface, (to which, as I newly intimated, it is still to be kept parallel) the oil in the horizontal leg will be driven out in drops, by the pressure of the other oil in the perpendicular leg.

THAT likewise, before you begin to raise the siphon, the lateral pressure of the water against the lower orifice of it is, at least in such experiments, near about the same with what would be the perpendicular pressure of a cylinder of water, reaching from the same orifice G (or some part of it) to the top of the water, may be gathered from hence, that the surface of the oil in the longer leg will be a little higher than that of the external water, as (by reason of the often mentioned comparative levity of the oil) it would be, if we suppose, that a pipe of glass of the

same bore, and reaching to the top of the water, being fitted to the orifice of the horizontal leg (as in the annexed figure the cylinder, G H) were filled with water.

AND, to make out the latter part of our proposition, we need add no more, than that, if you plunge the siphon deeper into the water, you shall find the oil, by the lateral pressure of the water, driven by degrees quite out of the shorter leg into the longer: and if you thrust it yet deeper, you may observe, that the longer leg will admit a cylinder of water, upon which that of oil will swim; the whole oil alone being unable to counterbalance the lateral pressure of the water at so great a depth.

BY which last circumstance, it appears, that water has also a lateral pressure against water itself, and that increased according to its depth; since otherwise the external water could not impel that in the horizontal leg of the siphon into the perpendicular leg, though, to do so, it must surmount the weight or resistance of the whole cylinder of oil, that must be here violently raised in the said perpendicular leg.

BUT if you gently raise the siphon again, the lateral pressure of the water against the immersed orifice being diminished, (according as the distance of that orifice G from the horizontal surface, A B, comes to be lessened,) the prevalent oil will drive out the water, first out of the longer leg, and then out of the shorter, and will at length flow out in drops at the immersed orifice, and thence emerge to the top of the water.

BESIDES, when the oil in the siphon does just counterbalance the external water, if you keep the shorter leg parallel to the surface of the water, and move the orifice of it this way or that way, and place it nearer or further off from the middle or from the sides of the glass, (provided you keep it always at the same depth under the water) you will find the oil in the longer leg to continue (as to sense) at the same height. Whence we may learn (what I have not yet found mentioned by any writer) that, even in the midst of the water, we may suppose a pillar of water, of a basis equal to the side of an immersed body, (and reaching to the lowest part of it;) and that, though this imaginary aqueous pillar, such as in our figure G H, be not included in any solid body, or stable superficies; nevertheless its lower parts will have a lateral pressure tending outwards, against the imaginary sides, from the weight of the water, that is above these subjacent and lateral parts; and will have that pressure increased proportionably to the height to which the imaginary pillar reaches above them. Which observation, being duly noted and applied, may be of no mean use in the explication of divers hydrostatical phenomena.

AND lastly, if, instead of holding E F, the longer leg of our siphon, perpendicular, (and consequently the shorter parallel to the horizon,) you variously incline the former, so as to bring it to make an obtuse or an acute

angle with the superficies of the water A B; though by this means the shorter and immersed leg, F G, will in situation sometimes respect the bottom, and sometimes the top of the glass; yet in all these oblique situations of this leg, and the immersed orifice of it, G, the oblique pressure of the water will so much depend upon the height of the surface of the liquor above the orifice, and so much conform to the observations already delivered, that you shall still see the surface of the oil I K, in the longer pipe, to be a little, and but a little superiour to that of the external water, A B, and so the æquilibrium betwixt the liquor, or liquors, within the siphon, and the water without it, will even in this case also be maintained.

SCHOLIUM.

REMEMBRING on this occasion an experiment, which, though it do not shew what the precise quantity of lateral pressure is, that the lower parts of the fluid may sustain from the more elevated; yet it may confirm the foregoing paradox, and by its phenomena afford some hints, that may render it not unacceptable; I shall subjoin it, as I set it down not long after I devised it.

IN the first place then, there was made a glass bubble with a slender neck; and (in a word) of the figure expressed in the annexed *Fig. XIV.* scheme: this bubble I caused to be so poised, that, though it would float upon the water, yet the addition of a weight small enough would suffice to make it sink.

THIS done, I provided a very large wide-mouthed glass, and caused to be fitted to it, as exactly as I could, a stopple of cork, which being strongly thrust in, would not easily be lifted up. In the middle of this cork there was burned, with a heated instrument, a round hole; through which was thrust a long slender pipe of glass; so that the lower end of it was a pretty way beneath the cork, and the upper part of it was, as near as could be, at right angles with the upper part of the said cork. And in another part of the stopple, near the edge, there was made another round hole, into which was likewise thrust another small pipe; whose lower part reached also a pretty way beneath the cork, but its upper part was but about two or three inches high; and the orifice of this upper part was carefully closed with a stopple and cement. Then the glass-vessel being filled with water, and the poised bubble being made to float upon it, the stopple or cover of the great glass-vessel was put on, and made fast with a close cement, that nothing might get in or out of the vessel, but at the long slender pipe; which was fastned into the cork (as was also the shorter pipe) not only by its own fitness to the hole it passed through, but by a sufficient quantity of the same cement, carefully applied to stop all crevices.

THE instrument thus prepared, (and inclined this or that way, till the floating bubble was at a good distance from that end

of the long pipe, which reached a pretty way downwards beneath the surface of the water,) we began to pour in some of that liquor at the open orifice of the pipe E F; and, the mouth of the vessel being exactly stopped, the water, for want of another place to receive it, ascended into the pipe, through which it had fallen before. And, if I held my hand, when the water I had poured in was able to reach but to a small height in the cylinder, as for instance, to the superficies J; the bubble X would yet continue floating. But, if I continued pouring, till the water in the pipe had attained a considerable height above the surface of that in the vessel, as if it reached to K; then the bubble X would presently sink to the bottom of the vessel, and there continue, as long as the water continued at so great a height in the pipe E F.

THIS experiment will not only teach us, that the upper parts of the water gravitate upon those, that are under them, but (which is the thing we are now to confirm) that in a vessel, that is full, all the lower parts are pressed by the upper, though these lower be not directly beneath the upper, but aside of them, and perhaps at a good distance from the line, in which they directly press; these things, I say, may be made out by our experiment. For the addition of the cylinder of water K J, in the pipe E F, makes the bubble X subside; as the force or pressure of any other heavy body upon the water in the vessel would do. And since (as may be gathered from the reason formerly given, in the proof of the second paradox, of the sinking of poised bubbles) the included air in our bubble was notably compressed; it will follow, that the cylinder of water K I did press the subjacent water in the vessel: for, without so doing, it could not be able to compress the air in the bubble. And since the said bubble did not swim directly under, or near the pipe E F, but at one side of it, and at a pretty distance from it, nay, and floated above the lower orifice F of the pipe; it is evident, that that aqueous cylinder J K does not only press upon the water, or other bodies, that are directly under it; but upon those also, that are laterally situated in respect of it, provided they be inferior to it.

AND, according to this doctrine, we may conceive, that every assignable part of the sides of the vessel does sustain a pressure, increased by the increase of that part's depth under water, and according to the largeness of the said part. And therefore, if any part were so weak, as that it would be easily beaten out, or broken by a weight equal to the cylinder I K, (making always a due abatement for the obliquity of the pressure) it would not be fit to be a part of our vessel: nay, the cork itself, though it be above the surface of the water in the vessel; yet, because the water in the pipe is higher than it, each of its parts resists a considerable pressure, proportionate to its particular bigness, and to the height of the water in the pipe. And therefore, if the cork be not well stopped in,

it may be lifted up by the pressure of the water in the pipe, if that be filled to a good height. And if the cement be not good and close, the water will (not without noise) make itself a passage through it. And if the stopple G, of the shorter pipe G H, (which is placed there likewise to illustrate the present conjecture) do not firmly close the orifice of it, it may be forced out, not without violence and noise. And, for further satisfaction, if, instead of the stopple G, you close the orifice with your finger, you shall find it pressed upwards as strongly, as it would be pressed downwards by the weight of a cylinder of water of the breadth of the pipe, and of a not inconsiderable height, (for it is not easy to determine precisely, what height :) so that (to be short) in the fluid body we made our trial with, the pressure of the superior parts was communicated, not only to those, that were placed directly under them, but even to those, that were but obliquely so, and at a distance from them.

I HAD forgot to confirm, that it was the pressure of the superior parts of the water, that made our floating bubble sink, by such another circumstance, as I took notice of in some of the former experiments; viz. that, when it lay quietly at the bottom of the vessel, if, by inclining the instrument, we poured off as much of the water in the pipe E F, as sufficed competently to diminish its height above the water in the vessel A B C D, the air in the bubble, finding its former pressure alleviated, would presently expand itself, and make the bubble emerge. And to show, that the very oblique pressure, which the bubble sustained from the water in the pipe, was not overmuch differing from that, which it would have sustained from an external force, or from the weight of water placed directly over it; I caused two such bubbles to be poised, and having put each of them into a long cylindrical glass, open above, and filled with water, upon which it floated, if we thrust it down a little way, it would (agreeably to what hath been above related) ascend again: so that we were forced to thrust it down to a good depth, before the pressure of the incumbent water was great enough to make it subside. See the proof of the second paradox.

AND, perhaps, it will not be impertinent to take notice, before we conclude, how the pressure of such differing fluids, as air and water, may be communicated to one another. For having sometimes forborn to fill the vessel A B C D quite full of water, so that, when the cork was fitted to it, there remained in it a pretty quantity of air, (as between the surface L M, and the cork;) nevertheless, if the stopple or cork were very closely put in, the pressure of the water, that was afterwards poured into the pipe E F, from J to K, would make the bubble sink little otherwise, for aught I took notice of, than if the vessel had been perfectly filled with water; the air, (above L M,) that was both imprisoned and compressed, communicating the pressure it received to the water contiguous to it.

P A R A D O X VIII.

That water may be made as well to depress a body lighter than itself, as to buoy it up.

HOW strange soever this may seem to those, that are prepossessed with the vulgar notions about gravity and levity; it need not be marvelled at by those, that have considered, what has been already delivered. For since, in fluid bodies, the upper parts press upon the lower, and upon other bodies, that lie beneath them: and since, when a body is unequally pressed by others, whether lighter, or heavier than itself, it must necessarily be thrust out of that place, where it is more pressed, to that, where it is less pressed; if that a parcel of oil be, by a contrivance, so exposed to the water, as that the water presses against its upper superficies, and not against the undermost, or lateral parts of it; if we suppose, that there is nothing (whose pressure is not inferior to that of the water) to hinder its descent, (supposing, withal, that the oil and water cannot pass by one another; for which cause we make use of a slender pipe;) the oil must necessarily give way downwards, and consequently be depressed, and not buoyed up. This is easily exemplified by the following experiment:

Fig. XV. TAKE a slender glass siphon EFGH, of the bore we have often mentioned, whose shorter leg GH may be about three or four inches long, and as parallel, as the artificer can make it, to the longer EF; dip the shorter leg in oil of turpentine, till the oil quite fill the shorter leg, and reach to an equal height in the longer, as from F to J. Then, stopping the orifice E of the longer leg with your finger, and immersing the replenished part of the siphon about an inch under water, you shall perceive, that, as you thrust it lower and lower, upon the removal of your finger, the oil in the shorter leg will be made to sink about an inch, or somewhat more; and as, afterwards, you thrust the pipe deeper, the oil in the shorter leg will, by the weight of the incumbent water HK, be driven downward more and more, till it come to the very bottom of the shorter leg; whence, by continuing the immersion, you may impel it into the longer. The cause of which phenomenon I suppose to be already clearly enough assigned, to make it needless to add any thing here about it.

Fig. XVI. IT remains, that, before I proceed to the next proposition, I add; that, to exemplify at once three paradoxes, (both this, and the next foregoing, and the second,) I caused to be made a slender glass-pipe, of the figure expressed in the annexed scheme, and having, by the lower orifice L, sucked into it as much oil of turpentine, as reached, in the longest leg NO, as high as the top of the other part of the glass; (namely, to the part P, in the same level with the orifice L;) I first stopped the upper orifice of it, O, with my finger. And then, thrusting it as before under water to a convenient depth, upon

the removal of my finger, the external water did first drive away the oil, that was in LM, that part of the crooked pipe which was parallel to the horizon; then it depressed the same oil to the bottom of the shorter leg, that is, from M to N: and lastly, it impelled it all up into the longer leg NPO, to what height I thought fit. So that the oil was pressed by the water, both laterally, downwards, and upwards: the causes of which are easily deducible from the doctrine already delivered.

P A R A D O X IX.

That, whatever is said of positive levity, a parcel of oil lighter than water, may be kept in water without ascending in it.

TO make out what I have to represent about this paradox the more intelligible, the best way perhaps will be to set down the considerations, that induced me to judge the thing it pretends to feasible. And in order to this, it would be expedient to consider, why it is, that a body lighter *in specie* than water, being placed never so much beneath the superficies of that liquor, will rather emerge to the top, than sink to the bottom of it; if we had not already considered that problem in the explication of the third paradox. But being now allowed to apply to our present purpose what hath been there delivered, I shall forthwith subjoin, that it was easy enough for me to collect from hence, that the reason, why it seems not possible, that a parcel of oil lighter than water should without violence be kept from emerging to the top of it, being this, *That since the surface of a vessel full of standing water is (physically speaking) horizontal, the water, that presses against the lower part of the immersed body, must needs be deeper than that, which presses against the upper:* If I could so order the matter, that the water, that leans upon the upper part of the body should, by being higher than the level of the rest of the water, have a height great enough to balance that, which presses against the lower, (and the bodies not shift places, by passing one by the other) the oil might be kept suspended betwixt two parcels of water.

To reduce this to practice, I took the following course; having sucked into a slender pipe (such as that employed about the first experiment) about an inch of water, and kept it suspended there, by stopping the orifice of the pipe; I thrust the lower part of the pipe about two inches beneath the surface of some oil of turpentine (which, to make the effect the clearer, I sometimes tinge deeply with copper;) then removing my finger, the oil being pressed against the immersed orifice with a greater force, than the weight of so little suspended water could resist, that oil was impelled into the lower part of the pipe to the height of near an inch; and then again I stopped the upper orifice of the pipe with my finger, and thereby keeping both the liquors suspended in it, I thrust the pipe into a glass full of water, three or four inches beneath the surface of it; and then (for the reason

reason just now given) the water; upon the removal of my finger, will press in at the lower orifice of the pipe, and impel up the oil, till they come to such a station, as that expressed
 Fig. XVII. in the annexed scheme: where P Q is the water, newly impelled up into the pipe, Q R is the oil, and R S the water, that was at first sucked into the pipe. For in this station these three liquors do altogether as much gravitate upon the part P, as the incumbent water alone does upon the other parts of the imaginary superficies G H; and yet the oil, R Q, does not ascend, because the diffuence of the water, R S, being hindered by the sides of the pipe, its superficies, T S, is higher than A D, the superficies of the rest of the water; by which means the incumbent water may be brought to have upon the upper part R of the oleous cylinder, as great a pressure as that of the water, that endeavours to impel upwards the lower part Q of the same suspended cylinder of oil.

P A R A D O X X.

That the cause of the ascension of water in siphons, and of its flowing through them, may be explicated without having a recourse to nature's abhorrency of a vacuum.

BOTH philosophers and mathematicians having too generally confessed themselves reduced to fly to a *fuga vacui*, for an account of the cause of the running of water, and other liquors through siphons: and even those moderns, that admit a vacuum, having (as far as I have met with) either left the phenomenon unexplicated, or endeavoured to explain it by disputable notions: I think the curious much obliged to Monsieur *Pascal*, for having ingeniously endeavoured to shew, that this difficult problem need not reduce us to have recourse to a *fuga vacui*. And indeed his explication of the motion of water in siphons, seems to me so consonant to hydrostatical principles, that I think it not necessary to alter any thing in it. But as for the experiment he propounds to justify his ratiocination, I fear his readers will scarce be much invited to attempt it. For, besides that it requires a great quantity of quicksilver, and a new kind of siphon, fifteen or twenty foot long; the vessels of quicksilver must be placed six or seven yards under water, that is, at so great a depth, that I doubt whether men, that are not divers, will be able conveniently to observe the progress of the trial.

WHEREFORE we will substitute a way, which may be tried in a glass tube, not two foot deep, by the help of another peculiarly contrived glass, to be prepared by a skilful hand. Provide then a glass tube A B C D, of a good wideness, and half a yard or more in depth; provide also a siphon of two legs, F K, and K G, whereunto is joined (at the upper part of the siphon) a pipe E K, in such manner, as that the cavity of the pipe communicates with the cavities of the siphon: so that if you should pour in water at E, it

would run out at F and G. To each of the two legs of this new siphon must be tied with a string a pipe of glass, I and H, sealed at one end, and open at the other; at which it admits a good part of the leg of the siphon to which it is fastned, and which leg must reach a pretty way beneath the surface of the water, wherewith the said pipe is to be almost filled. But as one of these legs is longer than the other, so the surface of the water in the suspended pipe I, that is fastned to the shorter leg K F, must be higher (that is, nearer to K or A B) than the surface of the water in the pipe H, suspended from the longer leg K G; that (according to what is usual in siphons) the water may run from a higher vessel to a lower.

ALL things being thus provided; and the pipe E K being held, or otherwise made fast, that it may not be moved; you must gently pour oil of turpentine into the tube A B C D, (which, if you have not much oil, you may beforehand fill with water, till the liquor reach near the bottom of the suspended pipes, as to the superficies X Y) till it reach higher than the top of the siphon F K G, (whose orifice E you may, if you please, in the mean time close with your finger, or otherwise, and afterwards unstop) and then the oil pressing upon the water, will make it ascend into the legs of the siphon; and pass through it, out of the uppermost vessel J, into the lowermost H; and if the vessel J were supplied with water, the course of the water through the siphon would continue longer, than here (by reason of the paucity of water) it can do.

Now in this experiment we manifestly see the water made to take its course through the legs of a siphon from a higher vessel into a lower; and yet the top of the siphon being perforated at K, the air has free access to each of the legs of it, through the hollow pipe E K, which communicates with them both. So that, in our case, (where there is no danger of a vacuum, though the water should not run through the siphon) the fear of a vacuum cannot with any shew of reason be pretended to be the cause of its running. Wherefore we must seek out some other.

AND it will not be very difficult to find, that it is partly the pressure of the oil, and partly the contrivance and situation of the vessels; if we will but consider the matter somewhat more attentively. For the oil, that reaches much higher than K, and consequently than the legs of the siphon, presses upon the surface of the external water, in each of the suspended pipes I and H. I say the external water, because the oil floating upon the water, and the orifices of both the legs F and G, being immersed under the water, the oil has no access to the cavity of either of those legs. Wherefore, since the oil gravitates upon the water without the legs, and not upon that within them, and since its height above the water is great enough to press up the water into the cavity

of the legs of the siphon, and impel it as high as K, the water must by that pressure be made to ascend.

AND this raising of the water happening at first in both legs, (for the cause is in both the same) there will be a kind of conflict about K betwixt the two ascending portions of water; and therefore we will now examine, which must prevail.

AND if we consider, that the pressure, sustained by the two parcels of water in the suspended pipes I and H, depends upon the height of the oil, that presses upon them respectively; it may seem (at the first view) that the water should be driven out of the lower vessel into the higher. For if we suppose that part of the shorter leg, that is unimmersed under water, to be six inches long, and the unimmersed part of the longer leg to be seven inches; because the surface of the water in the vessel I is an inch higher than that of the water in the vessel H, it will follow, that there is a greater pressure upon the water, whereinto the longer leg is dipped, by the weight of an inch of oil: so that that liquor being an inch higher upon the surface of the water in the pipe H, than upon that in the pipe I, it seems, that the water ought rather to be impelled from H towards K, than from I towards K.

BUT then we must consider, that, though the descent of the water in the leg G be more resisted than that in the other leg, by as much pressure as the weight of an inch of oil can amount to; yet being longer by an inch than the water in the leg F, it tends downwards more strongly by the weight of an inch of water, by which length it exceeds the water in the opposite leg. So that an inch of water being (*cæteris paribus*) heavier than an inch of oil; the water in the longer leg, notwithstanding the greater resistance of the external oil, has a stronger endeavour downwards, than has the water in the shorter leg; though the descent of this be resisted but by a depth of oil less by an inch. So that all things computed, the motion must be made towards that way, where the endeavour is most forcible; and consequently the course of the water must be from the upper vessel, and the shorter leg into the longer leg, and so into the lower vessel.

THE application of this to what happens in siphons is obvious enough. For, when once the water is brought to run through a siphon, the air (which is a fluid, and has some gravity, and has no access into the cavity of the siphon) must necessarily gravitate upon the water, whereinto the legs of the siphon are dipped, and not upon that, which is within the siphon: and consequently, though the incumbent air have somewhat a greater height upon the water in the lower vessel, than upon that in the upper; yet the gravitation it thereby exercises upon the former more than upon the latter, being very considerable, the water in the longer leg much preponderating (by reason of its length) the water in the shorter leg, the efflux must be

out of that leg, and not out of the other. And the pressure of the external air being able to raise water (as we find by sucking pumps) to a far greater height, than that of the shorter leg of the siphon; the efflux will continue, for the same reason, till the exhaustion of the water, or some other circumstance, alter the case. But, if the legs of the siphon should exceed thirty four or thirty five foot of perpendicular altitude, the water would not flow through it; the pressure of the external air being unable (as has been elsewhere declared) to raise water to such a height. And if a hole being made at the top of a siphon, that hole should be unstopped, while the water is running, the course of it would presently cease. For, in that case, the air would gravitate upon the water, as well within as without the cavity of the siphon; and so the water in each leg would, by its own weight, fall back into the vessel belonging to it.

BUT because this last circumstance, though clearly deducible from hydrostatical principles and experiments, has not, that I know of, been verified by particular trials, I caused two siphons to be made, the one of tin, the other of glass; each of which had, at the upper part of the flexure, a small round hole or socket, which I could stop and unstop, at pleasure, with the pulp of my finger. So that, when the water was running through the siphon, in case I removed my finger, the water would presently fall, partly into one of the subjacent vessels, and partly into the other. And if the legs of the siphon were so unequal in length, that the water in the one had a far greater height (or depth) than in the other; there seemed to be, when the liquor began to take its course through the siphon, some light pressure from the external air upon the finger, wherewith I stopped the orifice of the socket made at the flexure.

AND on this occasion I will add, what I have more than once tried; to shew, at how very minute a passage the pressure of the external air may be communicated to bodies fitted to receive it. For, having for this purpose stopped the orifice of one of the above mentioned siphons, (instead of doing it with my finger) with a piece of oiled paper, carefully fastned with cement to the sides of the socket; I found, as I expected, that though hereby the siphon was so well closed, that the water ran freely through, yet, if I made a hole with the point of a needle, the air would at so very little an orifice insinuate itself into the cavity of the siphon, and, thereby gravitating as well within as without, make the water in the legs to fall down into the vessels. And though, if I held the point of the needle in the hole I made, and then caused one to suck at the longer leg; this small stopple, without any other help from my hand, sufficed to make the siphon fit for use: yet if I removed the needle, the air would (not without some noise) presently get in at the hole, and put a final stop to the course of the water. Nor was I able to take out the needle, and

*In the
Physico-
mechanical Experiments*

put it in again so nimbly, but that the air found time to get into the siphon; and, till the hole were again stopped, render it useless; notwithstanding that the water was by suction endeavoured to be set a running.

PARADOX XI.

That a solid body, as ponderous as any yet known, though near the top of the water, it will sink by its own weight; yet if it be placed at a greater depth than that of twenty times its own thickness, it will not sink, if its descent be not assisted by the weight of the incumbent water.

THIS paradox having never been (that I know of) proposed as yet by any, has seemed so little credible to those to whom I have mentioned it, (without excepting mathematicians themselves,) that I can scarce hope it should be readily and generally received in this illustrious company, upon less clear testimony, than that of experience. And therefore, though, (if I mistake not) some part of this proposition may be plausibly deduced by the help of an instrument ingeniously thought upon by Monsieur Pascal; yet I shall have recourse to my own method for the making of it out, for these two reasons: the one, that a great part of the paradox must be explicated, as well as proved, by the doctrine already settled in this paper: the other, that the experiment proposed by Monsieur Pascal, being to be done in a deep river, and requiring a tube twenty foot long, whose bottom must be fitted with a brass cylinder, made with an exactness, scarce (if at all) to be hoped for from our workmen; if I should build any thing on this so difficult an experiment, (which himself does not affirm to have ever been actually tried,) I fear most men would rather reject the experiment as a chimerical thing, than receive for its sake a doctrine that appears to them very extravagant.

LET us then, to employ in this case also the method we have hitherto made use of, fill a glass vessel, ABCD, almost full of water; only, in regard that there is a great depth of water requisite to some circumstances of the experiment, this last must not be so shallow, as those hitherto employed: but a deep cylinder or tube, sealed at one end, whose depth must be at least two or three foot, though its breadth need not be above two or three inches; and, to keep it upright, it may be placed in a socket of metal, or wood, of a size and weight convenient for such a purpose. This glass being thus fitted in water, let us suppose EF to be a round and flat piece of solid brass, having about an inch in diameter, and a fourth, or sixth part of an inch in thickness. This cylinder, being immersed under water, till it be just covered by the uppermost surface of that liquor, and being let go, must necessarily fall downwards in it; because, if we suppose the imaginary

superficies GH to pass along the circle F, which is the lower part of the brass body; that metal being *in specie* far heavier than water, the brass, that leans upon the part F, must far more gravitate upon the said part F, than the incumbent water does upon any other part of the superficies GH; and, consequently, the subjacent water at F will be thrust out of place by the descending body. And because that, in what part soever of the water, not exceeding nine times its thickness; measured from the top of the water AC, the ponderous body EF shall happen to be; there will be still, by reason of the specific gravity of the metal, a greater pressure upon that part of the imaginary superficies, that passes along the bottom of the body, on which the part F shall happen to lean, than upon any other part of the same imaginary superficies; the brass body would still descend by virtue of its own weight, though it were not assisted by the weight of the water, that is over it. But let us suppose it to be placed under water on the designable plane JK; and let this plane, which (as all other imaginary planes) is, as well as the real surface of the water, to be conceived parallel to the horizon; and let the depth, or distance of this plane, from the uppermost surface of the water, be (somewhat) above nine times the thickness of the brass body: I say, that, in this case, the body would not descend, if it were not pressed downwards by the weight of the water it has over it. For, brass being but about nine times * as heavy as water of an equal bulk to it, the body EF alone would press upon the part F, but as much as a cylinder of water would, which, having an equal basis, were eight or nine times as high, as the brass is thick. But now, all the other parts of the imaginary surfaces IK being pressed upon by the incumbent water, which is as high above them, as the newly mentioned cylinder of water would be; there is no reason, why the part F should be depressed, rather than any other part of the superficies JK: but because it is true, which we formerly taught, namely, that water retains its gravity in water; and that too, though a body, heavier *in specie* than it, be placed immediately under it; it will necessarily happen, that in what part soever the solid body be placed, provided it be every way environed with the water, it must, for the reason newly given, be made to move downwards, partly by its own weight, and partly by that of the incumbent water; and must continue to sink, till it come to the bottom, or some other body, that hinders its farther descent.

BUT in case the water above the solid body did not gravitate upon it, and thereby assist its descent; or in case, that the incumbent water were, by some artifice or other, so removed, that none of the lateral water (if I may so call it) could succeed in its place to lean upon the solid; then it will follow, from

* The word, *about*, is added, because indeed the author, as he elsewhere delivers, did, by exact scales, find brass to weigh between eight and nine times as much as water; but judged it needless to his present argument, and inconvenient, to take notice of the fraction.

what we have newly shown, that the solid would be kept suspended. And in case it were placed much deeper in the water, as over-against the point L, or M; then, if we conceive the incumbent water to be removed, or fenced off from it, the pressure of the solid alone upon the part F, of the imaginary superficies LM, being very much inferior to that of the water upon the other parts of the same surface, the part F would be strongly impelled upwards, by a force proportionate to the difference of those two pressures. And therefore, since I have found by trials, purposely made in scales marvellously exact, and with refined gold, (purer than, perhaps, any that was ever weighed in water) that gold, though much the ponderoufest of bodies yet known in the world, is not full twenty times as heavy, as water of the same bulk; I kept within compass, (as well as employed a round number, as they call it) when I said, that no body (yet known) how ponderous soever, will subside in water by its own weight alone, if it were so placed under water, that the depth of the water did above twenty times exceed the height of the body; (not to mention here, that, though gold and water being weighed in the air, their proportion is above nineteen to one, yet, in the water, gold does, as other sinking bodies, lose as much of its weight, as that of an equal bulk of water amounts to.)

I WAS saying just now, that, in case the brazen body were placed low enough beneath the surface of the water, and kept from being depressed by any incumbent water, it would be supported by the subjacent water. And this is that very thing, that I am now to shew by an experiment.

Fig. XX. LET then the brass body EF be the cover of a brass valve, (as in the annexed figure :) and let the valve be fastened with some strong and close cement to a glass pipe, OP, (open at both ends) and of a competent length and wideness. For then the body EF, being the undermost part of the instrument, and not sticking to any other part of it, will fall by its own weight, if it be not supported. Now then, tying a thread to a button Q, (that is wont to be made in the middle of the doors of brass valves) you must, by pulling that string straight and upwards, make the body EF shut the orifice of the valve as close as you can; (which is easily and presently done.) Then, thrusting the valve under water, to the depth of a foot, or more, the cement and the sides of the glass OP, (which reaches far above the top of the water XY) will keep the water from coming to bear upon the upper part of the body EF; and consequently, the imaginary surface VW, (that passes by the lower part of the said body) will, where it is contiguous thereunto, be pressed upon only by the proper weight of the body EF; but, in its other parts, by the much greater weight of the incumbent water.

So that, though you let go the string, (that held the body EF close to the rest of the instrument) the said body will not at all sink, though there be nothing but water beneath it to support it.

AND to manifest, that it is only the pressure of the water, of a competent depth, that keeps the solid suspended; if you slowly lift up the instrument towards (XY) the top of the water; you shall find, that, though for a while the parts of the valve will continue united, as they were before; yet, when once it is raised so near the surface, (as between the plane JK and XY) that the single weight of EF, upon the subjacent part of the imaginary plane, that passes by it, is greater than the pressure of the incumbent water upon other parts of the same plane; that body, being no more supported as formerly, will fall down, and the water will get into the pipe, and ascend therein to the level of the external water.

BUT if, when the valve is first thrust under water, and before you let go the thread, that keeps its parts together, you thrust it down to a good depth, as to the superficies RS; then, though you should hang a considerable weight, as L, to the valve EF, (as I am going to shew you a trial with a massy cylinder of stone broader than the valve, and of divers inches in length) the surplussage of pressure on the other parts of the plane VW, (now in RS) over and above what the weight of the body EF, and that of the cylindrical stone L to boot, can amount to, on that part of the surface, which is contiguous to the said body EF, will be great enough to press so hard against the lower part of the valve, that its own weight, though assisted with that of the stone, will not be able to disjoin them.

BY which (to note that by the way) you may see, that though, when two flat and polished marbles are joined together, we find it is impossible to sever them without force; we need not have recourse to a *fuga vacui* to explicate the cause of their cohesion, whilst they are environed by the air, which is a fluid not devoid of gravity, and reaching above the marbles, no body knows how high.

AND, to evince, that it is only such a pressure of the water, as I have been declaring, that causes the cohesion of the parts of the valve; if you gently lift it up towards the top of the water, you will quickly find the brass body EF drawn down by the stone (L) that hangs at it; as you will perceive by the water's getting in between the parts of the valve, and ascending into the pipe.

TO which I shall only add, what you will quickly see, that, in perfect conformity to our doctrine, the pressure of the body EF, upon the subjacent water, being very much increased by the weight of the stone, that hangs at it, the valve needs not, as before, be lifted up above the plane JK, to overcome the resistance of the water, being now enabled to do it, before it is raised near so high.

APPENDIX I.

Containing an answer to seven objections, proposed by a late learned writer, to evince, that the upper parts of water press not upon the lower.

AFTER I had, this morning, made an end of reviewing the foregoing papers, there came into my hands some questions lately published, among other things, by a very recent writer of Hydrostaticks. In one of which questions, the learned author strongly defends the contrary to what has there been in some places proved, and divers places supposed.

THE author of these Erotemata asserts, that, *in consistent water, the upper parts do not gravitate, or press upon the lower.*

AND therefore, I think it will be neither useless, nor improper, briefly to examine here the arguments he produces. Not useless; because the opinion he asserts both is, and has long been, very generally received; and because too it is of so great importance, that many of the erroneous tenets and conclusions of those, that (whether professedly, or incidentally) treat of hydrostatical matters, are built upon it. And not improper; because our learned author seems to have done his reader the favour to sum up into one page all the arguments for his opinions; that are dispersedly to be found in his own, or other mens books. So that, in answering these, we may hope to do much towards a satisfactory decision of so important a controversy. And, after what we have already delivered, our answers will be so seasonable, that they will not need to be long; the things they are built on having been already made out in the respective places, whereto the reader is referred.

OUR author then maintains, that, in consistent water, the superiour do not actually press the inferiour parts, by the seven following arguments.

Object. 1. SAYS he, *Because else the inferiour parts of the water would be more dense than the superiour, since they would be compressed and condensed by the weight of them.*

Ans. BUT, if the corpuscles, whereof water consists, be supposed to be perfectly solid and hard, the inferiour corpuscles may be pressed upon by the weight of the superiour, without being compressed, or condensed by them; as it would happen, if diamond-dust were laid together in a tall heap: for, though the upper parts, being heavy and solid corpuscles, cannot be denied to lean, and press upon the lower; yet these, by reason of their adamantine hardness, would not be thereby compressed. And it is possible too, that the corpuscles of water, though not so perfectly hard, but that they may a little yield to an extreme force, be solid enough not to admit from such a weight, as that of the incumbent water, (at least in such small heights, as observations are wont to be made in,) any compression great enough to be sensible; as, besides some trials I have formerly mentioned in

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another place, those, made in the presence of this illustrious company, seem sufficiently to argue; *viz.* that water is not sensibly compressible by an ordinary force. And I find not, by those, that make the objection, that they ever took pains to try, whether, in deep places of the sea, the lower parts are not more condensed than the upper; nor do I see any absurdity, that would follow from admitting them to be so.

Object. 2. OUR author's second argument is, *Because divers feel not, under water, the weight of the water, that lies upon them.*

Ans. BUT, for answer to this argument, I shall content myself to make a reference to the ensuing appendix, where this matter will be considered at large; and where, I hope, it will be made to appear, that the phenomenon may proceed, partly from the firm texture of the diver's body, and partly from the nature of that pressure, which is exercised against bodies immersed in fluids; which, in that case, (as to sense) presses every where equally against all the parts of the body exposed to their action.

Object. 3. THE third argument is, *That even the slightest herbs, growing at the bottom of the water, and shooting up in it to a good height, are not oppressed, or laid by the incumbent water.*

Ans. BUT the answer to that is easy, out of the foregoing doctrine. For the plants, we speak of, sustain not the pressure of the water above them by their own strength, but by the help of the pressure of water, that is beneath: which, being itself pressed by the water, that is (though not perpendicularly over it) superiour to it, presses them upwards so forcibly, that, if they were not by their roots, or otherwise, fastened to the ground, they, being *in specie* lighter than water, would be buoyed up to the top of the water, and made to float; as we often see that weeds do, which storms, or other accidents have torn from their native soil.

Object. 4. A FOURTH objection is this; *That a heavy body, tied to a string, and let down under water, is supported, and drawn out with as much ease, as it would be, if it had no water incumbent on it; nay, with greater ease, because heavy bodies weigh less in water, than out of it.*

Ans. BUT an account of this is easy to be rendered out of our doctrine; for, though the water incumbent on the heavy body do really endeavour to make it sink lower, yet that endeavour is rendered ineffectual to that purpose by the equal pressure of the water upon all the other parts of the imaginary surface, that is contiguous to the bottom of the immersed body. And that pressure upon the other parts of that supposed plane being equal, not only to the pressure of the pillar of water, but to that pillar, and to the weight of as much water, as the immersed body fills the place of; it must needs follow, that not only the hand, that sustains the body, should not feel the weight of the incumbent water, but should be able to lift up the body more easily

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in the water, than in the air. But, though the pressure of the water incumbent on the stone cannot, for the reason assigned, be felt in the case proposed; yet, if you remove that water, (as in the experiment brought for the proof of the last paradox,) it will quickly appear by the pressure against the lower part of the heavy body, and its inability to descend by its own weight, when it is any thing deep under water; it will, I say, quickly appear, by what will follow upon the absence of the incumbent water, how great a pressure it exercised upon the stone, whilst it leaned on it.

Objekt. 5. THE fifth argument is proposed in these words; *Because a bucket full of water is lighter in the water, than out of it; nor does weigh more, when full within the water, than when empty out of it; nay, it weighs less, for the reason newly assigned, (in the fourth objection :) therefore the water of the bucket, because it is within water, does not gravitate, nor, consequently, press downwards either the bucket, or the water under the bucket.* This is the grand and obvious experiment, upon which the schools, and the generality of writers have very confidently built this axiom, *That the elements do not gravitate in their proper place;* and particularly, that water weighs not (as they speak) in its own element.

Ans. WHAT they mean by *proper, or natural place,* I shall not stand to examine; nor to inquire, whether they can prove, that water, or any other sublunary body possesses any place, but upon this account, that the cause of gravity, or some other movent, enables it to expel other contiguous bodies (that are less heavy, or less moved) out of the place they possessed before; and gives it an incessant tendency, or endeavour towards the lowermost parts of the earth.

BUT, as to the example proposed, it is very easy to give an account of it; for, suppose ABCD to be a well, wherein, by the string EF, the bucket is suspended under water, and has its bottom contiguous to the imaginary plane IK: if now we suppose the bucket to consist only of wood lighter than water, it will not only not press upon the hand, that holds the rope at E, but will be buoyed up, till the upper parts of the bucket be above the top of the water; because the wood, whereof the bucket is made, being lighter *in specie* than water, the pressure of the water in the bucket G, and the rest of the water incumbent on that, together with the weight of the bucket itself, must necessarily be unable to press the part H so strongly, as the other parts of the imaginary plane IK are pressed by the weight of the meer water incumbent on them. But if, as it is usual, the bucket consists partly of wood, partly of iron; the aggregate may often indeed be heavier than an equal bulk of water: but then the hand, that draws up the bucket by the rope FE, ought not, according to our doctrine, to feel the weight of all the bucket, much less that of the water contained in it. For though that aggregate of wood and iron, which we here call the bucket, be heavier than

so much water; yet it tends not downwards with its whole weight, but only with that surplussage of weight, whereby it exceeds as much water, as is equal to it in bulk; which surplussage is not wont to be very considerable. And as for the water in the cavity G of the bucket, there is no reason, why it should at all load the hand at E, though really the water, both in the bucket and over it, do tend downwards with their full weight; because that the rest of the water LI, and MK, do full as strongly press upon the rest of the imaginary superficies IK, as the bucket and the incumbent water do upon the part H; and consequently, the bottom of the bucket is every whit as strongly pressed upwards by the weight of the water upon all the other parts of the plane IK, as it tends downwards by virtue of the weight of the incumbent water, that is partly in the bucket, and partly above it; and so, these pressures balancing one another, the hand, that draws the rope at E, has no more to lift up, than the surplussage of weight, whereby the empty bucket exceeds the weight of as much water, as is equal in bulk (I say not to the bucket, as it is a hollow instrument, but) to the wood and iron, whereof the bucket consists.

AND because this example of the lightness of filled buckets within the water has for so many ages gained credit to, if it have not been the only ground of, the assertion, that water weighs not in its own element, or in its proper place; I shall add (though I can scarce present it to such a company as this without smiles) an experiment, that I made to convince those, that were, through unskillfulness or prejudice, indisposed to admit the hydrostatical account I have been giving of the phenomenon. I took then a round wooden box, which I substituted in the room of a bucket; and (having filled it with melted butter, into which, when it was congealed, some small bits of lead were put, to make it a little heavier than so much water,) I caused a small string of twined silk to pass through two small holes, made in the opposite parts of the upper edge of the box, and to be suspended at one end of the beam of a pair of goldsmiths scales; and then putting it into a vessel full of water, till it was let down there, to what depth I pleased, it appeared, that not only the least endeavour of my hand would either support it, or transport to and fro in the water, or draw it up to the top of it; and this, whether the box were made use of, or whether the butter and lead alone, without the box, were suspended by the silken string: but (to evince, that it was not the strength of my hand, or the smallness of the immersed body, that kept me from feeling any considerable resistance) I cast some grains into the scale, that hung at the other end of the above mentioned beam, and presently raised the lead and butter to the surface of the water. So that, unless the schoolmen will say, that the butter and lead were in their own element, we must be allowed to think, that the easy sustentation, and elevation

tion of the box, did not proceed from hence, that those bodies weighed not, because they were in their natural place. And yet in this case, the effect is the same with that, which happens, when a bucket is drawing out of a well.

AND, to manifest that it was the pressure of the water against the lower part of the surface of our suspended body, that made it so easy to be supported in the water, or raised to the top of it; I shall add, that though a few grains sufficed to bring the upper surface of the butter to the top of the water, yet afterwards there was a considerable weight requisite to raise more and more of its parts above the water's surface; and a considerable yet, to lift the whole body quite out of the water. Which is very consonant to our doctrine. For, suppose the bucket to be at the part N, half in and half out of the water: the hand or counterpoise, that supports it in that posture, must have a far greater strength than needed to sustain it, when it was quite under water; because that now the imaginary plain P Q, passing by the bottom of the bucket, has on its other parts but a little depth of water, as from L to P, or M to Q; and consequently the bottom of the bucket, H, will scarce be pressed upwards above half as strongly as when the bucket was quite under water. And if it be raised to O, and consequently quite out of the water; that liquor reaching no longer to the bottom of the bucket, can no longer contribute to its supportation; and therefore a weight not only equal, but somewhat superior to the full weight of the bucket, and all that it contains (being all supposed to be weighed in the air) will be necessary to lift it clear out of the water.

BUT to dwell longer on this subject cannot but be tedious to those, that have been any thing attentive to the former discourses. I proceed therefore to our author's sixth argument, which is,

Object. 6. *That horse-hairs, which are held to be of the same gravity with water, keep whatever place is given them in that liquor; nor are depressed by the weight of the super-incumbent water.*

Ans. Whether the matter of fact be strictly and universally true, is scarce worth the examining, especially since we find the difference in point of specific gravity, betwixt most horse hairs, and most waters, to be inconsiderable enough. But the phenomenon, supposing the truth of it, is very easily explicable, according to the doctrine above delivered. For supposing in the last scheme the body, R, to be bulk for bulk exactly equiponderant to water; it is plain there is no reason, why that body should press the part S, of the imaginary superficies I K, either more or less than that part S would be pressed, if the body R being annihilated or removed, it were succeeded by a parcel of water of just the same bulk and weight. And consequently, though all the water directly above the solid R do really lean upon that body,

and endeavour to depress it; yet that endeavour being resisted by an equal and contrary endeavour, that proceeds (as we have been but too often fain to declare) from the pressure exercised upon the other parts of the superficies, I K, by the water incumbent on them; the body R will be neither depressed nor raised. And its case being the same in what part of the water soever it be placed; provided it be perfectly environed with that liquor; it must keep in the water (which in this whole discourse we suppose to be homogeneous as to gravity) the place you please to give it.

AND (to add that, on this occasion) though mathematicians have hitherto contented themselves to prove, that in case a body could be found or provided, that were exactly equiponderant to water, it would retain any assignable place in it; yet the curiosity we had, to give an experimental proof of this truth, at length produced some glass-bubbles; which some gentlemen here present have not perhaps forgot, that were (by a dextrous hand we employed about it) so exquisitely poised, as, to the wonder of the beholders, to retain the places given them, sometimes in the middle, sometimes near the top, and sometimes near the bottom of the water (though that were homogeneous) for a great while, till some change of consistence or gravity in the water, or some of its parts, made the bubble rise or fall.

THE application of this to what has been objected concerning horse-hairs; being too easy to need to be insisted on, there remains to be dispatched our author's seventh and last argument, which is this:

Object. 7. *That, otherwise, all the inferior parts of the water would be in perpetual motion, and perpetually expelled by the superior.*

Ans. But if, by the inferior parts, he means such portions, as are of any considerable bulk; the answer newly made to the last objection (where we shewed, that the body, R, would retain its place any where in the water; and consequently near the bottom) will shew the invalidity of this objection. And unless we knew of what bigness and shape the corpuscles of water are, it would perhaps be to little purpose to dispute, how far it may be granted, or may be true in the particles, that water is made up of. Only this I shall add, that, whereas this learned author mentions it as an absurdity, that the lower parts of water should be in perpetual motion; and *Stevinus* himself, in the beginning of his hydrostatical elements, seems to me to speak somewhat inconsiderately of this matter; and though, as I lately said, I allow such sensible bodies, as those, whose gravity in water writers are wont to dispute of, to be capable of retaining their places in water, if they be *in specie* equiponderant to it: yet I am so far from thinking it absurd, that the inferior corpuscles of water should be perpetually in motion, that I see not how otherwise they could constitute a fluid body, that restless motion of their parts being one of the generallst attri-

attributes of liquors; and being, in water, though not immediately to be seen, yet to be easily discovered by its effects: as, when salt, being cast into water, the aqueous parts, that are contiguous to it, and consequently near to the bottom, do soon carry up many of the saline ones to the very top of the water; where, after a while, they are wont to disclose themselves in little floating grains of a cubical shape.

In the history of fluidity and firmness.

BUT of this restless motion of the parts of liquors having professedly treated elsewhere already; I shall add nothing at present, but rather take notice of what our author subjoins to the last of his arguments, (as the grand thing which they suppose) in these words: *Ratio porro, à priori, hujus sententiæ videtur esse, quia res non dicitur gravitare, nisi quatenus habet infra se corpus levius se in specie.* The erroneousness of which conceit if I should now go about solemnly to evince, I as well fear it would be tedious, as I hope it will be needless to those, that have not forgot what may concern this subject in the former part of the now at length finished discourse; and especially where I mention those experiments, which show, that neither a stone, nor gold itself, when placed deep under water, would sink in it, if the superiour water, that gravitates on it, did not contribute to its depression.

A P P E N D I X II.

Concerning the reason, why divers, and others, who descend to the bottom of the sea, are not oppressed by the weight of the incumbent water.

AMONGST the difficulties, that belong to the Hydrostaticks, there is one, which is so noble, and which does still so much both exercise and pose the wits of the curious, that perchance it will not be unacceptable, if to the former experiments we add, by way of appendix, one, that may conduce to the solving of this difficult problem; *viz.* why men, deep under water, feel no inconvenience by the pressure of so great a weight of water as they are placed under?

THE common answer of philosophers and other writers to this puzzling question is, that the elements do not gravitate in their own proper places; and so, water in particular has no gravitation upon water, nor consequently upon bodies every way surrounded with water. But that this solution is not to be admitted, may be easily gathered from our proofs of the first paradox, and from divers other particulars, applicable to the same purpose, that may be met with in the foregoing papers.

A FAMOUS writer, and, for aught I know, the recentest (except Monsieur Pascal) that has treated of Hydrostaticks, having rendered this reason of the phænomenon:

[The superiour parts of consistent water (as he speaks) press not the inferiour, unless beneath the inferiour there be a body lighter in specie than water; and therefore, since a human body is heavier in specie than water, it is

not pressed by the incumbent water, because this does not endeavour to be beneath a human body:] He subjoins, contrary to his custom, this confident epiphonema, *Qui aliam causam hujus rei assignant, errant, & alios decipiunt.*

BUT, by his favour, notwithstanding this confidence, I shall not scruple to seek another reason of the phænomenon. For I have abundantly proved, that (contrary to the assertion on which his explication is built) the upper parts of water press against the lower, whether a body heavier or lighter *in specie* than water be underneath the lower. And, the contrary of which being the *πρώτον ψεύδος* in this controversy, perhaps the matter may be somewhat cleared, by mentioning here a distinction; which I sometimes make use of. I consider then a body may be said to gravitate upon another body in two senses. For sometimes it actually sinks into, or gets beneath the body, that was under it, as a sinking stone gravitates upon water, and which I call prevalent, or successful gravitation; and sometimes it does not actually, at least not visibly descend, but only exercises its gravitation by pressing against the subjacent body that hinders its descent: as when a woman carries a pail of water on her head, though the weight do not actually get nearer the center of the earth; yet it actually presses with its whole gravity upon the woman's head, and back, and other subjacent parts, that hinder its actual descent. And, according to this doctrine, I cannot admit our author's reasoning, that because a man's body is bulk for bulk heavier than water, therefore the water does not endeavour to place itself beneath it. For water, being a heavy body, derives from the cause of its gravity (whatever that be) an incessant endeavour towards the center of the earth; nor is there any reason, why its happening to be incumbent on a body heavier *in specie* than itself, should destroy that endeavour. And therefore, though it may be said, that the water does not endeavour to place itself beneath a human body, because indeed an inanimate liquor cannot properly be said to act for this or any other end; yet the water being a heavy body, tends continually towards the lower part of the earth; and therefore will get beneath any body that is placed betwixt it and that, (without regard whether the inferiour body be heavier or lighter *in specie* than itself) as far as the degree of its gravity will enable it; nor would it ever rest, till it have reached the lowermost parts of the earth, if the greater ponderousness of the earth, and other heavy bodies, did not hinder, (not its endeavour downwards, nor its pressure upon subjacent bodies, but only) its actual descent.

THIS learned author himself tells us, (as well as Stevinus, and others, that have written of the Hydrostaticks, unanimously teach) that if the bottom of a vessel be parallel to the horizon, the weight of water, that rests upon it, is equal to a pillar of water, having that bottom for its basis, and for its height a perpendicular reaching thence to the uppermost

most surface of the water. Nor is it reasonable to conceive, that there will be any difference in this pressure of the incumbent water, whether the bottom be of deal, that will swim, or of box, that will sink in water; or, to speak more generally, whether it be of wood, *in specie* lighter than water, or of copper, or some other metal, that is *in specie* heavier than it. And since water, being not a solid body, but a fluid, consists (as other fluids) of innumerable corpuscles, that, though extremely minute, have their own sizes and figures; and since the pressure of water upon the bottom of a vessel is proportionate to its perpendicular height over the bottom; it is manifest, that the upper corpuscles press the bottom as well as the lower; which since they cannot do immediately, they must do by pressing the intermediate ones. And I have already shown (discouraging one of the former paradoxes) that the superiour parts of water do not only press those, that are directly under them, but communicate a pressure to those, that are aside of them, and at a distance from them.

AND if it be objected, that water endeavours to get beneath a bottom of glass-vessels, or other bodies heavier *in specie* than itself, because under that bottom there is air, which is a lighter body *in specie* than water: I say, that this is precarious; for the indisputable gravity of the water is alone sufficient to make it always tend downwards, (though it cannot always move downwards) whatever body be beneath it. And who can assure the makers of this objection, that there are not beneath even the bottom of rivers, or of the sea, (where yet they say water is consistent, and rests as in its own place) vast spaces replenished but with air, fumes, or fire, or some other body lighter than water? For, (not to mention, that the Cartesians take the earth we tread on, to be but a thin crust of the terrestrial globe, whose inside, as far as the center, is replenished with a subtile fluid matter, like that whereof the sun consists;) we know that in some places, as particularly at a famous coal-mine in *Scotland*, there are great cavities, that reach a good way under that ground, that serves there for a bottom to the sea: so that, for aught these objectors know, even according to their own doctrine, the water, even in the sea, may endeavour to get beneath a body heavier *in specie* than itself.

BUT, for my part, I cannot but think, that, to imagine the water knows, whether or no there be air or some lighter body than itself beneath the body it leans on, and the superiour parts do accordingly exercise or suspend their pressure upon the inferiour; is to forget that it is a heavy liquor, and an inanimate body.

ANOTHER solution there is of this hydrostatical problem we have been discoursing of, which I met with in a printed letter of Monsieur *Des Cartes*, in these terms:

Je ne me, &c. I remember not what reason it is, that Stevinus gives, why one feels not the

weight of water, when one is under it: but the true one is, that there can no more of water gravitate upon the body, that is in it, or under it, than as much water as could descend in case that body left its place. Thus, for example, if there were a man in the barrel B, that should with his body so stop the hole A, as to hinder the water's getting out, he would feel upon himself the weight of the whole cylinder of water ABC, of which I suppose the basis to be equal to the hole A: forasmuch as if he sunk down through the hole, all the cylinder would descend too; but if he be a little higher, as about B, so that he does no longer hinder the water from running out at the hole A, he ought not to feel any weight of the water which is over him, betwixt B and C; because if he should descend toward A, that water would not descend with him, but contrariwise a part of the water, which is beneath him towards A, of equal bulk to his body, would ascend into its place: so that, instead of feeling the water to press him from the top downward, he ought to feel, that it buoys him upward from the bottom; which by experience we see.

THUS far this subtile philosopher; for whose ratiocinations though I am wont to have much respect, yet I must take the liberty to confess myself unsatisfied with this. For, having already sufficiently proved, that the upper parts of water press the lower, and the bodies placed beneath them, whether such bodies be lighter *in specie* than water, or heavier; we have subverted the foundation, upon which Monsieur *Des Cartes's* ingenious, though unsatisfactory, explication is built. And yet I shall add, *ex abundanti*, that supposing what he says, that, in case the solid B should descend towards A, the incumbent water would not descend with it, but a part of the subjacent water, equal in bulk to the solid, would ascend, and succeed in its room; yet that is but accidental, by reason of the staunchness and fulness of the vessel. And though, indeed, the superiour water cannot actually descend upon the depression of the solid at B, if at the same time, while that body descends, an equal bulk of water succeeds in its place; yet both the solid about C, and the water, that succeeds it, do, in their turns, hinder the descent of the superiour water; which therefore must gravitate upon which soever of the two it be, that actually comes to be placed directly under it, if there be nothing before the displacing of the solid capable to take away the natural gravity, upon whose account the water over B and C does incessantly tend downwards. And though Monsieur *Des Cartes* does not so clearly express himself, whether he supposes the hole at A to be stopped with some other body, when the solid is placed about B; yet, because he is wont to speak consistently, I presume he means, that, when the solid is removed to B, the hole at A is otherwise sufficiently stopped; I say then, that the reason, why the solid, which, whilst at A, sustained a great pressure from the incumbent water, feels not the weight of it, when placed at B, is not that, which Monsieur

fieur *Des Cartes* gives, but this; That the solid being environed with water, the subjacent water does (as we have often had occasion to manifest) press it upwards full as strongly, (and somewhat more) as the weight of the incumbent water presses it downwards; so that a man's body, instead of sinking, would be buoyed up, if, as it is a little heavier, it were a little lighter *in specie* than water. Whereas, when the solid was that alone, which covered and stopped the hole, there was a manifest reason, why it should be forcibly thrust downwards by the weight of the incumbent water *BC*. For, in that case, there was no water underneath it at *A*, to support the solid; and, by its pressure, to enable it to resist so great a weight.

AND this (to hint that upon the by) may, perchance, help us to guess at the reason of what geographers relate of the lake *Asphaltites* in *Judea*, (in case the matter of fact be true,) that this *Dead Sea* (as they also call it) will not suffer any living creature to sink in it. For the body of a man (and, for aught we know, of other animals) is not much heavier *in specie* than common fresh water. Now, if in this lake (that stands, where *Sodom* and *Gomorrab* did, before those impious regions were destroyed by fire from heaven,) we suppose, (which the nature of the soil, and the sacred story makes probable enough,) that the water abounds with saline, or sulphurous corpuscles; (the former helping the latter to associate with the water, as we see in soap consisting of salt and oil, and in chymical mixtures of alcalis and brimstone dissoluble in water;) the liquor may have its gravity so augmented, as to become heavier *in specie* than the body of an animal. For I have learned of a light swimmer, that he could hardly begin to dive in salt water, though he easily could in fresh. And it is not difficult to make a brine or *lixivium* (which are but solutions of salt in water) heavy enough to keep up an egg from sinking. And not only barely by dissolving a metalline body in a saline *menstruum*, without otherwise thickening the liquor, I have brought solid pieces of amber itself to swim upon it; but I have tried, that certain saline solutions, which I elsewhere mention, nay, and a distilled liquor, (I used deflegmed oil of vitriol) without any thing dissolved in it, would do the same thing, by reason of the numerous, though minute, corpuscles of salt and sulphur, that it abounds with.

THERE remains but one solution more of our hydrostatical problem, that I think worth mentioning, and that is given by the learned *Stevinus* in these words:

OMNI pressu, quo corpus dolore afficitur, pars aliqua corporis luxatur; sed isto pressu nulla corporis pars luxatur; isto igitur pressu corpus dolore nullo afficitur. Assumptio syllogismi manifesta est; nam si pars aliqua, ut caro,

*sanguis, humor, aut quodlibet denique membrum luxaretur, in alium locum concedat necesse esset: atqui locus ille non est extra corpus; cum aqua undiquaque equali pressu circumfusa sit (quod vero pars ima, per undecimam propositionem Hydrostaticorum, paulo validius prematur superiori, id hoc casu nullius momenti est, quia tantula differentia partem nullam sua sede dimovere potest) neque item intra ipsum corpus concedit, cum istic corpore omnia oppleta sint, unde singulae partes singulis partibus equaliter resistunt, namque aqua undiquaque eadem ratione corpus totum circumstat. Quare cum locus is nec intra, nec extra corpus sit; absurdum, imo impossibile fuerit, partem ullam suo loco emovere, ideoque nec corpus hic afficitur dolore.**

THIS solution of *Stevinus* I esteem preferable by far to those, that are wont to be given of this difficult problem: but yet the phenomenon seems to me to have still somewhat in it of strange. It is true, that if the question were only that, which some put, *viz.* Why the body of a diver, when it is near the bottom of the sea, is not pressed down by so vast a weight of water, as is incumbent on it? it might be rationally answered, That the weight of so much water, as leans upon the body, is not sustained by the force of the body itself, but by that of the water, which is under it. For, by the experiments and explications, we have annexed to some of the foregoing paradoxes, it appears, that the subjacent water, by its pressure upwards, is able, not only to support the weight of the incumbent water, but so far to exceed it, that it would not only support the immersed body, and the incumbent water, but buoy up the body, if it were never so little lighter *in specie* than water. And as for what *Stevinus* insinuates, that, when the water presses the body every way, that pressure is not felt, though it would be, in case it pressed upon some parts, and not upon others; I am of the same opinion too: and, to prove it, shall not make use of the example he proposes, in the words immediately following those of his I just now recited; (for I doubt, that example is rather a supposition, than a tried thing;) but by an experiment, which may be easily made, and has divers times been so, in our pneumatical engine. For, though the air be a heavy fluid, and though, whilst it uniformly presses the whole superficies of the body, we feel not the pressure of it; and though, for this reason, you may lay the palm of your hand upon the open orifice of a small brass cylinder, applied to the engine instead of a receiver, without any hurt: yet when, by pumping, the air, that was before under the palm of your hand, is withdrawn, and consequently can no longer help to support your hand against the pressure of the external and incumbent air, the external air will lean so heavy upon the back of your hand, that you

* *Stevinus Hydrostat. lib. 5. pag. 149.*

Sed exemplo clarius ita intelliges, esto ABCD aqua, cujus fundum DC, in quo foramen E habeat epistomium sibi insertum, cui dorso incumbat homo F. Quæ cum ita sint, ab aquæ pondere ipsi insidente nulla pars corporis luxari poterit, cum aqua, ut dictum est, undiquaque equaliter urgeat.

Si vero ejus veritatem explorare libeat, eximito epistomium, tumque tergum nulla re fultum sustinebitur, ut in locis cæteris, ideoque istic tanto pressu afficitur, quantus tertio exemplo secundæ propositionis hujus demonstratus est: vid. quantum efficit columna aquea, cujus basis sit foramen E, altitudo autem eadem quæ aquæ ipsi insidentis. Quo exemplo propositi veritas manifeste declaratur.

you will imagine, some ponderous weight is laid upon it. And I remember, by such an experiment, I have not only had my hand put to much pain, but have had the back of it so bent downward, as if it were going to be broken.

BUT though such considerations, as these, may much lessen the difficulty of our phenomenon, whose cause is inquired into; yet still it seems somewhat odd to me, that (since it is evident from the nature of the thing, and by *Stevinus's* confession, that there is a vast pressure of water against every part of the body, whose endeavour tends inward,) so exceedingly forcible and pressure, (which thrusts, for instance, the muscles of the arms and thighs against the bones, and skin and flesh of the thorax against the ribs,) should not put the diver to any sensible pain; as I find not (by one that I examined) that it does; (though this man told me, he stayed a good while at the depth of betwixt eighty and one hundred foot under the sea-water, which is heavier than fresh water :) for, that which *Stevinus's* explication will only show is, that there must be no manifest dislocation of the greater parts of the body; whereas the bare compression of two small parts, one against another, is sufficient to produce a sense of pain.

BUT it seems, the texture of the bodies of animals is better able to resist the pressure of an every way ambient fluid, than, if we were not taught by experience, we should imagine. And therefore, to satisfy those, that (excluding the question about the sense of pain) think it an abundantly sufficient argument, (to prove, that bodies immersed under water, are not compressed by it,) that divers are not oppressed, and even crushed by so vast a load of water, (amounting, by *Stevinus's* computation, to many thousands of pounds) as is incumbent on them: we will add, that though an experiment, proposed by *Monsieur Pascal* to this purpose, were such, that at first sight I said, that it would not succeed, (and was not upon trial mistaken in my conjecture;) yet it gave me the occasion to make another, which will, I hope, fully make out the thing I designed it for.

THE ingenious *Monsieur Pascal* would persuade his readers, that if into a glass vessel, with luke-warm water in it, you cast a fly; and, by a rammer, forcibly press that water, you shall not be able to kill, or hurt the fly. Which, says he, will live as well, and walk up and down as lively, in lukewarm water, as in the air. But, upon trial with a strong fly, the animal was (as we expected) presently drowned, and so made moveless, by the lukewarm water.

WHEREFORE we substituted another experiment, that we knew would not only succeed, (as you will presently see it will do,) but teach us how great a pressure the included animal must have been exposed to. We took then a somewhat slender cylindrical pipe of glass, sealed at one end, and open at the other; and to this we fitted a rammer, which (by the help of some thongs of soft leather, that were carefully wound about it) did so exactly fill the

pipe, that it could not easily be moved to and fro; and would suffer neither water, nor air, to get by betwixt it and the internal surface of the glass. We also provided some small tadpoles (or *Gyrini*) about an inch long or less; which sort of animals we made choice of before any other, partly because they could, by reason of their smallness, swim freely to and fro in so little water as our pipe contained; and partly because those creatures, being as yet but in their infancy, were more tender, and consequently far more exposed to be injured by compression, than other animals of the same bulk, but come to their full age and growth, would be; (as indeed such young tadpoles are so soft and tender, that they seem, in comparison to the bigger sort of flies, to be but organized jelly.) One of these tadpoles being put into the water, and some inches of air being left in the pipe, for the use anon to be mentioned; the water and air, and consequently the tadpole, were by the intrusion of the plug or rammer, with as great a force, as a man was able to employ, violently compressed; and yet, though the tadpole seemed to be compressed into a little less bulk than it was of before, it swam freely up and down the water, without forbearing sometimes to ascend to the very top, though the instrument were held perpendicular to the horizon. Nor did it clearly appear to us, that the little animal was injured by this compression; and most manifest it is, he was not crushed to death, or sensibly hurt by it.

AND having repeated this experiment several times, and with tadpoles of differing ages; we may, I presume, safely conclude, that the texture of animals is so strong, that, though water be allowed to weigh upon water, yet a diver ought not to be oppressed by it: since, whether or no water weighs in water, it is manifest, that in our experiment, the water, and consequently the tadpole, was very forcibly by an external agent compressed betwixt the violently condensed air, and the rammer. And, by the notice we took of the quantity of air before the compression began, and that to which it was reduced by compression; the moderate estimate we could make, was, that it was reduced into an eighth, or tenth part of its former space; and so (according to what we have elsewhere proved) the pressure, that was upon the air, (and consequently upon the water, and the included tadpole,) was as great, as that of a cylinder of water, of above two hundred, if not three hundred foot high. And yet all this weight being unable to oppress, or so much as manifestly to hurt, the tender tadpole; (which a very small weight would suffice to have crushed, if it pressed only upon one part of it, and not upon the other;) we may thence learn the truth of what we have been endeavouring to evince: That though water be allowed to press against water, and all immersed bodies; yet a diver may very well remain unoppressed at a great depth under water, as long as the pressure of it is uniform against all the parts exposed thereunto.

A Confirmation of the former * ACCOUNT touching the late EARTHQUAKE near *Oxford*, and the Concomitants thereof.

First printed in the *Philosophical Transactions*, N^o XI. p. 179.
For April 2. 1666.

AS to the earthquake, your curiosity about it makes me sorry, that, though I think I was the first, that gave notice of it to several of the virtuosi at *Oxford*; yet the account, that I can send you about it, is not so much of the thing itself, as of the changes of the air, that accompanied it. To inform you of which, I must relate to you, that riding one evening somewhat late, betwixt *Oxford* and a lodging I have at a place four miles distant from it, the weather having been for a pretty while frosty, I found the wind so very cold, that it reduced me to put on some defensives against it; which I never since, nor, if I forget not, all the foregoing part of the winter was obliged to make use of. My unwillingness to stay long in so troublesome a cold, which continued very piercing, till I had got half way homeward, did put me upon galloping at no very lazy rate; and yet, before I could get to my lodgings, I found the wind turned, and felt the rain falling: which, considering the shortness of the time, and that this accident was preceded by a settled frost, was surprising to me, and induced me to mention it at my return, as one of the greatest and suddenest alterations of air I had ever observed. And what changes I found, have been taken notice of in the gravity of the atmosphere at the same time, by that accurate observer * Dr. *Wallis*, who then suspected nothing of what followed, as, I suppose, he has ere this told you himself. Soon after, by my guess about an hour, there was a manifest trembling in the house, where I was, (which stands high in comparison of *Oxford*;) but it was not there so great, but that I, who chanced to have my thoughts

busied enough on other matters than the weather, should not have taken notice of it as an earthquake, but have imputed it to some other cause, if one, that you know, whose hand is employed in this paper, and begins to be a diligent observer of natural things, had not advertised me of it, as being taken notice of by him, and the rest of the people of the house. And soon after there happened a brisk storm; whereupon I sent to make inquiry at a place called *Brill*, which standing upon a much higher ground, I supposed, might be more obnoxious to the effects of the earthquake, (of which, had I had any suspicion of it, my having formerly been in one near the *Lacus Lemanus* would have made me the more observant :) but the person I sent to, being disabled by sickness to come over to me, (which he promised to do, as soon as he could) wrote me only a ticket, whose substance was, That the earthquake was there much more considerable, than where I lodged; and that, at a gentleman's house, whom he names, (the most noted person, it seems, of the neighbourhood) the house trembled very much, so as to make the stones manifestly to move to and fro in the parlour, to the great amazement and fright of all the family. The hill, whereon this *Brill* stands, I have observed to be very well stored with mineral substances of several kinds, and from thence I have been informed by others, that this earthquake reached a good many miles; but I have neither leisure, nor inclination, to entertain you with uncertain reports of the extent and other circumstances; especially since a little further time and inquiry may enable me to give you a better warranted account.

* See Num x. of *Phil. Transactions*, p. 166—171; at the time of the printing whereof, this relation of Mr. *Boyle* was not yet come to hand.

Some OBSERVATIONS and DIRECTIONS about the BAROMETER.

First printed in the *Philosophical Transactions*, N^o XI. p. 181:

For April 2. 1666.

AS to the barometrical observations, (as for brevity's sake I use to call them) though you † guessed aright, that, when I saw those of the learned and inquisitive Dr. Beale, I had not mine by me, (for I left them some years since in the hands of a virtuoso, nor have I now the leisure to look after those papers;) yet since, by the communication you have made publick, it is probable, that divers ingenious men will be invited to attempt the like observations, I shall (notwithstanding my present haste) mention to you some particulars, which, perhaps, will not appear unseasonable, that came into my mind upon the reading of what you have presented the curious.

WHEN I did, as you may remember, some years ago, publicly express and desire, that some inquisitive men would make baroscopical observations in several parts of *England* (if not in foreign countries ‖ also;) and, to assist them to do so, presented some of my friends with the necessary instruments: the declared reason of my desiring this correspondence was, (among other things) that, by comparing notes, the extent of the *atmosphærical* changes, in point of *weight*, might be the better estimated. But not having hitherto received some account, that I hoped for, I shall now, without staying for them, intimate thus much to you: That it will be very convenient, that the observers take notice, not only of the day, but, as near as they can, of the hour; wherein the height of the mercurial cylinder is observed. For I have often found, that within less than the compass of one day, or, perhaps, half a day, the altitude of it has so considerably varied, as to make it, in many cases, difficult to conclude any thing certainly from observations, that agree but in the day.

It will be requisite also, that the observers give notice of the situation of the place, where their barometers stand, not only, because it will assist men to judge, whether the instruments were duly perfected, but principally, because that, though the baroscope be good, (nay, because it is so) the observations will much disagree, even when the atmosphere is in the same state, as to weight, if one of the instruments stand in a considerably higher part of the country, than the other.

To confirm both the foregoing admonitions, I must now inform you, that, having in these parts two lodgings, the one at *Oxford*, which, you know, stands in a bottom

by the *Thames* side, and the other at a place four miles thence, seated upon a moderate hill; I found, by comparing two baroscopes, that I made, the one at *Oxford*, the other at *Stanton St. John's*, that, though the former be very good, and have been noted for such, during some years, and the latter was very carefully filled; yet by reason, that in the higher place, the incumbent part of the atmosphere must be lighter than in the lower, there is almost always between two and three eighths of an inch difference betwixt them. And having sometimes ordered my servants to take notice of the disparity, and divers times carefully observed it myself, when I passed to and fro between *Oxford* and *Stanton*, I generally found; that the *Oxford* barometer, and the other, did, as it were, by common consent, rise and fall together so, as that in the former the mercury was usually $\frac{3}{8}$ higher than in the latter.

WHICH observations may teach us, that the subterraneous steams, which ascend into the air, or the other causes of the varying weight of the atmosphere, do many times, and at least in some places uniformly enough affect the air to a greater height than, till I had made this trial, I durst conclude.

BUT, as most of the barometrical observations are subject to exception, so I found the formerly mentioned to be. For (to omit lesser variations) riding one evening from *Oxford* to *Stanton*, and having, before I took horse, looked on the baroscope in the former of these two places, I was somewhat surpris'd to find at my coming to the latter, that in places no farther distant, and notwithstanding the shortness of the time (which was but an hour and a half, if so much) the barometer at *Stanton* was short of its usual distance from the other, near a quarter of an inch, though, the weather being fair and calm, there appeared nothing of manifest change in the air, to which I could ascribe so great a variation; and though also, since that time, the mercury in the two instruments hath, for the most part, proceeded to rise and fall as before.

AND these being the only observations I have yet met with, wherein baroscopes, at some distance of place, and difference of height, have been compared (though I cannot now send you the reflexions, I have elsewhere made upon them;) as the opportunity I had to make them myself, rendred them not unpleasant to me, so perhaps the novelty will keep them from being unwelcome to you.

VOL. II.

5 Y

And

† See Num. IX. of the *Phil. Transact.* p. 159, the last paragraph.

‖ Some whereof have been since invited by the Publisher, to give their concurrence herein.

And I confess I have had some flying suspicions, that the odd phænomena of the baroscope, which have hitherto more posed than instructed us, may in time, if a competent number of correspondents do diligently prosecute the inquiries (especially with baroscopes, accommodated with Mr. *Hook's* ingenious additions) make men some luciferous discoveries, that possibly we do not yet dream of.

I KNOW not, whether it will be worth while to add, that since I was obliged to leave *London*, I have been put upon so many lesser removes, that I have not been able to make baroscopical observations with such a constancy as I have wished; but, as far as I remember, the quicksilver has been for the most part so high, as to invite me to take notice of it; and to desire you to do me the favour to inquire among your correspondents whether they have observed the same thing*. For, if they have, this lasting, (though not uninterrupted) altitude of the quicksilver happening, when the seasons of the year have been extraordinary dry (so much as to become a grievance, and to dry up, as one of the late *Gazettes* informs us, some springs near *Weymouth*, that used to run constantly) it may be worth inquiry, whether these obstinate droughts may not, by cleaving of the ground too deep, and making it also in some places more porous, and, as it were, spungy, give a more copious vent, than is usual to subterranean steams; which ascending into the air, increase the gravity of it. The inducements I have to propose this inquiry, I must not now stay to mention. But perhaps, if the observation holds, it may prove not useless in reference to some diseases.

PERHAPS it will be needless to put you in mind of directing those virtuosi, that may desire your instructions about baroscopes, to set down in their diaries not only the day of the month, and the hour of the day, when the

mercury's height is taken, but (in a distinct column) the weather, especially the winds, both as to the quarters, whence they blow (though that be not always so easy nor necessary,) and as to the violence or remissness wherewith they blow. For, though it be more difficult, than one would think, to settle any general rule about the rising and falling of the quicksilver; yet in these parts, one of those, that seem to hold oftneft, is †, that when the high winds blow, the mercury is the lower; and yet that itself does sometimes fail: for, this very day (*March 3.*) though on that hill, where I am, the somewhat westerly winds have been blustering enough, yet ever since morning the quicksilver has been rising, and is now risen near $\frac{1}{2}$ of an inch.

I HAD thoughts to add something about another kind of baroscope (but inferiour to that in use) whereof I have given me intimation in one of the preliminaries to the *History of Cold*. But you have already so much of a letter, and my occasions, &c. to

THE same noble observer further intimates, That, as for that cause of the height of the quicksilver in droughts, which by him is suspected to be the elevation of steams from the crust or superficial parts of the earth, which by little and little may add to the weight of the atmosphere, being not, as in other seasons, carried down from time to time by the falling rain, it agrees not ill with what he has had since occasion to observe. For, whereas about *March 12th*, at *Oxford*, the quicksilver was higher than, for aught he knew, had been yet observed in *England*, viz. above $\frac{1}{2}$ above thirty inches, upon the first considerable showers, that have interrupted our long drought, as he affirms, he foretold divers hours before, that the quicksilver would be very low, (a blustering wind concurring with the rain) so he found it at *Stanton* to fall $\frac{1}{2}$ beneath 29 inches ‡.

* This hath been inquired into, and is found, that several accurate and curious persons (as the most noble President of the Royal Society, the Lord Viscount *Brounker*, Doctor *Beale*, Mr. *Hook*, &c.) have observed the same.

† See *Num. 12. Phil. Transact.* p. 157.—5, 8, 9: where the word *generally* signifies no more than *for the most part*.

‡ Dr. *Beale* concurs with this observation, when he saith, in a late letter of *March 19.* to his correspondent in *London*: *By change of weather and wind, the mercury is sunk more than an inch, since I wrote to you on Monday last, March 12. This last night, by rain and south-wind, it is sunk half an inch.*

T H E
O R I G I N
O F
F O R M S and Q U A L I T I E S,

According to the CORPUSCULAR PHILOSOPHY;

Illustrated by CONSIDERATIONS and EXPERIMENTS.

Written formerly by Way of NOTES upon an ESSAY from NITRE.

Augmented by a DISCOURSE of SUBORDINATE FORMS.

Audendum est, & veritas investiganda, quam etiamsi non assequamur, omnino tamen proprius, quam nunc sumus, ad eam perveniemus. GALEN.

The PUBLISHER to the Ingenious READER.

IN this curious and inquisitive age, when men, altogether dissatisfied and wearied out with the wranglings and idle speculations of the schools, are with equal zeal and industry so earnest in their quest and pursuit of a more solid; rational, and useful philosophy, it may prove a work very obliging and meritorious to help and guide them in their studies and researches, and to hang out a light to them, (as the *Egyptians* used to do from their highly celebrated *Pharos*, for direction to the mariners; that failed in those dangerous seas near *Alexandria*) whereby they may with better success steer their course through the vast ocean of learning, and make more full and perfect discoveries of hitherto unknown philosophical verities: which has been the chief design of this gentleman of honour; the most excellent and incomparable author, in this treatise now presented to your view, wherein principles are not (as was the mode and guise of former times) obtruded on the world upon the account of a great name, or involved in cloudy and mystical notions, which put the understanding upon the wreck, and yet when, with all this labour and toil of the brain, they are at last known, prove impertinent and useless to the making out with satisfaction, or so much as tolerably, the ordinary phænomena, which nature every day presents the world with; but such as are built upon the firm and immoveable foundation of reason, sense, and experience, plain and obvious, as well to the eye, as to the understanding, and no less accurate and certain in their application. And though the most noble author hath herein, for the main, espoused the atomical philosophy (corrected and purged from the wild fancies and extra-

vagancies of the first inventors of it, as to the origin of the universe, and still embraced with so much kindness and tenderness by some pretenders, against which he hath so learnedly disputed in his first part *Of the Usefulness of Experimental Philosophy*) in explicating the appearances; yet considering the several alterations and additions (the happy product of his penetrating judgment) made therein, I may not scruple to call it a new hypothesis, peculiar to the author, made out by daily observations, familiar proofs and experiments, and by exact and easily practicable chymical processes; whereby one of the most abstruse parts of natural philosophy, the origin of forms and qualities, which so much vexed and puzzled the ancients, and which, I would speak with the leave of the *Cartesians*, their ingenious master durst scarce venture upon, or at least was unwilling to handle at large, is now fully cleared and become manifest: so that from this very essay we may well take hope, and joyfully expect to see the noble project of the famous *Verulam* (hitherto reckoned among the *Desiderata*) receive its full and perfect accomplishment; I mean a real, useful, and experimental physiology, established and bottomed upon easy, true, and generally received principles. But I shall not forestall thy judgment either about the excellency of the author, or his subject, who hath so freely communicated to the world those treasures of learning, wherewith his mind is enriched, but shall soon refer you to the work itself, after I have given you these few advertisements.

THE following discourse (as is easily perceivable by divers passages thereof) being written several years since whol^{ly} and intire,
as

as now it is, I know not whether it will be worth while to intimate, that the author casually turning over of late a very recent chymical writer, found in one of his treatises (divers of which he never to this day read over) a part of the fifth experiment of the second section; but, as he professes, (and sure is like to be believed) he did not dream, that that chymist, or any other author whatsoever, had lighted on that part of the experiment, till a good while after he had made and examined that, among many others, concerning salts, as may be easily guessed by the peculiar uses and applications he made of it. And though he had met with so unlikely an experiment in a writer, who, whether he deserve it or no, has the ill fortune to be much accused of insincerity, and some of whose more easy processes our author (who yet is willing to spare his name, and seems to think his works not useless) could not find to succeed, he should not have taken it upon his authority, no more than he is wont to take other processes, divers of which he yet in the general supposes may be true upon the relation of other chymists, who, by blemishing their books by things untrue and justly suspicious, are not to be relied on, nor much thanked by wary men. But it will probably appear less pertinent to add any thing further on this subject, than to take notice, that when the author had once consented to the publication of the following papers, he several times wished for an opportunity to make the experiments and observations, he now presents to the publick, more full and compleat than they were when addressed to a private friend. But the contagion that drove him from the places where his accommodations for repeating experiments were, obliged him to apply himself to other studies and employments.

AND upon the same account, though he afterwards found many of his notes upon other parts of the essay of *Salt-petre*, and have lying by him divers papers concerning *sensible Qualities*, and *Sensation in general*, and the *Production of second Qualities*, together with a collection of *Notes about occult Qualities*, and some other subjects of kin to those of this book; yet having, upon the freshly intimated occa-

sion, diverted his thoughts to other subjects, he will not engage himself to put together and communicate his collections on these subjects by any publick promise.

FURTHERMORE, as the author has in the following disquisitions aimed not at the raising or abetting a faction in philosophy, but at the discovery of the truth; so he is not so solicitous, what every sort of reader will think of his attempts, (which it is easy to foresee are not like to be overwelcome to the votaries of the school-philosophy) as to refuse a compliance with the desires of his friends, who have been long since very earnest with him, not to spend that time in replies to particular persons, which might be more usefully employed in pursuing further discoveries of nature by experiments. If he meet with any cogent and material objections against any of his chief opinions, he is enough a lover of truth, to be disposed to think himself obliged by those that shall shew him his mistakes, and to take occasion to reform them. But if nothing new or weighty be urged, he considers, that he lives in an age, wherein he has observed (even in his own case) that truth, if recommended by real experiments, will in time make their own way, and wherein live store of ingenious men, who, for the main, approve the opinions, and probably will not dislike the arguments he has proposed; and who being more at leisure than he to write polemical books, will not silently suffer what they judge truth to be triumphed over, or oppressed by those, who, employing usually but scholastical arguments, may be confuted by answers of the like nature. And therefore he doubts not, but that some learned favourers of the corpuscularian philosophy (of which he hath endeavoured to make out those parts, wherein they almost all agree) will be both able and willing to defend those discoveries by rational disputations, that they have not opportunity to increase by new experiment.

IN the mean while, I have no temptation to doubt in the least, but that this curious and excellent piece will be entertained and received by all that have any regard to the great concerns of learning, with that gust, delight, respect, and estimation, which it so highly merits.

The AUTHOR'S Prooemial Discourse to the READER *.

AS it is the part of a mineralist, both to discover new mines, and to work those, that are already discovered, by separating and melting the ores to reduce them into perfect metal; so I esteem, that it becomes a naturalist, not only to devise hypotheses and experiments, but to examine and improve those, that are already found out. Upon this consideration, (among other motives) I was invited to make the following attempt, whose productions coming to be exposed to other eyes, than those, for which they were first written, it will be requisite to give the pub-

lick some account of the occasion, the scope, and some circumstances. And this I shall do the more fully, because the reasons I am to render of my way of writing, in reference to the Peripatetick philosophy, must contain intimations, which, perhaps, will not be useless to some sorts of readers, (especially gentlemen,) and, by being applied to most of those other parts of my writings, that relate to the school-philosophy, may do them good service, and save both my readers and me some trouble of repetitions.

HAVING

* The following preface being addressed only to *Pyrophilus*.

HAVING four or five years ago published a little physico-chymical tract about the differing parts and red integration of nitre, I found as well by other signs, as by the early solicitations of the stationer for a new edition, that I had no cause to complain of the reception, that had been given it: but I observed too, that the discourse, consisting chiefly of reflexions, that were occasionally made upon the phenomena of a single experiment, was more available to confirm those in the Corpuscularian philosophy, that had already somewhat inquired into it, than to acquaint those with the principles and notions of it, who were utter strangers to it; and, as to many readers, was fitter to excite a curiosity for that philosophy, than to give an introduction thereunto. Upon this occasion it came into my mind, that about the time, when I writ that essay about salt-petre, (which was divers years before it was published) I had also some thoughts of a history of qualities, and that having in loose sheets set down divers observations and experiments proper for such a design, I had also drawn up a discourse, which was so contrived, that though some parts of it were written in such a manner, as that they may serve for expository notes upon some particular passages of the essay; yet those parts with the rest might serve for a general Preface to the history of qualities, in case I should ever have conveniency, as well as inclination, to make the prosecuting of it my business; and in the mean time might present that *Pyrophilus*, to whom I writ some kind of introduction to the principles of the mechanical philosophy, by expounding to him, as far as my thoughts and experiments would enable me to do, in few words, what, according to the Corpuscularian notions, may be thought of the nature and origin of qualities and forms; the knowledge of which either makes or supposes the most fundamental and useful part of natural philosophy. And to invite me to make use of these considerations and trials about qualities and forms, it opportunely happened, that though I could not find many of the notes written about particular qualities, (my loose papers having been, during the late confusions, much scattered by the many removes I had then occasion to make;) yet when last winter, being urged to publish my History of Cold, (which soon after came forth) I rumaged among my loose papers, I found, that the several notes of mine, that he had met with under various heads, but yet all concerning the origin of forms and qualities, together with the preface addressed to *Pyrophilus*, (though written at distant times and places) had two or three years before, by the care of an industrious person, with whom I left them, been fairly copied out together, (which circumstance I mention, that the reader may not wonder to find the following book not written uniformly in one continued tenour) excepting some experiments, which having been of my own making, it was not difficult for me to perfect, either out of my notes and memory, or (where I doubted their sufficiency) by repeated trials.

So that if the urgency, wherewith divers ingenious men pressed the publication of my new experiments about cold, and my unwillingness to protract it, till the frosty season, that was fittest to examine and prove them, were all past, had not prevailed with me to let those observations be made publick the last winter, they might have been accompanied with the present essay of the *Origin of Qualities and Forms*, which may be premised to what I have written touching any of the particular qualities, since it contains experiments and considerations fit to be preliminary to them all.

BUT though I was by this means diverted from putting out the following treatise, at the same time with the History of Cold, yet I was without much difficulty prevailed with not to alter my intentions of suffering it to come abroad; because divers of my historical accounts of some particular qualities are to be reprinted, which may receive much light and confirmation by the things delivered in this present treatise about qualities and forms in general. To which inducement was added the persuasion of some ingenious persons, who are pleased to confess their having received more information and satisfaction in these papers, than I durst pretend to give them: though indeed the subject is so noble and so important, and does so much want the being illustrated by some distinct and experimental discourse, that not only, if I did not suspect my friends of partiality, I should hope, that it may gratify many readers, and instruct more than a few; but such as it is, I do not altogether despair, that it will prove neither unacceptable nor useless. And indeed the doctrines of forms and qualities, and generation, and corruption, and alteration, are wont to be treated of by scholastical philosophers in so obscure, so perplexed, and so unsatisfactory a way, and their discourses upon these subjects do consist so much more of logical and metaphysical notions and niceties than of physical observations and reasonings, that it is very difficult for any reader of but an ordinary capacity, to understand what they mean, and no less difficult for any intelligent and unprejudiced reader to acquiesce in what they teach: which is oftentimes so precarious and so contradictory to itself, that most readers, (without always excepting such as are learned and ingenious) frightened by the darkness and difficulties, wherewith these subjects have been surrounded, do not so much as look after or read over these general and controverted matters, about which the schools make so much noise; but despairing to find any satisfaction in the study of them, betake themselves immediately to that part of physicks, that treats of particular bodies. So that to these it will not be unacceptable to have any intelligible notions offered them of those things, which, as they are wont to be proposed, are not wont to be understood: though yet the subjects themselves, if I mistake not, may be justly reckoned not only amongst the noblest and most important, but (in

case they be duly proposed) among the usefullest and most delightful speculations, that belong to physicks.

I CONSIDER too, that among those, that are inclined to that philosophy, which I find I have been much imitated in calling Corpuscularian, there are many ingenious persons, especially among the nobility and gentry, who having been first drawn to like this new way of philosophy by the sight of some experiments, which for their novelty or prettiness they were much pleased with, or for their strangeness they admired, have afterwards delighted themselves to make or see variety of experiments, without having ever had the opportunity to be instructed in the rudiments or fundamental notions of that philosophy, whose pleasing or amazing productions have enamoured them of it. And as our *Pyrophilus*, for whom these notes were drawn up, did in some regards belong to this sort of virtuosi, so it is not impossible, but that such readers, as he was then, will not be sorry to meet with a treatise, wherein though my chief and proper business be the giving some account of the nature and origin of forms and qualities; yet by reason of the connection and dependance betwixt these and divers of the other principal things, that belong to the general part of physicks, I have been obliged to touch upon so many other important points, that this tract may in some sort exhibit a scheme of, or serve for an introduction into the elements of the Corpuscularian philosophy.

AND as those readers, that have had the curiosity to peruse what is commonly taught in the schools about forms, and generation, and corruption, and those other things we have been mentioning, and have (as is usual among ingenious readers) quitted the study of those unsatisfactory intricacies with disgust, will not be displeas'd to find in our notes such explications of those things, as render them at least intelligible; so it will not, perhaps, prove unacceptable to such readers, to find those matters, which the schools had interwoven with *Aristotle's* doctrine, reconciled and accommodated to the notions of the corpuscular physicks.

If it be said, that I have left divers things unmentioned, which are wont to be largely treated of by the Aristotelians, and particularly have omitted the discussion of several questions, about which they are wont very solemnly and eagerly to contend; I readily acknowledge it to be true: but I answer further, that to do otherwise than I have done, were not agreeable to the nature of my design, as is declared in the preface to *Pyrophilus*; and that though most readers will not take notice of it, yet such, as are conversant in that sort of authors, will, I presume, easily find, that I have not left them unconsulted, but have had the curiosity to resort to several both of the more and of the less recent scholastical writers about physicks, and to some of the best metaphysicians to boot, that I might the better inform myself, both what their opinions are, and upon what arguments they are grounded. But as I found those inquiries far more trou-

blesome than useful, so I doubt not, that my omissions will not much displease that sort of readers, for whose sake chiefly it is, that these papers are permitted to be made publick. For if I should increase the obscurity of the things themselves I treat of, by adding the several obscurer comments (rather than explications) and the perplexed and contradictory opinions I have met with among scholastic writers, I doubt, that such persons, as I chiefly write for, would, instead of better comprehending what I should so deliver, absolutely forbear to read it. And there being many doctrines, to which number this we are speaking of seems to belong, wherein the same innate light, or other arguments, that discover the truth, do likewise sufficiently shew the erroneousness of dissenting opinions; I hope it may suffice to propose and establish the notions, that are to be embraced, without solicitously disproving what cannot be true, if those be so. And indeed there are many opinions and arguments of good repute in the schools, which do so intirely rely upon the authority of *Aristotle*, or some of his more celebrated followers, that where that authority is not acknowledged, to fall upon a solemn confutation of what has been so precariously advanced, were not only unnecessary, but indiscreet, even in a discourse not confined to the brevity challenged by the nature of this of ours. And there are very many questions and controversies, which, though hotly and clamorously contended about, and indeed pertinent and fit enough to be debated in their philosophy, do yet so much suppose the truth of several of their tenets, which the new philosophers reject; or are grounded upon technical terms or forms of speaking, that suppose the truth of such opinions; or are expressions, whereof we neither do nor need make any use; that to have inserted such debates into such a discourse as mine, would have been, not only tedious, but impertinent. As (for instance) those grand disputes, whether the four elements are endowed with distinct substantial forms, or have only their proper qualities instead of them? and whether they remain in mixed bodies, according to their forms, or according to their qualities? And whether the former or the latter of those be or be not refracted? These, I say, and divers other controversies about the four elements and their manner of mixture, are quite out of doors in their philosophy, that acknowledge neither, that there are four elements, nor that cold, heat, dryness, and moisture are, in the Peripatetic sense, first qualities, or that there are any such things, as substantial forms *in rerum natura*. And it made me the more unwilling to stuff these papers with any needless school-controversies, because I found upon perusal of several scholastic writers, (especially the recenter, who may probably be supposed to be the most refined) that they do not always mean the same things by the same terms, but some employ them in one sense, others in another, and sometimes the same writer uses them in very different senses, which I am obliged to take notice of, that such readers as have consulted

consulted some of those authors, may not accuse me of mistaking or injuring some of the scholastical terms and notions he may meet with in these papers, when I have only employed them in the sense of other school-writers, which I judged preferable. And this puts me in mind of intimating, that whereas, on the contrary, I sometimes employed variety of terms and phrases to express the same thing, I did it purposely, though perhaps to the prejudice of my own reputation, for the advantage of *Pyrophilus*; both I and others having observed, that the same unobvious notions being several ways expressed, some readers, even among the ingenious sort of them, will take it up much better in one of those expressions, and some in another.

BUT perhaps it will be wondered at, even by some of the new philosophers, that dissenting so much as I do from *Aristotle* and the schoolmen, I should overlook or decline some arguments, which some very ingenious men think to be of very great force against the doctrine I oppose. But divers of these arguments being such, as the Logicians call *ad hominem*, I thought I might well enough spare them. For I have observed *Aristotle* in his Physics to write very often in so dark and ambiguous a way, that it is far more difficult than one would think, to be sure what his opinion was: and the unlearned and too frequently jarring glosses of his interpreters have often made the comment darker than the text; so that (though in most it be, yet) in divers cases it is not easy (especially without the expence of many words) to lay open the contradictions of the Peripatetick doctrine, besides that the urging such contradictions are oftentimes fitter to silence an unwary adversary, than satisfy a wary and judicious reader; it being very possible, that a man may contradict himself in two several places of his works, and yet not be in both of them in the wrong. For one of his assertions, though inconsistent with the other, may yet be consistent with truth. But this is not all I have to say on this occasion. For besides that having for many reasons elsewhere mentioned, purposely forbore the reading of some very much, and, for aught I know, very justly esteemed discourses about general hypotheses, it is very possible, that I may be a stranger to some of those arguments: besides this, I say, I confess I have purposely forbore to make use of others, which I have sufficiently taken notice of. For some of those ratiocinations would engage him, that should employ them, to adopt an hypothesis or theory, in which perhaps I am not so thoroughly satisfied, and of which I do not conceive myself to have, on this occasion, any necessity to make use: and accordingly I have forbore to employ arguments, that are either grounded on, or suppose indivisible corpuseles called *atoms*, or any innate motion belonging

to them; or that the essence of bodies consists in extension, or that a vacuum is impossible; or that there are such *globuli cœlestes*, or such a *materia subtilis*, as the Cartesians employ to explicate most of the phænomena of nature. For these and divers other notions, I (who here write rather for the Corpuscularians in general, than any party of them) thought it improper needlessly to take in, discoursing, either against those, to whom these things appear as disputable, as the Peripatetic tenets seem to me; or for to satisfy an ingenious person, whom it were not fair to impose upon with notions, that I did not myself think proper.

AND on the like account I forbore such arguments as those, that suppose in nature and bodies inanimate, designs and passions proper to living, and perhaps peculiar to intelligent beings; and (such as) some proofs, that are drawn from the theology of the schools; (which I wish less interwoven with *Aristotle's* philosophy.) For though there be some things, which seem to be of this sort, (as arguments drawn from final causes in divers particulars, that concern animals,) which in a sound sense I not only admit, but maintain; yet since, as they are wont to be proposed, they are liable enough to be questioned, I thought it expedient for my present design to pretermit them, as things, that I do not absolutely need; though the employing some of them would facilitate my task. And this I did the rather, because I also forbore to answer arguments, that however vehemently and subtilly urged by many of the modern schoolmen of the Roman Catholick communion, are either confessedly, or at least really built upon some theological tenets of theirs, which being opposed by the divines of other churches, and not left unquestioned by some acute ones of their own, would not be proper to be solemnly taken notice of by me, whose business in this tract is to discourse of natural things as a naturalist, without invading the province of divines, by intermeddling with supernatural mysteries; such as those, upon which divers of the physico-theological tenets of the schoolmen, especially about real qualities, and * the separableness of accidents from subjects of inherence, are manifestly, if not also avowedly grounded. But to return to the other things I was owing to have left unmentioned, notwithstanding all that I have been saying, I readily acknowledge, that in some recent authors, that have been imbracers of the new philosophy, I have met with some passages, that might well and pertinently be taken into the following discourse, but that having been (as I formerly intimated) transcribed some years ago, I cannot now so conveniently alter it: which I am the less troubled at, because these few additional arguments, thought fit to illustrate or confirm, being not necessary to make

* *Atque hæc sententia* (of the distinction and separableness of quantity from matter) *est omnino tenenda: quanquam enim non possit ratione naturali sufficienter demonstrari, tamen ex principiis theologiae convincitur esse vera, maxime propter mysterium eucharistiae: Suarez Disp. Metaph. 40. p. m. 341. paucisque interjectis.—Prima ratio pro hac sententia est, quia in mysterio eucharistiae Deus separavit quantitatem à substantiis panis & vini, &c. Et p. m. 342.—Hæc responsio & sententia [Adversariorum] sic explicata non potest facile & evidenter impugnari, sistendo in puro naturali; nihilominus tamen, partim ratione naturali, partim adjuncto mysterio sufficientissime improbat.*

make out what has been delivered, may safely be let alone, unless there happen (as it is not unlikely there may) an occasion of reprinting these notes, with such enlargements, as may make them the more fit to be an introduction into the corpuscular philosophy.

I HOPE then, upon the whole matter, that I have pitched upon that way, that was the most conducive to my design, partly by insisting only on those opinions, whether true or false, which for their importance or difficulty seemed to deserve to be particularly either explicated or disproved; and partly by chusing to imploy such arguments, as I thought the clearest, and cogentest, and by their assuming the least of any, seemed the easiest to be vindicated from exceptions; without troubling myself to answer objections, that appeared rather to be drawn from metaphysical or logical subtilties, or to be grounded upon the authority of men, than to be physical ratiocinations, founded upon experience, or the nature of the things under debate; especially having, in the proposal and confirmation of the truth, so laid the grounds, and intimated the ways of answering what is like to be colourably objected against it, that an ingenious man may well enough furnish himself with weapons to defend the truth, out of the notions, hints, and experiments, where-with in this tract care has been taken to accompany it. And my forbearing to prosecute some of the Peripatetick controversies any further than I have done, will not, I hope, be blamed by them, that have observed as well as I, how much those disputes are wont to be lengthened by such frivolous distinctions, as do not deserve to be solemnly examined, especially in such a compendious treatise as ours. For an attentive reader needs not be much conversant with the writings of the modern Peripateticks, about such subjects, as substantial forms, generation, corruption, &c. to take notice, that it is their custom, when they find themselves distressed by a solid argument, to endeavour to elude it by some pitiful distinction or other; which is usually so groundless, and so unintelligible, or so nugatory, or so impertinent to the subject, or at least so insufficient for the purpose it is alledged for, that to vouchsafe it a solicitous confutation, might question a writer's judgment with intelligent readers; who by such insignificant distinctions are satisfied of nothing so much, as that the framers of them had rather say (that which indeed amounts to) nothing, than not to seem to say something. And of such evasions they may probably be emboldened to make use, by the practice of *Aristotle* himself, to whom such obscure and unsatisfactory distinctions are so familiar, that I remember one of his own commentators* (and he one of the most judicious) could not forbear, upon a certain text of his master's,

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to complain of it, and particularly to take notice, that that one distinction of *actu & potentia* runs through almost all *Aristotle's* philosophy, and is imployed to shift off those difficulties he could not clearly explicate.

By which nevertheless I would not be understood to censure or decry the whole Peripatetick philosophy, much less to despise *Aristotle* himself; whose own writings give me sometimes cause a little to wonder, to find some absurdities so confidently fathered upon him by his scholastic interpreters. For I look upon *Aristotle* as one (though but as one amongst many) of those famed ancients, whose learning about *Alexander's* time ennobled *Greece*; and I readily allow him most of the praises due to great wits, excepting those, which belong to clear-headed naturalists. And I here declare once for all, that where in the following tract, or any other of my writings, I do indefinitely depreciate *Aristotle's* doctrine, I would be understood to speak of his physicks, or rather of the speculative part of them, (for his historical writings concerning animals I much esteem) nor do I say, that even these may not have their use among scholars, and even in universities, if they be retained and studied with due cautions and limitations; (of which I have elsewhere spoken.)

BUT to resume the discourse, whence the Peripatetick distinctions tempted me to digress; by any thing I formerly said, I would not in the least disparage those excellent, and especially those modern authors, that have professedly opposed the Aristotelian physicks: (such as *Lucretius*, *Verulam*, *Basso*, *Des Cartes* and his followers, *Gassendus*, the two *Boots*, *Magnenus*, *Pemle*, *Helmont*,) nor be thought to have made no use of any of their cogitations or arguments. For though some of their books I could not procure, when I had occasion to have recourse to them; and though the weakness of my eyes discouraged me from perusing those parts of others, that concerned not the subject I was treating of, yet I hope I have been benefited by those I have consulted, and might have been more so, by the learned *Gassendus's* little, but ingenious, *Syntagma Philosophiæ Epicuri*, if I had more seasonably been acquainted with it.

BUT whether we have treated of the nature and origin of forms and qualities in a more comprehensive way than others; whether we have by new and fit similitudes and examples, and other means, rendered it more intelligible than they have done; whether we have added any considerable number of notions and arguments, towards the compleating and confirming of the proposed hypothesis; whether we have with reason dismissed arguments unfit to be relied on; and whether we have proposed some notions and arguments so warily, as to keep them from being liable

to

* The author here meant is the inquisitive Peripatetick *Cabæus*, who in one place hath these words: *Ut hanc quæstionem solvat, recurrit ad illam distinctionem sibi valde familiarem, quâ utitur Aristoteles in tota sua Philosophia, quoties obviam habet aliquam gravem difficultatem, distinguit enim actu vel potentia, &c.* In another these:—*Quæ est distinctio quædam familiaris Aristoteli, quam applicat omnibus rebus, ubi difficultates urgent, & videtur istis vocibus quasi fatali gladio omnes rescindere difficultatis nodos; vix enim est difficultas, cui non putat se satisfacere distinguendo actu & potentia.*

to exceptions or evasions, whereto they were obnoxious as others have proposed them; whether (I say) we have done all or any of these in the first or speculative part of this treatise, we willingly leave the reader to judge. But in the second or historical part of it, perhaps he will be invited to grant, that we have done that part of physicks we have been treating of some little service; since by the lovers of real learning, it was very much wished, that the doctrines of the new philosophy (as it is called) were backed by particular experiments; the want of which I have endeavoured to supply, by annexing some, whose nature and novelty, I am made believe, will render them as well acceptable as instructive. For though, that I might not anticipate what belongs to other papers, I did not make the last section consist of above a decad of them, and though, for the reasons intimated in the advertisements premised to them, I did not expressly mention to *Pyrophilus* all that I could have told him about them; yet I have been careful so to chuse them, and to interweave hints in delivering them, that a sagacious reader, who shall have the curiosity to try them heedfully, and make reflections on the several phænomena, that in likelihood will occur to him, will (if I mistake not) receive no contemptible information, as of some other things, so particularly about the nature of mixtions, (which I take to be one of the most important and useful, though neglected and ill understood, doctrines of the practical part of physicks) and may probably light upon more than he expects, or I have fully delivered, and perhaps too more than I foresaw.

AND though some virtuosi, more conversant perhaps with things than books, presuming the decay of the Peripatetick philosophy to be every where as great, as it is among them in *England*, may think, that a doctrine, which they look on as expiring, need not have been so solicitously confuted; yet those, that know how deep rooting this philosophy has taken (both elsewhere, and particularly) in those academies, where it has flourished for many ages, and in some of which it is, exclusively to the mechanical philosophy, watered and fenced by their statutes or their superiors: and he, that also knows, how much more easy some (more subtle than candid) wits find it plausibly to defend an error, than ingenuously to confess it, will not wonder, that I should think, that a doctrine so advantaged, though it be too erroneous to be feared, is yet too considerable to be despised. And not to question, whether several of those, that most condemn the favourers of the Peripatetick hypothesis, as the later discoveries have reduced them to reform it, be not the least provided to answer their arguments; (not to que-

stion this, I say,) there are divers of our adversaries (misled only by education, and morally harmless prejudices) who do so much deserve a better cause, than that, which needs all their subtilty without being worthy of it, that I shall think more pains, than I have taken, very usefully bestowed, if my arguments and experiments prove so happy, as to undeceive persons, whose parts, too unluckily confined to narrow and fruitless notions, would render them illustrious champions for the truths they are able so subtilly to oppose; and who might questionless perform considerable things, if they employed as much dexterity to expound the mysteries of nature, as the riddles of the schoolmen, and laid out their wit and industry to surmount the obscurity of her works, instead of that of *Aristotle's*.

THERE might be a few other particulars fit to be taken notice of in this preface, but finding, that I had already mentioned them in that, which I had addressed to *Pyrophilus*, my haste makes me willing rather to refer the reader thither for them, than alter that, or lengthen this, (which I should think much too long already, if it were not possible, that it may hereafter prove preliminary to more papers than these it is now premised to.) So that there remains but one advertisement necessary to be given here, namely, that whereas in the following notes I several times speak of the author of the essay of salt-petre, as of a third person, the occasion of that was, that when these notes, and some about particular qualities, were written, I had a design to make two distinct sorts of annotations upon that essay; in the former whereof (which now comes forth) I assumed the person of a Corpuscularian, and discoursed at that rate. But I had thoughts too (in case God were pleased to grant me life and opportunity) to take a second review both of the treatise itself, and of the notes on it, and on that occasion to add what my riper thoughts and further experience might suggest unto me. And that in my animadversions I might with the more freedom and conveniency add, explain, alter, and even retract, as I should see cause, I thought it not amiss to write them, as if they were made on the work of another. By which intimation the reader may be assisted to guess, how much I intended in the following discourse, (in which, as in the prefaces belonging to it, I play the Corpuscularian) to reserve myself the freedom of questioning and correcting, upon the designed review, any thing delivered in these notes; and how much more it was in them my design to bring *Pyrophilus* experiments and queries, to illustrate obscure matters, than by hasty assertions to dogmatize about them.

The P R E F A C E.

THE origin, *Pyrophilus*, and nature of the qualities of bodies, is a subject, that I have long looked upon as one of the most important and useful, that the naturalist can pitch upon for his contemplation. For the knowledge we have of the bodies without us, being for the most part fetched from the informations the mind receives by the senses, we scarce know any thing else in bodies, upon whose account they can work upon our senses, save their qualities: for as to the substantial forms, which some imagine to be in all natural bodies, it is not half so evident, that there are such, as it is, that the wisest of those, that do admit them, confess, that they do not well know them*. And as it is by their qualities, that bodies act immediately upon our senses, so it is by virtue of those attributes likewise, that they act upon other bodies, and by that action produce in them, and oftentimes in themselves, those changes, that sometimes we call alterations, and sometimes generation or corruption.

AND it is chiefly by the knowledge, such as it is, that experience (not art) hath taught us, of these differing qualities of bodies, that we are enabled, by a due application of agents to patients, to exercise the little empire, that we have either acquired or regained over the creatures. But I think not the contemplation of qualities more noble and useful, than I find it difficult; for what is wont to be taught us of qualities in the schools, is so slight and ill-grounded, that it may be doubted, whether they have not rather obscured than illustrated the things they should have explained. And I was quickly discouraged from expecting to learn much from them of the nature of divers particular qualities, when I found, that, except some few, which they tell you in general may be deduced (by ways they leave those to guess at, that can,) from those four qualities, they are pleased to call the first, they confess, that the rest spring from those forms of bodies, whose particular natures the judiciousest of them acknowledge they cannot comprehend. And *Aristotle* himself not only doth (as we shall see anon) give us of quality in general, (which yet seems far more easily definable, than many a particular quality,) no other than such a definition, as is as obscure as the thing to be declared by it; but I observe, not without some wonder, that in his eight books of *Physicks*, where he professedly treats of the general affections of natural things, he leaves out the doctrine of qualities; as after him *Magirus*, and divers other writers of the Peripatetick physiology, have done: which (by the way) I cannot but look upon as an omission, since qualities do as well seem to belong to natural bodies generally considered, as place, time, motion, and those other things, which upon that account are wont to be treated of in the general

part of natural philosophy. The most ingenious *Des Cartes* has something concerning some qualities; but though, for reasons elsewhere expressed, I have purposely forbore to peruse his system of philosophy, yet I find by turning over the leaves, that he has left most of the other qualities untreated of; and of those, that are more properly called sensible, he speaks but very briefly and generally, rather considering what they do upon the organs of sense, than what changes happen in the objects themselves, to make them cause in us a perception sometimes of one quality, and sometimes of another. Besides that his explications do many of them so depend upon his peculiar notions (of a *Materia subtilis*, *globuli secundi elementi*, and the like) and these, as it became so great a person, he has so interwoven with the rest of his hypothesis, that they can seldom be made use of, without adopting his whole philosophy. *Epicurus* indeed, and his scholiast *Lucretius*, have given some good hints concerning the nature of some few qualities. But, besides that even these explications are divers of them either doubtful or imperfect, or both, there are many other qualities, which are left for others to treat of. And this is the second and main difficulty, which I find in investigating the nature of qualities; namely, that whatever be to be thought of the general theories of *Aristotle*, or other philosophers, concerning qualities, we evidently want that, upon which a theory, to be solid and useful, must be built; I mean, an experimental history of them. And this we do want, that except perhaps what mathematicians have done concerning sounds, and the observations (rather than experiments) that our illustrious *Verulam* hath (in some few pages) said of heat, in his short *Essay de Formâ Calidi*; I know not any one quality, of which any author has yet given us an any thing competent history. These things I mention to you, *Pyrophilus*, not at all to derogate from those great men, whose design seems rather to have been to deliver principles and summaries of philosophy, than to insist upon particulars; but for this purpose, that since the nature of qualities is so beneficial a speculation, my labours may not be looked upon as wholly useless, though I can contribute but a little to the clearing of it; and that since it is so abstruse a subject, I may be pardoned, if I sometimes miss the mark, and leave divers things uncompleted; that being but what such great philosophers have done before me.

BUT, *Pyrophilus*, before I proceed to give you my notes upon this part of our author's essay, that you may rightly understand my intention in them, it will be requisite to give you three or four advertisements.

AND first, whenever I shall speak indefinitely of substantial forms, I would always be under-

* *Nego tibi ullam esse formam nobis notam plenè & planè; nostramque scientiam esse umbram in sole.* Scaliger. (of whose confession to the same purpose more are cited hereafter.)

understood to except the reasonable soul, that is said to inform the human body, which declaration I here desire may be taken notice of once for all.

SECONDLY, Nor am I willing to treat of the origin of qualities in beasts; partly because I would not be engaged to examine of what nature their souls are, and partly because it is difficult in most cases, (at least for one, that is compassionate enough) either to make experiments upon living animals, or to judge what influence their life may have upon the change of qualities produced by such experiments.

THIRDLY, The occasion of the following reflections being only this, that our author, in that part of his essay concerning salt-petre, whereto these notes refer, does briefly intimate some notions about the nature and origin of qualities; you must not expect, that I, whose method leads me but to write some notes upon this and some other parts of this essay, should make solemn or elaborate discourses concerning the nature of particular qualities, and that I should fully deliver my own apprehensions concerning those subjects. For, as I elsewhere sufficiently intimate, that in these first notes I write as a Corpuscularian, and set down those things only, that seem to have a tendency to illustrate or countenance the notions or fancies implied in our author's essay; so I must here tell you, that I neither have now the leisure, nor pretend to the skill to deliver fully the history, or to explicate particularly the nature of each several quality.

FOURTHLY, But I consider, that the schools have of late much amused the world, with a way they have got of referring all natural effects to certain entities, that they call real qualities, and accordingly attribute to them a nature distinct from the modification of the matter they belong to, and in some cases separable from all matter whatsoever; by which means they have, as far forth as their doctrine is acquiesced in, made it thought needless or hopeless for men to employ their industry, in searching into the nature of particular qualities, and their effects. As if (for instance) it be demanded, how snow comes to dazzle the eyes, they will answer, that it is by a quality of whiteness, that is in it, which makes all very white bodies produce the same effect: and if you ask what this whiteness is, they will tell you no more in substance, than that it is a real entity, which denominates the parcel of matter, to which it is joined, white; and if you further inquire, what this real entity, which they call a quality, is, you will find, as we shall see anon, that they either speak of it much after the same rate that they do of their substantial forms, (as indeed some of the modernest teach, that a quality affects the matter it belongs to *per modum formæ secundariæ*, as they speak) or at least they will not explicate it more intelligibly.

AND accordingly, if you further ask them, how white bodies in general do rather produce this effect of dazzling the eyes, than green or blue ones, instead of being told, that the

former sort of bodies reflect outwards, and so to the eye, far more of the incident light than the latter; you shall perchance be told, that it is their respective natures so to act. By which way of dispatching difficulties, they make it very easy to solve all the phenomena of nature in general, but make men think it impossible to explicate almost any of them in particular.

AND though the unsatisfactoriness and barrenness of the school-philosophy have persuaded a great many learned men, especially physicians, to substitute the chymists three principles, instead of those of the schools; and though I have a very good opinion of chymistry itself, as it is a practical art; yet as it is by chymists pretended to contain a system of theoretical principles of philosophy, I fear it will afford but a very little satisfaction to a severe inquirer into the nature of qualities. For besides that, as we shall more particularly see anon, there are many qualities, which cannot with any probability be deduced from any of the three principles; those, that are ascribed to one or other of them, cannot intelligibly be explicated, without recourse to the more comprehensive principles of the Corpuscularian philosophy: to tell us, for instance, that all solidity proceeds from salt, only informing us, (where it can plausibly be pretended) in what material principle or ingredient that quality resides, not how it is produced; for this doth not teach us, (for example) how water even in exactly-closed vessels comes to be frozen into ice; that is, turned from a fluid to a solid body, without the accession of a saline ingredient (which I have not yet found pretended, especially glass being held impervious to salts.) Wherefore, *Pyrophilus*, I thought it might much conduce to the understanding the nature of qualities, to shew how they are generated; and by the same way, I hoped it might remove in some measure the obstacle, that these dark and narrow theories of the Peripateticks and Chymists may prove to the advancement of solid and useful philosophy. That then, which I chiefly aim at, is to make it probable to you by experiments, (which I think hath not yet been done,) that almost all sorts of qualities, most of which have been by the schools either left unexplicated, or generally referred to I know not what incomprehensible substantial forms, may be produced mechanically; I mean by such corporeal agents, as do not appear either to work otherwise than by virtue of the motion, size, figure, and contrivance of their own parts, (which attributes I call the mechanical affections of matter, because to them men willingly refer the various operations of mechanical engines:) or to produce the new qualities exhibited by those bodies, their action changes, by any other way, than by changing the texture or motion, or some other mechanical affection of the body wrought upon. And this if I can in any passable measure do, though but in a general way, in some or other of each of these three sorts, into which the Peripateticks are wont to divide the qualities of bodies, I hope I shall have done

no useless piece of service to natural philosophy; partly by exciting you, and your learned friends, to inquire after more intelligible and satisfactory ways of explicating qualities, and partly by beginning such a collection of materials towards the history of those qualities, that I shall the most largely insist on, as heat, colours, fluidity and firmness, as may invite you and other ingenious men to contribute also their experiments and observations to so useful a work, and thereby lay a foundation, whereon you, and perhaps I, may superstruct a more distinct and explicate theory of qualities, than I shall at present adventure at. And though I know, that some of the things

my experiments, tend to manifest, may likewise be confirmed by the more obvious phenomena of nature, yet I presume you will not dislike my chusing to entertain you with the former, (though without at all despising, or so much as strictly forbearing to employ the latter,) because the changes of qualities made by our experiments, will, for the most part, be more quick and conspicuous; and the agents made use of to produce them, being of our own applying, and ostentives of our own preparation, we may be thereby assisted the better to judge of what they are, and to make an estimate of what it is they do.

CONSIDERATIONS

AND

EXPERIMENTS,

TOUCHING THE

ORIGIN of FORMS and QUALITIES.

The THEORETICAL PART.

THAT, before I descend to particulars, I may, *Pyrophilus*, furnish you with some general apprehension of the doctrine (or rather the hypothesis) which is to be collated with, and to be either confirmed or disproved by the historical truths, that will be delivered concerning particular qualities, (and forms;) I will assume the person of a Corpuscularian, and here, at the entrance, give you (in a general way) a brief account of the hypothesis it self, as it concerns the origin of qualities (and forms;) and for distinction's sake, I shall comprize it in the eight following particulars, which, that the whole scheme may be the better comprehended, and as it were surveyed under one prospect, I shall do little more than barely propose them, that either seem evident enough by their own light, or may without prejudice have divers of their proofs reserved for proper places in the following part of this treatise. And though there be some other particulars, to which the importance of the subjects, and the greatness of the (almost universal) prejudices, that lie against them, will oblige me immediately to annex (for the seasonable clearing and justifying of them) some annotations; yet that they may, as little as I can, obscure the coherence of the whole discourse, as much of them as

conveniently may be shall be included in [] paratheses.

I. I AGREE with the generality of philosophers so far, as to allow, that there is one catholick or universal matter common to all bodies, by which I mean a substance extended, divisible, and impenetrable.

II. **B**UT because this matter being in its own nature but one, the diversity we see in bodies must necessarily arise from somewhat else, than the matter they consist of. And since we see not, how there could be any change in matter, if all its (actual or designable) parts were perpetually at rest among themselves, it will follow, that to discriminate the catholick matter into variety of natural bodies, it must have motion in some or all its designable parts: and that motion must have various tendencies, that which is in this part of the matter tending one way, and that which is in that part tending another; as we plainly see, in the universe or general mass of matter, there is really a great quantity of motion, and that variously determined, and that yet divers portions of matter are at rest.

THAT there is local motion in many parts of matter is manifest to sense, but how matter came by this motion was of old, and is still hotly disputed of: for the antient Corpuscularian

cularian philosophers, (whose doctrine in most other points, though not in all, we are the most inclinable to,) not acknowledging an author of the universe, were thereby reduced to make motion congenite to matter, and consequently coeval with it. But since local motion, or an endeavour at it, is not included in the nature of matter, which is as much matter when it rests, as when it moves; and since we see, that the same portion of matter may from motion be reduced to rest, and after it hath continued at rest, as long as other bodies do not put it out of that state, may by external agents be set a moving again; I, who am not wont to think a man the worse naturalist for not being an atheist, shall not scruple to say with an eminent philosopher of old, whom I find to have proposed among the Greeks that opinion (for the main) that the excellent *Des Cartes* has revived amongst us, that the origin of motion in matter is from God; and not only so, but that thinking it very unfit to be believed, that matter barely put into motion, and then left to it self, should casually constitute this beautiful and orderly world: I think also further, that the wise author of things did, by establishing the laws of motion among bodies, and by guiding the first motions of the small parts of matter, bring them to convene after the manner requisite to compose the world, and especially did contrive those curious and elaborate engines, the bodies of living creatures, endowing most of them with a power of propagating their species. But though these things are my persuasions, yet because they are not necessary to be supposed here, where I do not pretend to deliver any compleat discourse of the principles of natural philosophy, but only to touch upon such notions, as are requisite to explicate the origin of qualities and forms; I shall pass on to what remains, as soon as I have taken notice, that local motion seems to be indeed the principal amongst second causes; and the grand agent of all that happens in nature: for though bulk, figure, rest, situation, and texture do concur to the phenomena of nature, yet in comparison of motion they seem to be, in many cases; effects, and in many others, little better than conditions, or requisites, or causes *sine quibus non*, which modify the operation, that one part of matter by virtue of its motion hath upon another; as in a watch, the number, the figure, and coaptation of the wheels and other parts is requisite to the shewing the hour, and doing the other things, that may be, performed by the watch; but till these parts be actually put into motion, all their other affections remain inefficacious. And so in a key, though it were too big or too little, or if its shape were incongruous to that of the cavity of the lock, it would be unfit to be used as a key, though it were put into motion; yet let its bigness and figure be never so fit, unless actual motion intervene, it will never lock or unlock any thing, as without the like actual motion, neither a knife nor razor will actually cut, how much soever their shape and o-

ther qualities may fit them to do so. And so brimstone, what disposition of parts soever it have to be turned into flame, would never be kindled, unless some actual fire, or other parcel of vehemently and variously agitated matter, should put the sulphureous corpuscles into a very brisk motion.

III. THESE two grand and most catholic principles of bodies, matter and motion, being thus established, it will follow, both that matter must be actually divided into parts, that being the genuine effect of variously determined motion, and that each of the primitive fragments, or other distinct and intire masses of matter, must have two attributes, its own magnitude, or rather size, and its own figure or shape. And since experience shews us (especially that, which is afforded us by chymical operations, in many of which matter is divided into parts, too small to be singly sensible,) that this division of matter is frequently made into insensible corpuscles or particles, we may conclude, that the minutest fragments, as well as the biggest masses of the universal matter, are likewise endowed each with its peculiar bulk and shape. For being a finite body, its dimensions must be terminated and measurable: and though it may change its figure, yet for the same reason it must necessarily have some figure or other. So that now we have found out, and must admit three essential properties of each intire or undivided, though insensible part of matter; namely, magnitude, (by which I mean not quantity in general, but a determined quantity, which we in english oftentimes call the size of a body) shape, and either motion or rest, (for betwixt them two there is no mean:) the two first of which may be called inseparable accidents of each distinct part of matter; inseparable, because being extended, and yet finite, it is physically impossible, that it should be devoid of some bulk or other, and some determinate shape or other; and yet accidents, because that whether or no the shape can by physical agents be altered, or the body subdivided, yet mentally both the one and the other may be done, the whole essence of matter remaining undestroyed.

WHETHER these accidents may not conveniently enough be called the moods or primary affections of bodies, to distinguish them from those less simple qualities, (as colours, tastes, and odours,) that belong to bodies upon their account; or whether, with the Epicureans, they may not be called the conjuncts of the smallest parts of matter; I shall not now stay to consider; but one thing the modern schools are wont to teach concerning accidents, is too repugnant to our present doctrine, to be in this place quite omitted; namely, that there are in natural bodies store of real qualities, and other real accidents, which not only are no moods of matter, but are real entities distinct from it, and, according to the doctrine of many modern schoolmen, may exist separate from all matter whatsoever. To clear this point a little, we must take notice, that accident is among logicians and philosophers

phers used in two several senses, for sometimes it is opposed to the fourth predicable, (property,) and is then defined; That, which may be present or absent without the destruction of the subject; as a man may be sick or well, and a wall white or not white, and yet the one be still a man, the other a wall: and this is called in the schools *accidens prædicabile*, to distinguish it from what they call *accidens prædicamentale*, which is opposed to substance: for when things are divided by logicians into ten predicaments or highest genus's of things, substance making one of them, all the nine other are of accidents. And as substance is commonly defined to be a thing, that subsists of itself, and is the subject of accidents, (or more plainly, a real entity or thing, that needs not any (created) being, that it may exist :) so an accident is said commonly to be *id cuius esse est inesse*; and therefore *Aristotle*, who usually calls substances simply *ὄντα*, *entities*, most commonly calls accidents *ὄντα ἐν ὄντι*, *entities of entities*; these needing the existence of some substance or other, in which they may be, as in their subject of inhesion. And because logicians make it the discriminating note of substance and accident, that the former is a thing, that cannot be in another, as in its subject of inhesion, it is requisite to know, that, according to them, that is said to be in a subject, which hath these three conditions; That however it (1) be in another thing, (2) is not in it as a part, and (3) cannot exist separately from the thing or subject wherein it is: as a white wall is the subject of inhesion of the whiteness we see in it, which self-same whiteness, though it be not in the wall as a part of it, yet cannot the self-same whiteness, according to our logicians, exist any where out of the wall, though many other bodies may have the like degree of whiteness. This premised, it will not be hard to discover the falsity of the lately mentioned scholastick opinion touching real qualities, and accidents, their doctrine about which does, I confess, appear to me to be either unintelligible, or manifestly contradictory. For speaking in a physical sense, if they will not allow these accidents to be modes of matter, but entities really distinct from it, and in some cases separable from all matter, they make them indeed accidents in name,

but represent them under such a notion, as belongs only to substances; the nature of a substance consisting in this, that it can subsist of itself, without being in any thing else, as in a subject of inhesion. So that to tell us, that a quality, or other accident, may subsist without a subject, is indeed, whatever they please to call it, to allow it the true nature of substance; nor will their groundless distinctions do any more than keep them from seeming to contradict themselves in words, whilst unprepossessed persons see, that they do it in effect. Nor could I ever find it intelligibly made out, what these real qualities may be, that they deny to be either matter or modes of matter, or immaterial substances. When a bowl runs along or lies still, that motion or rest, or globous figure of the bowl, is not nothing, and yet is not any part of the bowl; whose whole substance would remain, though it wanted which you please of these accidents: and to make them real and physical entities, (for we have not here to do either with logical or metaphysical ones) is, as if, because we may consider the same man sitting, standing, running, thirsty, hungry, weary, &c. we should make each of these a distinct entity, as we do give some of them (as hunger, weariness, &c.) distinct names. Whereas the subject of all these qualities is but the same man, as he is considered with circumstances, that make him appear different in one case from what he appears in the other: and it may be very useful to our present scope to observe, that not only diversity of names, but even diversity of definitions, doth not always infer a diversity of physical entities in the subject, whereunto they are attributed. For it happens in many of the physical attributes of a body, as in those other cases, wherein a man that is a father, a husband, a master, a prince, &c. may have a peculiar definition (such as the nature of the thing will bear) belong unto him in each of these capacities; and yet the man in himself considered is but the same man, who, in respect of differing capacities, or relations to other things, is called by differing names, and described by various definitions, which yet (as I was saying) conclude not so many real and distinct entities in the person so variously denominated.

An EXCURSION about the relative Nature of PHYSICAL QUALITIES.

BUT because I take this notion to be of no small importance towards the avoiding of the grand mistake, that hath hitherto obtained about the nature of qualities, it will be worth while to illustrate it a little farther. We may consider then, that when *Tubal-Cain*, or whoever else were the smith, that invented locks and keys, had made his first lock, (for we may reasonably suppose him to have made that before the

key, though the comparison may be made use of without that supposition,) that was only a piece of iron, contrived into such a shape; and when afterwards he made a key to that lock, that also in itself considered was nothing but a piece of iron of such a determinate figure: but in regard, that these two pieces of iron might now be applied to one another after a certain manner, and that there was a congruity betwixt the wards of the

the lock and those of the key, the lock and the key did each of them now obtain a new capacity, and it became a main part of the notion and description of a lock, that it was capable of being made to lock or unlock by that piece of iron we call a key, and it was looked upon as a peculiar faculty and power in the key, that it was fitted to open and shut the lock, and yet by these new attributes there was not added any real or physical entity either to the lock or to the key, each of them remaining indeed nothing but the same piece of iron, just so shaped as it was before. And when our smith made other keys of differing bignesses, or with differing wards, though the first lock was not to be opened by any of those keys, yet that indisposition, however it might be considered as a peculiar power of resisting this or that key, and might serve to discriminate it sufficiently from the locks those keys belonged to, was nothing new in the lock, or distinct from the figure it had before those keys were made. To carry this comparison a little further, let me add, that though one, that would have defined the first lock and the first key, would have given them distinct definitions with reference to each other; and yet (as I was saying) these definitions being given but upon the score of certain respects, which the defined bodies had one to another, would not infer, that these two iron instruments did physically differ otherwise than in the figure, size, or contrivement of the iron, whereof each of them consisted. And proportionably hereunto, I do not see, why we may not conceive, that as to those qualities (for instance) which we call sensible, though, by virtue of a certain congruity or incongruity in point of figure or texture, (or other mechanical attributes) to our sensories, the portions of matter they modify are enabled to produce various effects, upon whose account we make bodies to be endowed with qualities; yet they are not in the bodies, that are endowed with them, any real or distinct entities, or differing from the matter itself, furnished with such a determinate bigness, shape, or other mechanical modifications. Thus, though the modern goldsmiths and refiners reckon amongst the most distinguishing qualities of gold, by which men may be certain of its being true and not sophisticated, that it is easily dissoluble in aqua regis, and that aqua fortis will not work upon it; yet these attributes are not in the gold any thing distinct from its peculiar texture, nor is the gold we have now of any other nature than it was in *Pliny's* time, when aqua fortis and aqua regis had not been found out (at least in these parts of the world,) and were utterly unknown to the Roman goldsmiths. And this example I have the rather pitched upon, because it affords me an opportunity to represent, that, unless we admit the doctrine I have been proposing, we must admit, that a body may have an almost infinite number of new real entities accruing to it, without the intervention of any physical change

in the body itself. As for example, gold was the same natural body immediately before aqua regis and aqua fortis were first made, as it was immediately after; and yet now it is reckoned amongst its principal properties, that it is dissoluble by the former of those two menstrooms, and that it is not like other metals dissoluble or corrodible by the latter. And if one should invent another menstruum, (as possibly I may think myself master of such a one) that will but in part dissolve pure gold, and change some part of it into another metalline body, there will then arise another new property, whereby to distinguish that from other mettals; and yet the nature of gold is not a whit other now, than it was before this last menstruum was first made. There are some bodies not cathartick, nor sudorifick, with some of which gold being joined, acquires a purgative virtue, and with others a power to procure sweat; and, in a word, nature herself doth sometimes otherwise, and sometimes by chance produce so many things, that have new relations unto others: and art, especially assisted by chymistry, may, by variously dissipating natural bodies, or compounding either them or their constituent parts with one another, make such an innumerable company of new productions, that will each of them have new operations either immediately upon our sensories, or upon other bodies, whose changes we are able to perceive, that no man can know, but that the most familiar bodies may have multitudes of qualities, that he dreams not of, and a considering man will hardly imagine, that so numerous a croud of real physical entities can accrue to a body, whilst in the judgment of all our senses it remains unchanged, and the same, that it was before.

To clear this a little further, we may add, that beaten glass is commonly reckoned among poisons; and (to skip what is mentioned out of *Sanctorius*, of the dysentery procured by the fragments of it,) I remember * *Cardan* hath a story, that in a cloister, where he had a patient then like to die of torments in the stomach, two other nuns had been already killed by a distracted woman, that having casually got free, had mixed beaten glass with peas, that were eaten by these three, and divers others of the sisters (who yet escaped unharmed.) Now though the powers of poisons be not only looked upon as real qualities, but are reckoned among the abstrusest ones; yet this deleterious faculty, which is supposed to be a peculiar and super-added entity in the beaten glass, is really nothing distinct from the glass itself, (which though a concrete made up of those innocent ingredients, salt and ashes, is yet a hard and stiff body,) as it is furnished with that determinate bigness, and figure of parts, which have been acquired by comminution. For these glassy fragments being many, and rigid, and somewhat small, (without yet being so small as dust,) and endowed with sharp points and cutting edges, are enabled by these mechanical affections to pierce or wound the tender membranes

* *Cardan. Contradiet. 9. lib. 2. Tract. 5. apud Schenkium.*

membranes of the stomach and guts, and cut the slender vessels, that they may meet with there; whereby naturally ensue great gripings and contorsions of the injured parts, and oftentimes bloody fluxes occasioned by the perforation of the capillary arteries, and the great irritation of the expulsive faculty, and sometimes also not only horrid convulsions by consent of the brain and cerebellum, with some of the nervous or membranous parts, that happen to be hurt, but also drop-sies, occasioned by the great loss of blood we were just now speaking of. And it agrees very well with this conjecture, that beaten glass hath divers times been observed to have done no mischief to animals, that have swallowed it: for there is no reason it should, in case the corpuscles of the powder either chance to be so small, as not to be fit to wound the guts, which are usually lined with a slimy substance, wherein very minute powders may be as it were sheathed, and by that means hindered from hurting the guts, (inasmuch that a fragment of glass with three very sharp corners hath been observed to have for above eighteen months * lain inoffensive even in a nervous and very sensible part of the body,) out of which they may, with the grosser excrements of the lower belly, be harmlessly excluded, especially in some individuals, whose guts and stomach too may be of a much stronger texture, and better lined or stuffed with gross and slimy matter than those of others. And accordingly we see, that the fragments of sapphires, crystals, and even rubies, which are much harder than glass, are innocently, though perhaps not very effectually, used by physicians, (and I have several times taken that without inconvenience) in cordial compositions, because of their being by grinding reduced to a powder too subtle to excoriate, or grate upon the stomach or guts; and probably it was upon some such account, that that happened, which is related by *Cardan* in the same place; namely, that though the three nuns we have been speaking of were poisoned by the glass, yet many others, who eat of the other portions of the same mingled peas, received no mischief thereby. (But of this subject more † elsewhere.)

AND this puts me in mind to add, that the multiplicity of qualities, that are sometimes to be met with in the same natural bodies, needs not make men reject the opinion we have been proposing, by persuading them, that so many differing attributes, as may be sometimes found in one and the same natural body, cannot proceed from the bare texture and other mechanical affections of its matter. For we must consider each body, not barely as it is in itself, an intire and distinct portion of matter, but as it is a part of the universe, and consequently placed among a great number and variety of other bodies, upon which

it may act, and by which it may be acted on in many ways, (or upon many accounts,) each of which men are wont to fancy as a distinct power or quality in the body, by which those actions, or in which those passions are produced. For if we thus consider things; we shall not much wonder, that a portion of matter, that is indeed endowed but with a very few mechanical affections; as such a determinate texture and motion, but is placed among a multitude of other bodies; that differ in those attributes from it and one another; should be capable of having a great number and variety of relations to those other bodies, and consequently should be thought to have many distinct inherent qualities, by such as look upon those several relations or respects it may have to bodies without it, as real and distinct entities implanted in the body itself. When a curious watch is going, though the spring be that, which puts all the parts into motion, yet we do not fancy (as an Indian or Chinese would perchance do) in this spring one faculty to move the index uniformly round the dial-plate, another to strike the hour, and perhaps a third to give an alarm, or shew the age of the moon, or the tides; all the action of the spring, (which is but a flexible piece of steel, forcibly coiled together,) being but an endeavour to dilate or unbind itself, and the rest being performed by the various respects it hath to the several bodies (that compose the watch) among which it is placed, and which they have one to another. We all know, that the sun hath a power to harden clay, and soften wax, and melt butter, and thaw ice, and turn water into vapours, and make air expand itself in weather-glasses, and contribute to blanch linen, and make the white skin of the face swarthy, and mowed grass yellow, and ripen fruit, hatch the eggs of silk-worms, caterpillars, and the like insects, and perform I know not how many other things, divers of which seem contrary effects; and yet these are not distinct powers or faculties in the sun, but only the productions of its heat, (which itself is but the brisk, and confused local motion of the minute parts of a body) diversified by the differing textures of the body, that it chances to work upon, and the condition of the other bodies, that are concerned in the operation. And therefore whether the sun in some cases have any influence at all distinct from its light and heat, we see, that all those phænomena, we have thought fit to name, are producible by the heat of the common culinary fire duly applied and regulated. And so, to give an instance of another kind, when some years since, to try some experiments about the propagation of motion with bodies less capable of being battered by one another, than those, that have been formerly employed, I caused some solid balls of iron skilfully hardened and exquisitely shaped and glazed, to be purposely

* This memorable accident happened to a senator of *Berne*, who was cured by the experienced *Fabricius Hildanus*, that gives a long account of it to the learned *Horstius*, among whose observations it is extant, (*Lib. 2. Observ. 35.*) who ascribes the indolence of the part, whilst uncompresssed, to some slimy juice, (familiar enough to those tendinous parts,) wherein the glassy fragment was as it were bedded.

† In those notes about Occult Qualities, where the deleterious faculty attributed to diamonds is considered.

made; each of these polished balls was a spherical looking-glass, which, placed in the midst of a room, would exhibit the images of the objects round about it, in a very regular and pleasing perspective. It would contract the image, and reflect the beams of the sun after a manner differing from flat and from convex looking-glasses. It would in a neat perspective lessen the image of him, that looked upon it, and bent it, and it would shew, that image, as if it were behind the surface, and within the solid substance of the sphere; and in some it had all those distinct, and some of them wonderful properties, which either ancient or modern writers of catoptricks have demonstrated to belong to spherical specula, as such: and yet the globe, furnished with all these properties and affections, was but the iron itself reduced by the artificer to a spherical figure; (for the glass, that made it specular, was not distinct from the superficial parts of the iron, reduced all of them to a physically equal distance from the center.) And of specula, spherical enough as to sense, you may make store in a trice, by breaking a large drop of quick-silver into several little ones, each of which will serve for objects placed pretty near it, and the smaller of which, (being the least depressed in the middle by their own weight, and consequently more perfectly globous,) may with a good microscope placed in a window, afford you no unpleasant prospect of the neighbouring objects; and yet to reduce a parcel of stagnant quick-silver, which will much emulate a flat looking-glass, into many of these little spherical specula, whose properties are so differing from those of plain ones, there intervenes nothing but a slight local motion, which, in the twinkling of an eye, changeth the figure of the self-same matter.

I HAVE said thus much, *Pyrophilus*, to remove the mistake, that every thing men are wont to call a quality, must needs be a real and physical entity, because of the importance of the subject; and yet I have omitted some things, that might have been pertinently added, partly because I may hereafter have opportunity to take them in, and partly because I would not any farther lengthen this excursion, which yet I must not conclude, till I have added this short advertisement.

THAT I have chosen to declare what I mean by qualities, rather by examples, than definitions, partly because being immediately or reductively the objects of sense, men generally understand pretty well what one another mean, when they are spoken of: as to say, that the taste of such a thing is saline or sour,

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* Since the writing of this, the author found, that some of the eminentest of the modern schoolmen themselves have been as well as he unsatisfied with the Aristotelian definition of quality: concerning which (not to mention *Revius*, a learned Protestant annotator upon *Suarez*) *Ariaga* says (*disp. 5. sect. 2. subf. 1.*) *Per hanc nihil explicatur; nam de hoc quærimus, quid sit esse quale, dices habere qualitatem; bonus circulus: qualitas est id, quo quis fit qualis, & esse quale est habere qualitatem.* And even the famous Jesuit *Suarez*, though he endeavours to excuse it, yet confesseth, that it leaves the proper notion of quality as obscure to us as before: (*Quæ definitio, sicut he, licet ea ratione essentialis videatur, quod datur per habitudinem ad effectum formalem, quem omnis forma essentialiter respicit, tamen quod ad nos spectat, æque obscura nobis manet propria ratio qualitatis.*) *Suarez disputat. metaphys. 42.* But *Hurtadus* (in his metaphysical disputations) speaks more boldly, telling us roundly, that it is *non tam definitio, quam inanis quædam nugatio*; which makes me the more wonder, that a famous Cartesian (whom I forbear to name) should content himself to give us such an insignificant or at least superficial definition of quality.

or that such a sound is melodious, shrill, or jarring, (especially if, when we speak of sensible qualities, we add some enumeration of particular subjects, wherein they do the most eminently reside,) will make a man as soon understood, as if he should go about to give logical definitions of those qualities: and partly because the notions of things are not yet so well stated and agreed on, but that it is many times difficult to assign their true genus's. And *Aristotle* himself doth not only define accidents without setting down their genus, but when he comes to define qualities, he tells us, that quality is that, by which a thing is said to be *qualis*; where I would have you take notice, both, that in his definition he omits the genus, and that it is no such easy thing to give a very good definition of qualities, since he, that is reputed the great master of logick, where he pretends to give us one, doth but upon the matter define the thing by the same thing: for it is supposed to be as little known what *qualis* is, as what *qualitas* is; and methinks he does just as if I should define whiteness to be that, for which a thing is called white, or virtue that, for which a man is said to be virtuous*. Besides that, I much doubt, whether his definition be not untrue as well as obscure: for to the question, *Qualis res est?* answer may be returned out of some, if not all, of the other predicaments of accidents: which some of the modern logicians being aware of, they have endeavoured to save the matter with certain cautions and limitations, which, however they may argue the devisers to be ingenious, do, for aught I can discern, leave us still to seek for a right and intelligible definition of quality in general; though to give such a one be probably a much easier task, than to define many qualities, that may be named in particular, as saltiness, sourness, green, blue, and many others, which when we hear named, every man knows what is meant by them, though no man (that I know of) hath been able to give accurate definitions of them.

IV. AND if we should conceive, that all the rest of the universe were annihilated, except any of these intire and undivided corpuscles, (treated of in the 3d particular foregoing,) it is hard to say what could be attributed to it, besides matter, motion, (or rest,) bulk, and shape. Whence by the way you may take notice, that bulk, though usually taken in a comparative sense, is in our sense an absolute thing, since a body would have it, though there were no other in the world. But now there being actually in the universe, great multitudes of corpuscles mingled among

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themselves, there arise in any distinct portion of matter, which a number of them make up, two new accidents or events: the one doth more relate to each particular corpuscle in reference to the (really or supposed) stable bodies about it, namely its posture; (whether erected, inclined, or horizontal:) and when two or more of such bodies are placed one by another, the manner of their being so placed, as one besides another, or one behind another, may be called their order; as I remember, *Aristotle* in his *Metaphysics*, *lib. 1. cap. 4.* recites this example out of the ancient Corpuscularians, that A and N differ in figure, and A N and N A in order, Z and N in situation: and indeed posture and order seem both of them reducible to situation. And when many corpuscles do so convene together, as to compose any distinct body, as a stone, or a metal, then from their other accidents (or modes,) and from these two last mentioned there doth emerge a certain disposition or contrivance of parts in the whole, which we may call the texture of it.

V. AND if we should conceive all the rest of the universe to be annihilated, save one such body, suppose a metal or a stone, it were hard to shew, that there is physically any thing more in it than matter, and the accidents we have already named. But now we are to consider, that there are *de facto* in the world, certain sensible and rational beings, that we call men; and the body of man having several external parts, as the eye, the ear, &c. each of a distinct and peculiar texture, whereby it is capable to receive impressions from the bodies about it, and upon that account it is called an organ of sense, we must consider, I say, that these sensories may be wrought upon by the figure, shape, motion, and texture of bodies without them after several ways, some of those external bodies being fitted to affect the eye, others the ear, others the nostrils, &c. And to these operations of the objects on the sensories, the mind of man, which upon the account of its union with the body, perceives them, giveth distinct names, calling the one light or colour, the other sound, the other odour, &c. And because also each organ of sense, as the eye, or the palate, may be itself differently affected by external objects, the mind likewise gives the objects of the same sense distinct appellations, calling one colour green, the other blue, and one taste sweet, and another bitter, &c. Whence men have been induced to frame a long catalogue of such things, as, for their relating to our senses, we call sensible qualities; and because we have been conversant with them before we had the use of reason, and the mind of man is prone to conceive almost every thing (nay, even privations, as blindness, death, &c.) under the notion of a true entity or substance; as itself is; we have been from our infancy apt to imagine, that these sensible qualities are real beings, in the objects they denominate, and have the faculty or power to work such and such things; as gravity hath a power to stop the motion of a bullet shot upwards,

and carry that solid globe of matter toward the center of the earth; whereas indeed (according to what we have largely shewn above) there is in the body, to which these sensible qualities are attributed, nothing of real and physical, but the size, shape, and motion, or rest, of its component particles, together with that texture of the whole, which results from their being so contrived as they are; nor is it necessary they should have in them any thing more, like to the ideas they occasion in us, those ideas being either the effects of our prejudices or inconsiderateness, or else to be fetched from the relation, that happens to be betwixt those primary accidents of the sensible object, and the peculiar texture of the organ it affects: As when a pin, being run into my finger, causeth pain, there is no distinct quality in the pin answerable to what I am apt to fancy pain to be, but the pin in itself is only slender, stiff, and sharp, and by those qualities happens to make a solution of continuity in my organ of touching, upon which, by reason of the fabrick of the body, and the intimate union of the soul with it, there ariseth that troublesome kind of perception which we call pain, and I shall anon more particularly shew, how much that depends upon the peculiar fabrick of the body.

VI. BUT here I foresee a difficulty, which being perhaps the chiefest, that we shall meet with against the corpuscular hypothesis, it will deserve to be, before we proceed any farther, taken notice of. And it is this, that whereas we explicate colours, odours, and the like sensible qualities by a relation to our senses, it seems evident, that they have an absolute being irrelative to us: for snow (for instance) would be white, and a glowing coal would be hot, though there were no man or any other animal in the world. And it is plain, that bodies do not only by their qualities work upon our senses, but upon other, and those, inanimate bodies; as the coal will not only heat or burn a man's hand if he touch it, but would likewise heat wax, (even so much as to melt it and make it flow,) and thaw ice into water, although all the men and sensitive beings in the world were annihilated. To clear this difficulty, I have several things to represent: and,

1. I SAY not, that there are no other accidents in bodies than colours, odours, and the like; for I have already taught, that there are simpler and more primitive affections of matter, from which these secondary qualities, if I may so call them, do depend: and that the operations of bodies upon one another spring from the same, we shall see by and by.

2. Nor do I say, that all qualities of bodies are directly sensible; but I observe, that when one body works upon another, the knowledge we have of their operation proceeds either from some sensible quality, or some more catholick affection of matter, as motion, rest, or texture, generated or destroyed in one of them; for else it is hard to conceive, how we shall come to discover what passes betwixt them.

3. We must not look upon every distinct body, that works upon our senses, as a bare lump of matter of that bigness and outward shape, that it appears of; many of them having their parts curiously contrived, and most of them perhaps in motion too. Nor must we look upon the universe that surrounds us as upon a moveless and undistinguished heap of matter, but as upon a great engine, which having either no vacuity, or none that is considerable betwixt its parts (known to us,) the actions of particular bodies upon one another must not be barely estimated, as if two portions of matter of their bulk and figure were placed in some imaginary space beyond the world, but as being situate in the world, constituted as it now is, and consequently as having their action upon each other liable to be promoted or hindered or modified by the actions of other bodies besides them: as in a clock, a small force applied to move the index to the figure of XII, will make the hammer strike often and forcibly against the bell, and will make a far greater commotion among the wheels and weights, than a far greater force would do, if the texture and contrivance of the clock did not abundantly contribute to the production of so great an effect. And in agitating water into froth, the whiteness would never be produced by that motion, were it not that the sun, or other lucid body, shining upon that aggregate of small bubbles, enables them to reflect confusedly great store of little and as it were contiguous lucid images to the eye. And so the giving to a large metalline speculum a concave figure, would never enable it to set wood on fire, and even to melt down metals readily, if the sun-beams, that in cloudless days do, as to sense, fill the air, were not, by the help of that concavity, thrown together to a point. And to shew you by an eminent instance, how various and how differing effects the same action of a natural agent may produce, according to the several dispositions of the bodies it works upon, do but consider, that in two eggs, the one prolifick, the other barren, the sense can perhaps distinguish before incubation no difference at all; and yet these bodies, outwardly so like, do so differ in the internal disposition of their parts, that if they be both exposed to the same degree of heat, (whether of a hen, or an artificial oven,) that heat will change the one into a putrid and stinking substance, and the other into a chick, furnished with great variety of organical parts of very differing consistences, and curious as well as differing textures.

4. I Do not deny, but that bodies may be said, in a very favourable sense, to have those qualities we call sensible, though there were no animals in the world: for a body in that case may differ from those bodies, which now are quite devoid of quality, in its having such a disposition of its constituent corpuscles, that in case it were duly applied to the sensory of an animal, it would produce such a sensible quality, which a body of another texture would not: as though if there were no

animals, there would be no such thing as pain, yet a pin may, upon the account of its figure, be fitted to cause pain, in case it were moved against a man's finger; whereas a bullet, rather blunt body, moved against it with no greater force, will not cause any such perception of pain. And thus snow, though if there were no lucid body nor organ of sight in the world, it would exhibit no colour at all, (for I could not find it had any in places exactly darkened,) yet it hath a greater disposition than a coal or foot, to reflect store of light outwards, when the sun shines upon them all three. And so we say, that a lute is in tune, whether it be actually played upon or no, if the strings be all so duly stretched, as that it would appear to be in tune, if it were played upon. But as if you should thrust a pin into a man's finger, both a while before and after his death, though the pin be as sharp at one time as at another, and maketh in both cases alike a solution of continuity; yet in the former case the action of the pin will produce pain, and not in the latter, because in this the pricked body wants the soul, and consequently the perceptive faculty: so if there were no sensitive beings, those bodies, that are now the objects of our senses, would be but dispositively, if I may so speak, endowed with colours, tastes, and the like; and actually but only with those more catholic affections of bodies, figure, motion, texture, &c.

To illustrate this yet a little farther: suppose a man should beat a drum at some distance from the mouth of a cave, conveniently situated to return the noise he makes; although men will presently conclude, that that cave hath an echo, and will be apt to fancy upon that account some real property in the place, to which the echo is said to belong; and although indeed the same noise, made in many other of the neighbouring places, would not be reflected to the ear, and consequently would manifest those places to have no echos; yet to speak physically of things, this peculiar quality or property we fancy in the cave, is in it nothing else but the hollowness of its figure, whereby it is so disposed, as when the air beats against it, to reflect the motion towards the place whence that motion began; and that, which passeth on this occasion, is indeed but this, that the drum-stick falling upon the drum makes a percussion of the air, and puts that fluid body into an undulating motion, and the airy waves thrusting on one another, till they arrive at the hollow superficies of the cave, have, by reason of its resistance and figure, their motion determined the contrary way; namely, backwards towards that part, where the drum was, when it was struck. So that in that, which here happens, there intervenes nothing but the figure of one body, and the motion of another; though if a man's ear chance to be in the way of these motions of the air forwards and backwards, it gives him a perception of them, which he calls sound. And because these perceptions, which are supposed to proceed

ceed from the same percussion of the drum, and thereby of the air, are made at distinct times one after another, that hollow body, from whence the last sound is conceived to come to the air, is imagined to have a peculiar faculty, upon whose account men are wont to say, that such a place hath an echo.

5. AND whereas one body doth often seem to produce in another divers such qualities, as we call sensible, which qualities therefore seem not to need any reference to our senses; I consider, that when one inanimate body works upon another, there is nothing really produced by the agent in the patient, save some local motion of its parts, or some change of texture consequent upon that motion: and so, if the patient come to have any sensible quality, that it had not before, it acquires it upon the same account, upon which other bodies have it, and it is but a consequent to this mechanical change of texture, that by means of its effects upon our organs of sense, we are induced to attribute this or that sensible quality to it. As in case a pin should chance by some inanimate body to be driven against a man's finger, that, which the agent doth, is but to put a sharp and slender body into such a kind of motion; and that which the pin doth, is to pierce into a body, that it meets with, not hard enough to resist its motion; and so that upon this there should ensue such a thing as pain, is but a consequent, that superadds nothing of real to the pin, that occasions that pain. So if a piece of transparent ice be, by the falling of some heavy and hard body upon it, broken into a gross powder, that looks whitish, the falling body doth nothing to the ice but break it into very small fragments, lying confusedly upon one another; though by reason of the fabrick of the world, and of our eyes, there doth in the day-time upon this comminution ensue such a kind of copious reflection of the incident light to our eyes, as we call whiteness. And when the sun, by thawing this broken ice, destroys the whiteness of that portion of matter, and makes it become diaphanous, which it was not before, it doth no more than alter the texture of the component parts, by putting them into motion, and thereby into a new order; in which, by reason of the disposition of the pores intercepted betwixt them, they reflect but few of the incident beams of light, and transmit most of them. Thus when with a burnisher you polish a rough piece of silver, that which is really done, is but the depression of the little protuberant parts into one level with the rest of the superficies; though upon this mechanical change of the texture of the superficial parts, we men say, that it hath lost the quality of roughness, and acquired that of smoothness; because that, whereas before the little extancies by their figure resisted a little the motion of our fingers, and grated upon them a little, our fingers now meet with no such offensive resistance. It is true, that the fire doth thaw ice, and also both make wax flow, and enable it to burn a man's hand; and yet this doth not necessarily argue

in it any inherent quality of heat, distinct from the power it hath of putting the small parts of the wax into such a motion, as that their agitation surmounts their cohesion; which motion, together with their gravity, is enough to make them *pro tempore* constitute a fluid body; and aqua fortis, without any (sensible) heat, will make camphire cast on it assume the form of a liquor distinct from it; as I have tried, that a strong fire will also make camphire fluid: not to add, that I know a liquor into which certain bodies being put, when both itself (as well as they) is actually cold, (and consequently when you would not suspect it of an actual inherent heat) will not only speedily dissipate many of their parts into smoke, but leave the rest black, and burnt almost like a coal. So that though we suppose the fire to do no more than variously and briskly to agitate the insensible parts of the wax, that may suffice to make us think the wax endowed with a quality of heat: because if such an agitation be greater than that of the spirit, and other parts of our organs of touching, that is enough to produce in us that sensation we call heat; which is so much a relative to the sensory which apprehends it, that we see, that the same lukewarm water, that is, whose corpuscles are moderately agitated by the fire, will appear hot to one of a man's hands, if that be very cold, and cold to the other, in case it be very hot, though both of them be the same man's hands. To be short, if we fancy any two of the bodies about us, as a stone, a metal, &c. to have nothing at all to do with any other body in the universe, it is not easy to conceive either how one can act upon the other, but by local motion (of the whole body, or its corporeal effluvia;) or how by motion it can do any more than put the parts of the other body into motion too, and thereby produce in them a change of situation and texture, or of some other of its mechanical affections: though this (passive) body being placed among other bodies in a world constituted as ours now is, and being brought to act upon the most curiously contrived sensories of animals, may upon both these accounts exhibit many differing sensible phenomena; which however we look upon them as distinct qualities, are consequently but the effects of the often mentioned catholick affections of matter, and deducible from the size, shape, motion (or rest,) posture, order, and the resulting texture of the insensible parts of bodies. And therefore though, for shortness of speech, I shall not scruple to make use of the word *qualities*, since it is already so generally received, yet I would be understood to mean them in a sense suitable to the doctrine above delivered. As if I should say, that roughness is apt to grate and offend the skin, I should mean, that a file or other body, by having upon its surface a multitude of little hard and extant parts, and of an angular or sharp figure, is qualified to work the mentioned effect: and so if I should say, that heat melts metals, I should mean, that this fusion is effected by fire,

fire, or some other body, which, by the various and vehement motion of its insensible parts, does to us appear hot. And hence, (by the way,) I presume you will easily guess at what I think of the controversy so hotly disputed of late betwixt two parties of learned men, whereof the one would have all accidents to work only in virtue of the matter they reside in, and the other would have the matter to act only in virtue of its accidents: for considering, that on the one side, the qualities we here speak of, do so depend upon matter, that they cannot so much as have a being but in and by it; and on the other side, if all matter were but quite devoid of motion, (to name now no other accidents,) I do not readily conceive, how it could operate at all; I think it is safest to conclude, that neither matter, nor qualities apart, but both of them conjointly do perform what we see done by bodies to one another, according to the doctrine of qualities just now delivered.

Of the Nature of a FORM.

VII. **W**E may now advance somewhat further, and consider, that men having taken notice, that certain conspicuous accidents were to be found associated in some bodies, and other conventions of accidents in other bodies, they did for conveniency, and for the more expeditious expression of their conceptions, agree to distinguish them into several sorts, which they call genders or species, according as they referred them either upwards to a more comprehensive sort of bodies, or downward to a narrower species, or to individuals; as, observing many bodies to agree in being fusible, malleable, heavy, and the like, they gave to that sort of body the name of *metal*, which is a genus in reference to gold, silver, lead, and but a species in reference to that sort of mixed bodies they call *fossilia*: this superiour genus comprehending both metals, stones, and divers other concretions, though itself be but a species in respect of mixed bodies. Now when any body is referred to any particular species (as of a metal, a stone, or the like) because men have for their convenience agreed to signify all the essentials requisite to constitute such a body by one name, most of the writers of physicks have been apt to think, that besides the common matter of all bodies, there is but one thing, that discriminates it from other kinds, and makes it what it is, and this, for brevity's sake, they call a form: which because all the qualities and other accidents of the body must depend on it, they also imagine to be a very substance, and indeed a kind of soul, which, united to the gross matter, composes with it a natural body, and acts in it by the several qualities to be found therein, which men are wont to ascribe to the creature so composed. But as to this affair I observe, that if (for instance) you ask a man what gold is, if he cannot shew you a piece of gold, and tell you, this is gold, he will describe it to you as a body, that is extremely ponderous, very malleable and ductile, fusible and yet fixed in the

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fire, and of a yellowish colour; and if you offer to put off to him a piece of brass for a piece of gold, he will presently refuse it, and (if he understand metals) tell you, that though your brass be coloured like it, it is not so heavy, nor so malleable, neither will it like gold resist the utmost brunt of the fire, or resist aqua fortis. And if you ask men, what they mean by a ruby, or nitre, or a pearl, they will still make you such answers, that you may clearly perceive, that whatever men talk in theory of substantial forms, yet that, upon whose account they really distinguish any one body from others, and refer it to this or that species of bodies, is nothing but an aggregate or convention of such accidents, as most men do by a kind of agreement (for the thing is more arbitrary than we are aware of) think necessary or sufficient to make a portion of the universal matter belong to this or that determinate genus or species of natural bodies. And therefore not only the generality of chymists, but divers philosophers, and, what is more, some schoolmen themselves, maintain it to be possible to transmute the ignobler metals into gold; which argues, that if a man could bring any parcel of matter to be yellow, and malleable and ponderous, and fixed in the fire, and upon the test, and indissoluble in aqua fortis, and in some to have a concurrence of all those accidents, by which men try true gold from false, they would take it for true gold without scruple. And in this case the generality of mankind would leave the school-doctors to dispute, whether being a factitious body, (as made by the chymist's art) it have the substantial form of gold, and would upon the account of the convention of the freshly mentioned accidents, let it pass current amongst them, notwithstanding most mens greater care not to be deceived in a matter of this nature than in any other. And indeed since to every determinate species of bodies there doth belong more than one quality, and for the most part a concurrence of many is so essential to that sort of bodies, that the want of any one of them is sufficient to exclude it from belonging to that species; there needs no more to discriminate sufficiently any one kind of bodies from all the bodies in the world, that are not of that kind; as the chymists *luna fixa*, which they tell us wants not the weight, the malleableness, nor the fixedness, nor any other property of gold, except the yellowness, (which makes them call it white gold) would by reason of that want of colour be easily known from true gold. And you will not wonder at this, if you consider, that though spheres and parallelopipedons differ but in shape, yet this difference alone is the ground of so many others, that *Euclid*, and other geometricians have demonstrated I know not how many properties of the one, which do no way belong to the other; and * *Aristotle* himself somewhere tells us, that a sphere is composed of brass and roundness. And I suppose it would be thought a man's own fault, if he could not distinguish a needle from a file, or a key from a pair of

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scissors,

scissors, though these being all made of iron, and differing but in bigness and shape, are less remarkably diverse than natural bodies, the most part of which differ from each other in far more accidents than two. Nor need we think, that qualities being but accidents, they cannot be essential to a natural body; for accident, as I formerly noted, is sometimes opposed to substance, and sometimes to essence. And though an accident cannot be but accidental to matter, as it is a substantial thing, yet it may be essential to this or that particular body: as in *Aristotle's* newly mentioned example, though roundness is but accidental to brass, yet it is essential to a brazen sphere; because, though the brass were devoid of roundness, (as if it were cubical, or of any other figure,) it would still be a corporeal substance, yet without that roundness it could not be a sphere. Wherefore since an aggregate or convention of qualities is enough to make the portion of matter it is found in what it is, and denominate it of this or that determinate sort of bodies; and since those qualities, as we have seen already, do themselves proceed from those more primary and catholic affections of matter, bulk, shape, motion or rest, and the texture thence resulting, why may we not say, that the form of a body being made up of those qualities united in one subject, doth likewise consist in such a convention of those newly named mechanical affections of matter, as is necessary to constitute a body of that determinate kind. And so, though I shall for brevity's sake retain the word *form*, yet I would be understood to mean by it, not a real substance distinct from matter, but only the matter itself of a natural body, considered with its peculiar manner of existence; which I think may not inconveniently be called either its specific or its denominating state, or its essential modification, or, if you would have me express it in one word, its stamp. For such a convention of accidents is sufficient to perform the offices, that are necessarily required in what men call a form, since it makes the body such as it is, making it appertain to this or that determinate species of bodies, and discriminating it from all other species of bodies whatsoever: As for instance, ponderousness, ductility, fixedness, yellowness, and some other qualities concurring in a portion of matter, do with it constitute gold, and making it belong to that species we call metals, and to that sort of metals we call gold, do both denominate and discriminate it from stones, salts, margarites, and all other sorts of bodies, that are not metals, and from silver, brass, copper, and all metals except gold. And whereas it is said by some, that the form also of a body ought to be the principle of its operation, we shall hereafter consider in what sense that is to be admitted or rejected; in the mean time it may suffice us, that even in the vulgar philosophy it is acknowledged, that natural things for the most part operate by their qualities, as snow dazzles the eyes by its whiteness, and water scattered into drops of rain falls from the

clouds upon the account of its gravity. To which I shall add, that how great the power may be, which a body may exercise by virtue of a single quality, may appear by the various and oftentimes prodigious effects, which fire produces by its heat, when thereby it melts metals, calcines stones, destroys whole woods and cities, &c. And if several active qualities convene in one body, (as that which in our hypothesis is meant by form, usually comprises several of them,) what great things may be thereby performed, may be somewhat guessed at by the strange things we see done by some engines, which, being as engines, undoubtedly devoid of substantial forms, must do those strange things they are admired for, by virtue of those accidents, the shape, size, motion, and contrivance of their parts. Not to mention, that in our hypothesis, besides those operations, that proceed from the essential modification of the matter, as the body (composed of matter and necessary accidents) is considered *per modum unius*, as one intire corporeal agent, it may in divers cases have other operations, upon the account of those particular corpuscles, which though they concur to compose it, and are, in reference to the whole, considered but as its parts, may yet retain their own particular nature, and divers of the peculiar qualities: as in a watch, besides those things, which the watch performs as such, the several parts, whereof it consists as the spring, the wheels, the string, the pins, &c. may have each of them its peculiar bulk, shape, and other attributes, upon the account of one or more of which the wheel or spring, &c. may do other things than what it doth, as merely a constituent part of the watch. And so in the milk of a nurse, that hath some hours before taken a potion, though the corpuscles of the purging medicine appear not to sense distinct from the other parts of the milk, which in far greater numbers concur with them to constitute that white liquor; yet these purgative particles, that seem to be but part of the matter whereof the milk consists, do yet so retain their own nature and qualities, that being sucked in with the rest by the infant, they quickly discriminate and discover themselves by purging him. But of this subject more hereafter.

Of Generation, Corruption, and Alteration.

VIII. **I**T now remains, that we declare, what, according to the tenor of our hypothesis, is to be meant by generation, corruption, and alteration; (three names, that have very much puzzled and divided philosophers.) In order hereunto we may consider,

1. THAT there are in the world great store of particles of matter, each of which is too small to be, whilst single, sensible; and being intire or undivided, must needs both have its determinate shape, and be very solid. Inasmuch, that though it be mentally, and by divine omnipotence divisible, yet by reason of its smallness and solidity, nature doth scarce ever actually divide it; and these may in this sense be called *minima* or *prima naturalia*.

2. THAT

2. THAT there are also multitudes of corpuscles, which are made up of the coalition of several of the former *minima naturalia*; and whose bulk is so small, and their adhesion so close and strict; that each of these little primitive concretions or clusters (if I may so call them) of particles is singly below the discernment of sense, and though not absolutely indivisible by nature into the *prima naturalia*, that composed it, or perhaps into other little fragments, yet, for the reasons freshly intimated, they very rarely happen to be actually dissolved or broken, but remain intire in great variety of sensible bodies, and under various forms or disguises. As, not to repeat what we lately mentioned, of the undestroyed purging corpuscles of milk; we see, that even grosser and more compounded corpuscles may have such a permanent texture: for quicksilver, for instance, may be turned into a red powder for a fusible and malleable body, or a fugitive smoke, and disguised I know not how many other ways, and yet remain true and recoverable mercury. And these are, as it were, the seeds or immediate principles of many sorts of natural bodies, as earth, water, salt, &c. and those singly insensible, become capable, when united, to affect the sense: as I have tried, that if good camphire be kept a while in pure spirit of wine, it will thereby be reduced into such little parts, as totally to disappear in the liquor, without making it look less clear than fair water; and yet, if into this mixture you pour a competent quantity of water, in a moment the scattered corpuscles of the camphire will, by reuniting themselves, become white, and consequently visible, as before their dispersion.

3. THAT as well each of the *minima naturalia*, as each of the primary clusters above mentioned, having its own determinate bulk and shape, when these come to adhere to one another, it must always happen, that the size, and often, that the figure of the corpuscle composed by their juxtaposition and cohesion, will be changed: and not seldom too, the motion either of the one, or the other, or both, will receive a new tendency, or be altered as to its velocity or otherwise: and the like will happen, when the corpuscles, that compose a cluster of particles, are disjoined, or any thing of the little mass is broken off. And whether any thing of matter be added to a corpuscle, or taken from it in either case, (as we just now intimated,) the size of it must necessarily be altered, and for the most part the figure will be so too, whereby it will both acquire a congruity to the pores of some bodies, (and perhaps some of our sensories,) and become incongruous to those of others; and consequently be qualified, as I shall more fully shew you hereafter, to operate on divers occasions, much otherwise than it was fitted to do before.

4. THAT when many of these insensible corpuscles come to be associated into one visible body, if many or most of them be put into motion, from what cause soever the motion proceeds, that itself may produce great

changes, and new qualities in the body they compose; for not only motion may perform much, even when it makes not any visible alteration in it, as air put into swift motion, (as when it is blown out of bellows) acquires a new name, and is called *wind*, and to the touch appears far colder than the same air not so formed into a stream; and iron, by being briskly rubbed against wood, or other iron, hath its small parts so agitated, as to appear hot to our sense: but this motion oftentimes makes visible alterations in the texture of the body into which it is received; for always the moved parts strive to communicate their motion, or somewhat of the degree of it, to some parts, that were before either at rest, or otherwise moved, and oftentimes the same moved parts do thereby either disjoin or break some of the corpuscles they hit against, and thereby change their bulk or shape, or both; and either drive some of them quite out of the body, and perhaps lodge themselves in their places, or else associate them anew with others. Whence it usually follows, that the texture is for a while at least, and unless it be very stable and permanent, for good and all, very much altered, and especially in that the pores or little intervals intercepted betwixt the component particles will be changed as to bigness, or figure, or both, and so will cease to be commensurate to the corpuscles that were fit for them before, and become commensurate to such corpuscles of other sizes and shapes, as till then were incongruous to them. Thus we see, that water, by losing the wonted agitation of its parts, may acquire the firmness and brittleness we find in ice, and lose much of the transparency it had whilst it was a liquor. Thus also, by very hard rubbing two pieces of resinous wood against one another, we may make them throw out divers of their looser parts into steams and visible smoke; and may, if the attrition be duly continued, make that commotion of the parts so change the texture of the whole, as afterwards to turn the superficial parts into a kind of coal. And thus milk, especially in hot weather, will by the intestine, though languid motions of its parts, be in a short time turned into a thinner sort of liquor than milk, and into cream, and this (last named) will, by being barely agitated in a churn, be turned in a shorter time into that unctuous and consistent body we call butter, and into thin, fluid, and four butter-milk. And thus (to dispatch) by the bruising of fruit; the texture is commonly so changed, that, as we see particularly in apples, the bruised part soon comes to be of another nature than the sound part, the one differing from the other both in colour, taste, smell, and consistence. So that (as we have already inculcated) local motion hath, of all other affections of matter, the greatest interest in the altering and modifying of it; since it is not only the grand agent or efficient among second causes, but is also oftentimes one of the principal things that constitutes the form of bodies. As when two sticks are set on fire by long and vehement attrition, local motion

is not only that, which kindles the wood, and so as an efficient produces the fire, but is that, which principally concurs to give the produced stream of shining matter, the name and nature of flame: and so it concurs also to constitute all fluid bodies.

5. AND that since we have formerly seen, that it is from the size, shape, and motion of the small parts of matter, and the texture that results from the manner of their being disposed in any one body, that the colour, odour, taste, and other qualities of that body are to be derived, it will be easy for us to recollect, that such changes cannot happen in a portion of matter, without so much varying the nature of it, that we need not deride the antient atomists, for attempting to deduce the generation and corruption of bodies from the famed σύγκρισις ἢ διάκρισις, the *convention* and *dissolution*, and the alterations of them, from the transposition of their (supposed) atoms. For though indeed nature is wont in the changes she makes among things corporeal, to imploy all the three ways, as well in alterations as generations and corruptions; yet if they only meant, as probably enough they did, that of the three ways proposed, the first was wont to be the principal in the generation of bodies, the second in the corruption, and the third in their alterations; I shall not much oppose this doctrine: though I take the local motion or transposition of parts in the same portion of matter to bear a great stroke as well in reference to generation and corruption, as to alteration: as we see when milk or flesh, or fruit, without any remarkable addition or loss of parts, turns into maggots, or other insects; and as we may more conspicuously observe in the precipitation of mercury, without addition, in the vitrification of metals, and other chymical experiments to be hereafter mentioned.

These things premised, it will not now be difficult to comprise in few words such a doctrine, touching the generation, corruption, and alteration of bodies, as is suitable to our hypothesis and the former discourse. For if in a parcel of matter there happen to be produced (it imports not much how) a concurrence of all those accidents, (whether those only or more) that men by tacit agreement have thought necessary and sufficient to constitute any one determinate species of things corporeal, then we say, that a body belonging to that species, as suppose a stone, or a metal, is generated or produced *de novo*. Not that there is really any thing of substantial produced, but that those parts of matter, that did indeed before præexist, but were either scattered and shared among other bodies, or at least otherwise disposed of, are now brought together, and disposed of after the manner requisite, to entitle the body, that results from them, to a new denomination, and make it appertain to such a determinate species of natural bodies, so that no new substance is in generation produced, but only that, which was præexistent, obtains a new modification, or manner of existence. Thus

when the spring, and wheels, and string, and balance, and index, &c. necessary to a watch, which lay before scattered, some in one part, some in another of the artificer's shop, are first set together in the order requisite to make such an engine, to shew how the time passes, a watch is said to be made: not that any of the mentioned material parts is produced *de novo*, but that till then the divided matter was not so contrived and put together, as was requisite to constitute such a thing as we call a watch. And so when sand and ashes are well melted together, and suffered to cool, there is generated by the colliquation that sort of concretion we call glass, though it be evident, that its ingredients were both præexistent, and do but by their association obtain a new manner of existing together. And so when, by the churning of cream, butter and butter-milk are generated, we find not any thing substantial produced *de novo* in either of them, but only that the serum, and the fat corpuscles, being put into local motion, do by their frequent occurrences extricate themselves from each other, and associate themselves in the new manner, requisite to constitute the bodies, whose names are given them.

AND as a body is said to be generated, when it first appears clothed with all those qualities, upon whose account men have been pleased to call some bodies stones; others, metals; others, salts, &c. so when a body comes to lose all or any of those accidents, that are essential, and necessary to the constituting of such a body, it is then said to be corrupted or destroyed, and is no more a body of that kind, but loses its title to its former denomination. Not that any thing corporeal or substantial perishes in this change, but only that the essential modification of the matter is destroyed: and though the body be still a body, (no natural agent being able to annihilate matter,) yet it is no longer such a body, as it was before, but perisheth in the capacity of a body of that kind. Thus, if a stone, falling upon a watch, break it to pieces, as, when the watch was made, there was no new substance produced, all the material parts (as the steel, brass, string, &c.) being præexistent somewhere or other, (as in iron and copper mines in the bellies of those animals, of whose guts men use to make strings;) so not the least part of the substance of the watch is lost, but only displaced and scattered; and yet that portion of matter ceases to be a watch, as it was before. And so (to resume our late example) when cream is by churning turned into butter, and a ferrous liquor, the parts of the milk remain associated into those new bodies, but the white liquor perisheth in the capacity of milk. And so when ice comes to be thawed in exactly-closed vessels, though the corruption be produced only (for aught appears) by introducing a new motion and disposition into the parts of the frozen water, yet it thereupon ceases to be ice, however it be as much water, and consequently as much a body, as before it

was frozen or thawed. These, and the like examples, may teach us rightly to understand that common axiom of naturalists, *Corruptio unius est generatio alterius*; & à contrà: for since it is acknowledged on all hands, that matter cannot be annihilated, and since it appears by what we have said above, that there are some properties, namely, size, shape, motion, (or, in its absence, rest,) that are inseparable from the actual parts of matter; and since also the coalition of any competent number of these parts is sufficient to constitute a natural body, endowed with divers sensible qualities, it can scarce be otherwise, but that the same agents, that shatter the frame, or destroy the texture of one body, will by shuffling them together, and disposing them after a new manner, bring them to constitute some new sort of bodies: as the same thing, that by burning destroys wood, turns it into flame, soot, and ashes. Only I doubt, whether the axiom do generally hold true, if it be meant, that every corruption must end in the generation of a body belonging to some particular species of things, unless we take powders and fluid bodies indefinitely for species of natural bodies; since it is plain, there are multitudes of vegetables, and other concretions, which, when they rot, do not, as some others do, turn into worms, but either into some slimy or watery substance, or else (which is the most usual) they crumble into a kind of dust or powder, which, though looked upon as being the earth, into which rotten bodies are at length resolved, is very far from being of an elementary nature, but as yet a compounded body, retaining some, if not many qualities, which often makes the dust of one sort of plant or animal differ much from that of another. And this will supply me with this argument *ad hominem*, viz. That since in those violent corruptions of bodies, that are made by outward agents, shattering them into pieces, if the axiom hold true, the new bodies emergent upon the dissolution of the former, must be really natural bodies, as (indeed divers of the moderns hold them to be,) and generated according to the course of nature; as when wood is destroyed by fire, and turned partly into flame, partly into soot, partly into coals, and partly into ashes, I hope we may be allowed to conclude, that those chymical productions, which so many would have to be but factitious bodies, are natural ones, and regularly generated. For it being the same agent, the fire, that operates upon bodies, whether they be exposed to it in close glasses, or in chimneys, I see no sufficient reason, why the chymical oils, and volatile salts, and other things, which Spagyrites obtain from mixed bodies, should not be accounted natural bodies, as well as the soot and ashes, and charcoal, that by the same fire are obtained from kindled wood.

BUT before we pass away from the mention of the corruption of bodies, I must take some notice of what is called their putrefaction. This is but a peculiar kind of corrup-

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tion, wrought slowly (whereby it may be distinguished from destruction by fire, and other nimble agents) in bodies: it happens to them for the most part by means of the air, or some other ambient fluid, which by penetrating into the pores of the body, and by its agitation in them doth usually call out some of the more agile and less intangled parts of the body, and doth almost ever loosen and dislocate the parts in general, and thereby so change the texture, and perhaps too the figure of the corpuscles, that compose it, that the body, thus changed, acquires qualities unsuitable to its former nature, and for the most part offensive to our senses, especially of smelling and tasting: which last clause I therefore add, not only because the vulgar look not upon the change of an egg into a chick as a corruption, but as a perfection of the egg; but because also I think it not improbable, that if by such slow changes of bodies, as make them lose their former nature, and might otherwise pass for putrefaction, many bodies should acquire better scents or tastes than before; or if nature, custom, or any other cause should much alter the texture of our organs of tasting and smelling, it would not perhaps be so well agreed on what should be called putrefaction, as that imports an impairing alteration, but men would find some favourabler notion for such changes. For I observe, that medlars, though they acquire in length of time such a colour and softness as rotten apples, and other putrified fruits do; yet, because their taste is not then harsh as before, we call that ripeness in them, which otherwise we should call rottenness. And though upon the death of a four-footed beast, we generally call that change, which happens to the flesh or blood, putrefaction, yet we pass a more favourable judgment upon that, which happens to the flesh, and other softer parts of that animal, (whether it be a kind of large rabbits, or very small and hornless deer,) of which in *China*, and in the *Levant*, they make musk; because by the change, that ensues the animal's death, the flesh acquires not an odious, but a grateful smell. And we see, that some men, whose appetites are gratified by rotten cheese, think it then not to have degenerated, but to have attained its best state, when having lost its former colour, smell, and taste, and, which is more, being in great part turned into those insects called mites, it is both in a philosophical sense corrupted, and in the estimate of the generality of men grown putrid. But because it very seldom happens, that a body by generation acquires no other qualities than just those, that are absolutely necessary to make it belong to the species, that denominates it, therefore in most bodies there are divers other qualities, that may be there, or may be missing, without essentially changing the subject: as water may be clear or muddy, odorous or stinking, and still remain water; and butter may be white or yellow, sweet or rancid, consistent or melted, and still be called butter. Now therefore whensoever

a parcel of matter does acquire or lose a quality, that is not essential to it, that acquisition or loss is distinctly called alteration, (or by some, mutation :) the acquire only of the qualities, that are absolutely necessary to constitute its essential and specific difference, or the loss of any of those qualities, being such a change, as must not be called meer alteration, but have the particular name of generation or corruption ; both which, according to this doctrine, appear to be but several kinds of alteration, taken in a large sense, though they are distinguished from it in a more strict and limited acceptation of that term.

AND here we have a fair occasion to take notice of the fruitfulness and extent of our mechanical hypothesis : for since, according to our doctrine, the world we live in is not a moveless or indigested mass of matter, but an *Ἀυτόματον*, or *self-moving engine*, wherein the greatest part of the common matter of all bodies is always (though not still the same parts of it) in motion, and wherein bodies are so close set by one another, that (unless in some very few and extraordinary, and as it were preternatural cases) they have either no vacuities betwixt them, or only here and there interposed and very small ones : And since, according to us, the various manner of the coalition of several corpuscles into one visible body is enough to give them a peculiar texture, and thereby fit them to exhibit divers sensible qualities, and to become a body, sometimes of one denomination, and sometimes of another ; it will very naturally follow, that from the various occurrences of those innumerable swarms of little bodies, that are moved to and fro in the world, there will be many fitted to stick to one another, and so compose concretions ; and many (though not in the self-same place) disjoined from one another, and agitated apart ; and multitudes also, that will be driven to associate themselves, now with one body, and presently with another. And if we also consider on the one side, that the sizes of the small particles of matter may be very various, their figures almost innumerable ; and that if a parcel of matter do but happen to stick to one body, it may chance to give it a new quality, and if it adhere to another, or hit against some of its parts, it may constitute a body of another kind ; or if a parcel of matter be knocked off from another, it may barely by that leave it, and become itself of another nature than before : If, I say, we consider these things on the one side, and on the other side, that (to use *Lucretius* his comparison) all that innumerable multitude of words, that are contained in all the languages of the world, are made of the various combinations of some of the twenty four letters of the alphabet ; it will not be hard to conceive, that there may be an incomprehensible variety of associations and textures of the minute parts of bodies, and consequently a vast multitude of portions of matter endowed with store enough of differing qualities,

to deserve distinct appellations ; though for want of heedfulness and fit words, men have not yet taken so much notice of their less obvious varieties, as to sort them as they deserve, and give them distinct and proper names. So that though I would not say, that any thing can immediately be made of every thing, as a gold ring of a wedge of gold, or oil, or fire of water ; yet since bodies, having but one common matter, can be differenced but by accidents, which seem all of them to be the effects and consequents of local motion, I see not, why it should be absurd to think, that (at least among inanimate bodies) by the intervention of some very small addition or subtraction of matter, (which yet in most cases will scarce be needed,) and of an orderly series of alterations, disposing by degrees the matter to be transmuted, almost of any thing, may at length be made any thing : as, though out of a wedge of gold one cannot immediately make a ring, yet by either wire-drawing that wedge by degrees, or by melting it, and casting a little of it into a mould, that thing may be easily effected. And so though water cannot immediately be transmuted into oil, and much less into fire ; yet if you nourish certain plants with water alone, (as I have done,) till they have assimilated a great quantity of water into their own nature, you may, by committing this transmuted water (which you may distinguish and separate from that part of the vegetable you first put in) to distillation in convenient glasses, obtain, besides other things, a true oil, and a black combustible coal, (and consequently fire ;) both of which may be so copious, as to leave no just cause to suspect, that they could be any thing near afforded by any little spirituous parts, which may be presumed to have been communicated by that part of the vegetable, that is first put into the water, to that far greater part of it, which was committed to distillation.

BUT, *Pyrophilus*, I perceive the difficulty and fruitfulness of my subject have made me so much more prolix than I intended, that it will not now be amiss to contract the summary of our hypothesis, and give you the main points of it with little or no illustration, and without particular proofs, in a few words. We teach then (but without peremptorily asserting it,)

1. THAT the matter of all natural bodies is the same ; namely, a substance extended and impenetrable.

2. THAT all bodies thus agreeing in the same common matter, their distinction is to be taken from those accidents, that do diversify it.

3. THAT motion, not belonging to the essence of matter, (which retains its whole nature when it is at rest,) and not being originally producible by other accidents, as they are from it, may be looked upon as the first and chief mood or affection of matter.

4. THAT motion, variously determined, doth naturally divide the matter it belongs to into actual fragments of parts ; and this division,

vision, obvious experience (and more eminently, chymical operations) manifest to have been made into parts exceedingly minute, and very often too minute to be singly perceivable by our senses.

5. WHENCE it must necessarily follow, that each of these minute parts or *minima naturalia*, (as well as every particular body, made up by the coalition of any number of them,) must have its determinate bigness or size, and its own shape. And these three; namely, bulk, figure, and either motion or rest, (there being no mean between these two) are the three primary and most catholic moods or affections of the insensible parts of matter, considered each of them apart.

6. THAT when divers of them are considered together, there will necessarily follow here below both a certain position or posture in reference to the horizon (as erected, inclining, or level) of each of them, and a certain order or placing before or behind, or besides one another; as when in a company of soldiers one stands upright, the other stoops, the other lies along upon the ground, they have various postures; and their being placed besides one another in ranks, and behind one another in files are varieties of their order: and when many of these small parts are brought to convene into one body from their primary affections, and their disposition or contrivance as to posture and order, there results that, which by one comprehensive name we call the texture of that body. And indeed these several kinds of location, (to borrow a scholastical term,) attributed in this sixth number to the minute particles of bodies, are so near of kin, that they seem all of them referable to (that one event of their convening) situation or position. And these are the affections, that belong to a body, as it is considered in itself, without relation to sensitive beings, or to other natural bodies.

7. THAT yet there being men in the world, whose organs of sense are contrived in such differing ways, that one sensory is fitted to receive impressions from some, and another from other sorts of external objects or bodies without them, (whether these act as intire bodies, or by emission of their corpuscles, or by propagating some motion to the sensory,) the perceptions of these impressions are by men called by several names, as heat, colour, sound, odour; and are commonly imagined to proceed from certain distinct and peculiar qualities in the external object, which have some resemblance to the ideas, their action upon the senses excites in the mind; though indeed all these sensible qualities, and the rest, that are to be met with in the bodies without us, are but the effects or consequents of the above mentioned primary affections of matter, whose operations are diversified, ac-

ording to the nature of the sensories, or other bodies they work upon.

8. THAT when a portion of matter, either by the accession or recess of corpuscles, or by the transposition of those it consisted of before, or by any two or all of these ways, happens to obtain a concurrence of all those qualities, which men commonly agree to be necessary and sufficient to denominate the body, which hath them, either a metal or a stone, or the like, and to rank it in any peculiar and determinate species of bodies, then a body of that denomination is said to be generated.

9. THIS convention of essential accidents being taken (not any of them apart, but all) together for the specific difference that constitutes the body, and discriminates it from all other sorts of bodies, is by one name, because considered as one collective thing, called its form, (as beauty, which is made up of symmetry of parts, and agreeableness of colours,) which is consequently but a certain character, (as I sometimes call it,) or a peculiar state of matter, or, if I may so name it, an essential modification; a modification, because it is indeed but a determinate manner of existence of the matter, and yet an essential modification, because that though the concurrent qualities be but accidental to matter, (which, with others instead of them, would be matter still,) yet they are essentially necessary to the particular body, which without those accidents would not be a body of that denomination, as a metal or a stone, but of some other.

10. Now a body being capable of many other qualities besides those, whose convention is necessary to make up its form; the acquisition or loss of any such quality is by naturalists, in the more strict sense of that term, named alteration: as when oil comes to be frozen, or to change colour, or to grow rancid; but if all or any of the qualities, that are reputed essential to such a body, come to be lost or destroyed, that notable change is called corruption. As when oil being boiled takes fire, the oil is not said to be altered in the former sense, but corrupted or destroyed, and the emergent fire generated; and when it so happens, that the body is slowly corrupted, and thereby also acquires qualities offensive to our senses, especially of smell and taste, (as when flesh or fruit grows rotten,) that kind of corruption is by a more particular name called putrefaction. But neither in this, nor in any other kind of corruption is there any thing substantial destroyed, (no such thing having been produced in generation, and matter itself being on all hands acknowledged incorruptible;) but only that special connexion of the parts; or manner of their co-existence, upon whose account the matter (whilst it was in its former state) was, and was called a stone, or a metal, or did belong to any other determinate species of bodies.

A N

E X A M E N

O F T H E

O R I G I N and D O C T R I N E

O F

S U B S T A N T I A L F O R M S,

As it is wont to be taught by the PERIPATETICKS.

THE origin of forms, *Pyrophilus*, as it is thought the noblest, so, if I mistake not, it hath been found one of the most * perplexed inquiries, that belong to natural philosophy: and, I confess, it is one of the things, that has invited me to, look about for some more satisfactory account than the schools usually give of this matter, that I have observed, that the wisest, that have busied themselves in explicating forms according to the Peripatetick notions of them, have either knowingly confessed themselves unable to explain them, or unwittingly proved themselves to be so, by giving but unsatisfactory explications of them.

It will not, I presume, be expected, that I, who now write but notes, should enumerate, much less examine all the various opinions touching the origin and nature of forms; it being enough for our purpose, if having already intimated in our hypothesis, what, according to that, may be thought of this subject; we now briefly consider the general opinion of our modern Aristotelians and the schools concerning it: I say, the modern Aristotelians, because divers of the ancient, especially Greek commentators of *Aristotle*, seem to have understood their masters doctrine of forms much otherwise, and less incongruously, than his Latin followers, the schoolmen and others, have since done. Nor do I expressly mention *Aristotle* himself among the champions of substantial forms, because though he seem in a place or two expressly enough to reckon forms among substances, yet elsewhere the examples he employs to set forth the forms of natural things by, being taken from the figures of artificial things, (as of a statue, &c.) which are confessedly but accidents, and making very little use, if any, of substantial forms to explain the phenomena of nature, he seems to me upon the whole matter either to have been irresolved,

whether there were any such substances or no, or to speak ambiguously and obscurely enough of them, to make it questionable what his opinions of them were.

But the sum of the controversy betwixt us and the schools is this, whether or no the forms of natural things (the souls of men always excepted) be in generation educed, as they speak, out of the power of the matter, and whether these forms be true substantial entities, distinct from the other substantial principle of natural bodies, namely matter.

THE reasons, that move me to embrace the negative, are principally these three: first, that I see no necessity of admitting in natural things any such substantial forms; matter, and the accidents of matter, being sufficient to explicate as much of the phenomena of nature, as we either do or are like to understand. The next, that I see not what use this puzzling doctrine of substantial forms is of in natural philosophy; the acute *Scaliger*, and those, that have most busied themselves in the indagation of them, having freely acknowledged (as the more candid of the Peripateticks generally do,) that the true knowledge of forms is too difficult and abstruse to be attained by them. And how like it is, that particular phenomena will be explained by a principle, whose nature is confessedly ignored, I leave you to judge. But because to these considerations I often have had, and shall have here and there occasion to say something in the body of these notes, I shall at present insist upon the third; which is, that I cannot conceive, neither how forms can be generated, as the Peripateticks would have it, nor how the things they ascribe to them are consistent with the principles of true philosophy, or even with what themselves otherwise teach.

THE manner how forms are educed out of the power of the matter, according to that part of the doctrine of forms, wherein the schools

* *Formarum cognitio est rudis, confusa, nec nisi per περιεχόντις, neque verum est, formæ substantialis speciem recipi in intellectu, non enim in sensu usquam fuit.* J. C. Scalig.

Formæ substantiales sunt incognitæ nobis, quia insensibiles: ideo per qualitates, quæ sunt principia immediata transformationis, exprimentur. Aquinas ad 1. de generat. & corrupt.

In hac humanæ mentis caligine æquæ forma ignis ac magnetis nobis ignota est. Sennertus.

schools generally enough agree, is a thing so inexplicable, that I wonder not it hath put acute men upon several hypotheses to make it out. And indeed the number of these is of late grown too great to be fit to be here recited, especially since I find them all so very unsatisfactory, that I cannot but think the acute sticklers for any of them are rather driven to embrace it by the palpable inconveniences of the ways they reject, than by any thing they find to satisfy them in that, which they make choice of: and for my part I confess, I find so much reason in what each party says against the explications of the rest, that I think they all confute well, and none does well establish.

BUT my present way of writing forbidding me to insist on many arguments against the doctrine, wherein they most agree, I shall only urge that, which I confess chiefly sticks with me; namely, that I find it not comprehensible.

I KNOW the modern schoolmen fly here to their wonted refuge of an obscure distinction, and tell us, that the power of matter in reference to forms is partly educive, as the agent can make the form out of it, and partly receptive, whereby it can receive the form so made. But since those, that say this, will not allow, that the form of a generated body was actually præexistent in its matter, or indeed any where else, it is hard to conceive, how a substance can be educed out of another substance, totally distinct in nature from it, without being, before such education, actually existent in it. And as for the receptive power of the matter, that but fitting it to receive or lodge a form, when brought to be united with it, how can it be intelligibly made out to contribute to the production of a new substance of a quite differing nature from that matter, though it harbours it when produced? And it is plain, that the human body hath a receptive power in reference to the human soul, which yet themselves confess both to be a substantial form, and not to be educed out of the power of matter. Indeed if they would admit the form of a natural body to be but a more fine and subtile part of the matter, as spirit of wine is of wine, which upon its recess remains no longer wine, but phlegm or vinegar, then the educive power of matter might signify something: and so it might, if with us they would allow the form to be but a modification of the matter; for then it would import, but that the matter may be so ordered or disposed by fit agents, as to constitute a body of such a sort and denomination: and so (to resume that example) the form of a sphere may be said to lurk potentially in a piece of brass, in as much as that brass may, by casting, turning, or otherwise, be so figured as to become a sphere. But this they will not admit, lest they should make forms to be but accidents, though it is, for aught I know, as little intelligible how what is educed out of any matter, without being either præexistent, or being any part of the matter, can be a true substance, as how that

roundness, that makes a piece of brass become a sphere, can be a new substance in it. Nor can they admit the other way of educing a form out of matter, as spirit is out of wine, because then not only matter will be corruptible against their grounds, but matter and form would not be two differing and substantial principles, but one and the same, though diversified by firmness, grossness, &c. which are but accidental differences. I know they speak much of the efficacy of the agent upon the matter in the generation of natural bodies, and tell us strange things of his manner of working. But not to spend time in examining those obscure niceties, I answer in short, That since the agent, be he what he will, is but a physical and finite agent, and since what way soever he works, he can do nothing repugnant to the nature of things, the difficulty, that sticks with me, will still remain. For if the form produced in generation be, as they would have it, a substance, that was not before to be found any where out of that portion of matter, wherewith it constitutes the generated body; I say, that either it must be produced by refining or subtiliating some parts of the matter into form, or else it must be produced out of nothing, that is, created: (for I see no third way, how a substance can be produced *de novo*.) If they allow the first, then will the form be indeed a substance, but not, as they hold it is, distinct from matter; since matter, however subtiliated, is matter still, as the the finest spirit of wine is as truly a body, as was the wine itself that yielded it, or as is the grosser phlegm, from which it was extracted: besides that, the Peripateticks teach, that the form is not made of any thing of the matter; nor indeed is it conceivable, how a physical agent can turn a material into an immaterial substance, especially matter being, as they themselves confess, as well incorruptible as ingenerable. But if they will not allow, as indeed they do not, that the substantial form is made of any thing, that is material, they must give me leave to believe, that it is produced out of nothing, till they shew me, how a substance can be produced otherwise, that existed no where before. And at this rate every natural body of a special denomination, as gold, marble, nitre, &c. must not be produced barely by generation, but partly by generation and partly by creation. And since it is confessed on all sides, that no natural agent can produce the least atom of matter, it is strange they should in generation allow every physical agent the power of producing a form, which, according to them, is not only a substance, but a far nobler one than matter; and thereby attribute to the meanest creatures that power of creating substances; which the ancient naturalists thought too great to be ascribed to God himself, and which indeed is too great to be ascribed to any other than him. And therefore some schoolmen and philosophers have derived forms immediately from God; but this is not only to desert *Aristotle* and the Peripatetick philosophy they would seem to

maintain, but to put omnipotence upon working I know not how many thousand miracles every hour, to perform that (I mean, the generation of bodies of new denominations) in a supernatural way, which seems the most familiar effect of nature in her ordinary course.

AND as the production of forms out of the power of matter is for these reasons incomprehensible to me; so those things, which the Peripateticks ascribe to their substantial forms, are some of them such, as, I confess, I cannot reconcile my reason to: for they tell us positively, that these forms are substances, and yet at the same time they teach, that they depend upon matter both *in fieri* and *in esse*, as they speak; so that out of the matter, that supports them, they cannot so much as exist, (whence they are usually called material forms) which is to make them substances in name, and but accidents in truth. For not to ask, how (among physical things) one substance can be said to depend upon another *in fieri*, that is not made of any part of it, the very notion of a substance is to be a self-subsisting entity, or that, which needs no other created being to support it, or to make it exist. Besides that, there being but two sorts of substances, material and immaterial, a substantial form must appertain to one of the two, and yet they ascribe things to it, that make it very unfit to be referred to either. To all this I add, that these imaginary material forms do almost as much trouble the doctrine of corruption, as that of generation: for if a form be a true substance really distinct from matter, it must, as I lately noted, be able to exist of itself, without any other substance to support it; as those I reason with confess, that the soul of man survives the body it did before death inform: whereas they will have it, that in corruption the form is quite abolished, and utterly perishes, as not being capable of existing, separated from the matter, whereunto it was united. So that here again, what they call a substance they make indeed an accident, and besides contradict their own vulgar doctrine, that natural things are upon their corruption resolved into the first matter; since, at this rate they should say, that such things are but partly resolved into the first matter, and partly either into nothing, or into forms, which being as well immaterial as the souls of men, must, for aught appears, be also, like them, accounted immortal.

I SHOULD now examine those arguments, that are wont to be employed by the schools to evince their substantial forms; but, besides that the nature and scope of my present work enjoins me brevity, I confess, that, one or two excepted, the arguments I have found mentioned, as the chief, are rather metaphysical, or logical, than grounded upon the principles and phænomena of nature, and respect rather words than things; and therefore I, who have neither inclination nor leisure to wrangle about terms, shall content my self to propose, and very briefly answer two or three of those, that are thought the plausiblest.

FIRST then they thus argue, *Omne compositum*

substantiale (for it is hard to English well such uncouth terms) *requirit materiam & formam substantialem, ex quibus componatur. Omne corpus naturale est compositum substantiales ergo, &c.* In this syllogism some do plausibly enough deny the consequence, but for brevity's sake, I shall rather chuse to deny the minor, and desire the proposers to prove it. For I know not any thing in nature, that is composed of matter, and a substance distinct from matter, except man, who alone is made up of an immaterial form, and a human body: and if it be urged, that then other bodies cannot be properly said to be *composita substantialem*, I shall, rather than wrangle with them, give them leave to find out some other name for other natural things.

BUT then they argue, in the next place, that, if there were no substantial forms, all bodies would be but *entia per accidens*, as they speak, which is absurd. To which I answer, that in the notion, that divers learned men have of an *ens per accidens*, namely, that it is that, which consists of those things, *quæ non ordinantur ad unum*, it may be said, that though we do not admit substantial forms, yet we need not admit natural bodies to be *entia per accidens*; because in them the several things, that concur to constitute the body, as matter, shape, situation, and motion, *ordinantur per se & intrinsicè* to constitute one natural body. But, if this answer satisfy not, I shall add, that for my part, that which I am solicitous about, is what nature hath made things to be in themselves, not what a logician or metaphysician will call them in the terms of his art; it being much fitter in my judgment to alter words, that they may better fit the nature of things, than to affix a wrong nature to things, that they may be accommodated to forms of words, that were probably devised, when the things themselves were not known or well understood, if at all thought on.

WHEREFORE I shall but add one argument more of this sort; and that is, that if there were no substantial forms, neither could there be any substantial definitions; but the consequent is absurd, and therefore so is the antecedent. To which I reply, that since the Peripateticks themselves confess the forms of bodies to be of themselves unknown, all that this argument seems to me to conclude, is but this, that if we do not admit some things, that are not *in rerum naturâ*, we cannot build our definitions upon them: nor indeed could we, if we should admit substantial forms, give substantial definitions of natural things, unless we could also define natural bodies by things that we know not; for such * the substantial forms are (as we have seen already) confessed to be, by the wisest Peripateticks, who pretend not to give the substantial definition of any natural *compositum*, except man. But it may suffice us to have, instead of substantial, essential definitions of things; I mean, such as are taken from the essential differences of things, which constitute them in such a sort of natural bodies, and discriminate them from all those of any other sort.

THESE

* *Nego tibi ullam esse formam nobis notam plenè & planè, nostramque scientiam esse umbram in sole.* Scalig.

THESE three arguments, *Pyrophilus*, for substantial forms, you may possibly, as well as I, find variously proposed, and perhaps with some light alterations multiplied in the writings of the Peripateticks and schoolmen; but all the arguments of this kind, that I have met with, may, if I mistake not, be sufficiently solved by the answers we have given to these, or at least by the grounds, upon which those answers are built; those seemingly various arguments agreeing in this, that either they respect rather words than things, or that they are grounded upon precarious suppositions; or lastly, that they urge that as an absurdity, which, whether it be one or not in those, that admit the Peripatetick philosophy, to me, that do as little acquiesce in many of their other principles, as I do in their substantial forms, doth not appear any absurdity at all. And it is perhaps for fear, that arguments of this sort should not much prevail with naturalists, that some of the modern assertors of the forms we question, have thought it requisite to add some more physical arguments, which (though I have not found them all in the same writers, yet) being in all but few, I shall here briefly consider them.

FIRST then, among the physical arguments, that are brought to prove substantial forms, I find that the most confidently insisted on, which is taken from the spontaneous return of heated water to coldness; which effects, say they, must necessarily be ascribed to the action of the substantial form, whose office it is to preserve the body in its natural state, and, when there is occasion, to reduce it thereunto: and the argument indeed might be plausible, if we were sure, that heated water would grow cold again (without the avolation of any parts more agitated than the rest,) supposing it to be removed into some of the imaginary spaces beyond the world; but, as the case is, I see no necessity of flying to a substantial form, the matter seeming to be easily explicable otherwise. The water we heat is surrounded with our air, or with some vessel, or other body contiguous to the air, and both the air and the water in these climates are most commonly less agitated than the juices in our hands, or other organs of touching, which makes us esteem and call those fluids, cold. Now when the water is exposed to the fire, it is thereby put into a new agitation, more vehement than that of the parts of our sensory, which you will easily grant, if you consider, that when the heat is intense, it makes the water boil and smoke, and oftentimes run over the vessel; but when the liquor is removed from the fire, this acquired agitation must needs by degrees be lost, either by the avolation of such fiery corpuscles as the Epicureans imagine to be got into heated water, or by the water's communicating the agitation of its parts to the contiguous air, or to the vessel that contains it, till it have lost its surplusage of motion, or by the ingress of those frigorifick atoms, wherewith (if any such be to be granted) the air in these climates is wont to abound, and so be reduced into its former

temperature: which may as well be done without a substantial form, as if a ship swimming slowly down a river, should by a sudden gust of wind, blowing the same way the stream runs, be driven on much faster than before, the vessel upon the ceasing of the wind may, without any such internal principle, return after a while to its former slowness of motion. So that in this phenomenon, we need not have recourse to an internal principle, the temperature of the external air being sufficient to give an account of it. And if water be kept, (as is usual in poor men's houses, that want cellars,) in the upper rooms of the house, in case the climate be hot, the water will, in spite of the form, continue far less cold, than, according to the Peripateticks, its nature requires, all the summer long. And let me here represent to the champions of forms; that, according to their doctrine, the fluidity of water must at least as much proceed from its form, as the coldness; and yet this does so much depend upon the temperature of the air, that in *Nova Zembla* vast quantities of water are kept in the hard and solid form of ice all the year long by the sharp cold of the ambient air, notwithstanding all the pretended office and power of the substantial form to keep it fluid; which it will never be reduced to be, unless by such a thawing temperature of the air, as would it self, for aught appears, make it flow again, although there were no substantial form *in rerum natura*.

THERE is another argument much urged of late by some learned men, the substance whereof is this, that matter being indifferent to one sort of accidents as well as to another, it is necessary there should be a substantial form to keep those accidents, which are said to constitute it, united to the matter they belong to, and preserve both them and the body in their natural state: for since it is confessed, that matter hath no appetite to these accidents more than to any others, they demand, how without a substantial form these accidents can be contained and preserved? To this I might represent, that I am not so well satisfied with the notion wont to be taken for granted, not only by the vulgar, but by philosophers, of the natural state of bodies; as if it were undeniable, that every natural body (for as to some I shall not now question it) has a certain state, wherein nature endeavours to preserve it, and out of which it cannot be put, but by being put into a preternatural state. For the world being once constituted by the great author of things as it now is, I look upon the phenomena of nature to be caused by the local motion of one part of matter hitting against another, and am not so fully convinced, that there is such a thing as nature's designing to keep such a parcel of matter in such a state, that is clothed with just such accidents, rather than with any other. But I look upon many bodies, especially fluid ones, as frequently changing their state, according as they happen to be more or less agitated, or otherwise wrought upon by the sun, and other considerable agents in nature. As the air, water,
and

and other fluids, if the temperature, as to cold, or heat and rarefaction or condensation, which they are in at the beginning of the spring here at *London*, be pitched upon as their natural state; then not only in the torrid and frozen zones they must have other and very differing natural states, but here it self they will almost all the summer and all the winter (as our weather-glasses inform us) be in a varying preternatural state, because they will be in those seasons either more hot and rarified, or more cold and condensed, than in the beginning of the spring. And in more stable and constant bodies, I take in many cases the natural state to be but either the most usual state, or that, wherein that, which produces a notable change in them, finds them. As when a slender piece of silver, that is most commonly flexible, and will stand bent every way, comes to be well hammered, I count that flexibility to be the natural state of that metal, because most commonly silver is found to be flexible, and because it was so before it was hammered; but the springiness it acquires by hammering is a state, which is properly no more unnatural to the silver than the other, and would continue with the metal as long as it, if both pieces of silver, the one flexible, the other springy, were let alone and kept from outward violence. And as the silver, to be deprived of its flexibleness, needed the violent motion of the hammer, so to deprive it of its spring it needs the violent agitation of a nealing fire. These things and much more I might here represent; but to come close to the objection, I answer, that the accidents spoken of are introduced into the matter by the agents or efficient causes, whatever they be, that produce in it what (in the sense formerly explained) we call an essential (though not a substantial) form. And these accidents being once thus introduced into the matter, we need not seek for a new substantial principle to preserve them there, since by the general law or common course of nature the matter qualified by them must continue in the state such accidents have put it into, till by some agent or other it be forcibly put out of it, and so divested of those accidents: as in the formerly mentioned example, borrowed from *Aristotle*, of a brazen sphere, when once the motion of tools, impelled and guided by the artificer, have turned a piece of brass into a sphere, there needs no new substance to preserve that round figure, since the brass must retain it, till it be destroyed by the artificer himself, or some other agent able to overcome the resistance of the matter to be put into another figure. And on this occasion let me confirm this *ad hominem*, by representing, that there is not an inconsiderable party among the Peripateticks themselves, who maintain, that in the elements the first qualities (as they call them) are instead of forms, and that the fire (for instance) hath no other form than heat and dryness, and the water than coldness and moisture. Now if these bodies, that are the vastest and the most important of the sublunary world,

consist but of the universal matter and the few accidents; and if in these there needs no substantial form to keep the qualities of the matter united to it, and conjoined among themselves, and preserve them in that state as long as the law of nature requires; though besides the four qualities, that are called first, the elements have divers others, as gravity and levity, firmness and fluidity, opacousness and transparency, &c. why should the favourers of this opinion deny, that in other bodies besides the elements, qualities may be preserved and kept united to the matter they belong to, without the band or support of a substantial form? And as, when there is no competent destructive cause, the accidents of a body will by the law of nature remain such as they were; so if there be, it cannot with reason be pretended, that the substantial form is able to preserve all those accidents of a body, that are said to flow from it, and to be as it were under its care and tuition. For if, for instance, you expose a sphere or bullet of lead to a strong fire, it will quickly lose (not to mention its figure) both its coldness, its consistence, its malleableness, its colour, (for it will appear of the colour of fire,) its flexibility, and some other qualities; and all this in spite of the imaginary substantial form, which, according to the Peripatetick principles, in this case must still remain in it without being able to help it. And though upon the taking the lead from off the fire, it is wont to be educed to most of its former qualities, (for it will not of it self recover its sphericity,) yet that may well be ascribed partly to its peculiar texture, and partly to the coldness of the ambient air, according to what we lately discoursed touching heated and refrigerated water; which temperature of the air is an extrinsecal thing to the lead, and indeed it is but accidental, that the lead upon refrigeration regains its former qualities: for in case the lead have been exposed long enough to a sufficiently intense fire, it will (as we have purposely tried) be turned into glass, and lose its colour, its opacity, its malleableness, and (former degree of) flexibleness, and acquire a reddishness, a degree of transparency, a brittleness, and some other qualities that it had not before: and let the supposed substantial form do what it can, even when the vessel is removed from the fire, to reduce or restore the body to its natural state and accidents, yet the former qualities will remain lost, as long as these preternatural ones introduced by the fire continue in the matter; and neither the one will be restored, nor the other destroyed, till some sufficiently powerful extrinsecal agent effect the change. And on the other side I consider, that the fruit, when sever'd from the tree it grew on, is confessed to be no longer animated (at least the kernels or seeds excepted) by the vegetative soul or substantial form of the plant; yet in an orange or lemon (for instance) plucked from the tree, we see, that the same colour, the same odour, the same taste, the same figure, the same consistence, and, for aught we know,

the same other qualities, whether sensible or even occult, as are its antidotal and antiscorbatical virtues, that must before be said to have flowed from the soul of the tree, will continue many months, perhaps some years, after the fruit has ceased to have any commerce with the tree, (nay, though the tree, whereon it grew, be perhaps in the mean time hewn down or burnt, and though consequently its vegetative soul or form be destroyed,) as when it grew thereon, and made up one plant with it. And we find, that tamarinds, rhubarb, senna, and many other simples will, for divers years after they have been deprived of their former vegetative soul, retain their purgative and other specific properties.

I FIND it likewise urged, that there can be no reason, why whiteness should be separable from a wall, and not from snow or milk; unless we have recourse to substantial forms. But in case men have agreed to call a thing by such a name, because it has such a particular quality, that differences it from others, we need go no farther to find a reason, why one quality, is essential to one thing, and not to another. As in our former example of a brass sphere, the figure is that, for which we give it that name; and therefore, though you may alter the figure of the matter, yet by that very alteration the body perishes in the capacity of a sphere, whereas its coldness may be exchanged for heat, without the making it the less a sphere, because it is not for any such quality, but for roundness, that a body is said to be a sphere. And so firmness is an inseparable quality of ice, though this or that particular figure be not, because that it is for want of fluidity, that any thing, that was immediately before a liquor, is called ice; and congruously hereunto, though whiteness were inseparable from snow and milk, yet that would not necessarily infer, that there must be a substantial form to make it so: for the firmness of the corpuscles, that compose snow, is as inseparable from it as the whiteness; and yet it is not pretended to be the effect of the substantial form of the water, but of the excess of the coldness of the air, which (to use vulgar, though perhaps unaccurate expressions) puts the water out of its natural state of fluidity, and into a preternatural one of firmness and brittleness. And the reason, why snow seldom loses its whiteness but with its nature, seems to be, that its component particles are so disposed, that the same heat of the ambient air, that is fit to turn it into a transparent body, is also fit to make it a fluid one, which when it is become, we no longer call it snow, but water; so that the water loses its whiteness, though the snow do not. But if there be a cause proper to make a convenient alteration of texture in the snow, without melting or resolving it into water, it may then exchange its whiteness for yellowness, without losing its right to be called snow: as I remember I have read in an eminent writer, that *de facto* in the northern regions towards the pole, those parcels of snow, that have lain very long on the ground, degenerated

in time into a yellowish colour, very differing from that pure whiteness to be observed in the neighbouring snow lately fallen.

BUT there yet remains an argument for substantial forms, which, though (perhaps because physical) wont be overlooked or slightly answered by their opposers, will for the same reason deserve to be taken notice of here; and it is, that there seems to be a necessity of admitting substantial forms in bodies, that from thence we may derive all the various changes, to which they are subject, and the differing effects they produce, the preservation and restitution of the state requisite to each particular body, as also the keeping of its several parts united into one *totum*. To the answering of this argument so many things will be found applicable both in the past and subsequent parts of these notes, that I shall at present but point the chief particulars, on which the solution is grounded.

I CONSIDER then first, that many and great alterations may happen to bodies, which seem manifestly to proceed from their peculiar texture, and the action of outward agents upon them, and of which it cannot be shewn, that they would happen otherwise, though there were no substantial forms *in rerum natura*: as we see, that tallow (for instance) being melted by the fire, loses its coldness, firmness, and its whiteness, and acquires heat, fluidity, and some transparency; all which being suffered to cool, it presently changes for the three first named qualities. And yet divers of these changes are plainly enough the effects partly of the fire, partly of the ambient air, and not of I know not what substantial form: and as it is both evident and remarkable, what great variety of changes in qualities, and productions in new ones, the fire (that is, a body consisting of insensible parts, that are variously and vehemently moved) doth effect by its heat, that is, by a modified local motion; I consider further, that various operations of a body may be derived from the peculiar texture of the whole, and the mechanical affections of the particular corpuscles or other parts, that compose it, as we have often occasion to declare here and there in this treatise; and particularly by an instance, ere long to be further insisted on, namely, that though vitriol made of iron with a corrosive liquor be but a factitious body, made by a convenient apposition of the small parts of the saline menstruum to those of the metal, yet this vitriol will do most, if not all, of the same things, that vitriol made by nature in the bowels of the earth, and digged out thence, will perform: and each of these bodies may be endowed with variety of differing qualities, which I see not, why they must flow in the native vitriol from a substantial form; since in the factitious vitriol the same qualities belong to a form, that does plainly emerge from the coalition of metalline and saline corpuscles, associated together, and disposed of after a certain manner.

AND lastly, as to what is very confidently, as well as plausibly pretended, That a sub-

substantial form is requisite to keep the parts of a body united, without which it would not be one body; I answer, That the contrivance of conveniently figured parts; and in some cases their juxta-position, may, without the assistance of a substantial form, be sufficient for this matter. For not to repeat what I just now mentioned concerning vitriol made by art, whose parts are as well united and kept together, as those of the native vitriol, I observe, that a pear grafted upon a thorn, or a plumb inoculated upon an apricock, will bear good fruit, and grow up with the stock, as though they both made but one tree, and were animated but by the same common form; whereas indeed both the stock, and the inoculated or grafted plant, have each of them its own form, as may appear by the differing leaves and fruits, and seeds they bear. And that, which makes to our present purpose, is, that even vegetation and the distribution of aliments are in such cases well made, though the nourished parts of the total plant, if I may so call it, have not one common soul or form; which is yet more remarkable in the mistletoes, that I have seen growing upon old hazle-trees, crab-trees, apple-trees, and other plants, in which the mistletoe often differs very widely from that kind of plant, on which it grows and prospers. And for the durableness of the union betwixt bodies, that a substantial form is not requisite to procure it, I have been induced to think, by considering, that silver and gold, being barely mingled by infusion, will have their minute parts more closely united, than those of any plant or animal, that we know of. And there is scarce any natural body, wherein the form makes so strict, durable, and indissoluble an union of the parts it consists of, as that, which in that factitious concrete we call glass, arises from the bare commision of the corpuscles of sand with those saline ones, wherewith they are colligated by the violence of the fire: and the like may be said of the union of the proper accidents of glass with the matter of it, and betwixt one another.

To draw towards a conclusion, I know it is alleged as a main consideration on the behalf of substantial forms, that these being in natural bodies the true principles of their properties, and consequently of their operations, their natural philosophy must needs be very imperfect and defective, who will not take in such forms: but for my part I confess, that this very consideration does rather indispose than incline me to admit them. For if indeed there were in every natural body such a thing as a substantial form, from which all its properties and qualities immediately flow, since we see, that the actions of bodies upon one another are for the most part (if not all) immediately performed by their qualities or accidents, it would scarce be possible to explicate very many of the explicable phenomena of nature, without having recourse to them; and it would be strange, if many of

the abstruser phenomena were not explicable by them only. Whereas indeed almost all the rational accounts to be met with of difficult phenomena, are given by such as either do not acknowledge, or at least do not take notice of substantial forms. And it is evident by the clear solutions (untouched by many vulgar philosophers,) we meet with of many phenomena in the Staticks, and other parts of the Mechanicks, and especially in the Hydrostaticks, and Pneumaticks, how clearly many phenomena may be solved, without imploying a substantial form. And on the other side, I do not remember, that either Aristotle himself (who perhaps scarce ever attempted it,) or any of his followers, has given a solid and intelligible solution of any one phenomenon of nature by the help of substantial forms; which you need not think it strange I should say, since the greatest patrons of forms acknowledging their nature to be * unknown to us, to explain any effect by a substantial form, must be to declare (as they speak) *ignotum per ignotius*, or at least *per æquè ignotum*. And indeed to explicate a phenomenon being to deduce it from something else in nature, more known to us than the thing to be explained by it, how can the imploying of incomprehensible (or at least uncomprehended) substantial forms, help us to explain intelligibly this or that particular phenomenon? For to say, that such an effect proceeds not from this or that quality of the agent, but from its substantial form, is to take an easy way to resolve all difficulties in general, without rightly resolving any one in particular; and would make a rare philosophy, if it were not far more easy than satisfactory: for if it be demanded, why jet attracts straws, rhubarb purges choler, snow dazzles the eyes rather than grass, &c. to say, that these and the like effects are performed by the substantial forms of the respective bodies, is at best but to tell me, what is the agent, not how the effect is wrought; and seems to be but such a kind of general way of answering, as leaves the curious inquirer as much to seek for the causes and manner of particular things, as men commonly are for the particular causes of the several strange things performed by witchcraft, though they be told, that it is some devil, that does them all. Wherefore I do not think, but that natural philosophy, without being for that the more defective, may well enough spare the doctrine of substantial forms as an useless theory; not that men are arrived to be able to explicate all the phenomena of nature without them, but because whatever we cannot explicate without them, we cannot neither intelligibly explicate by them.

AND thus, *Pyrophilus*, I have offered you some of those many things, that indisposed me to acquiesce in the received doctrine of substantial forms; but in case any more piercing inquirer shall persuade himself, that he understands it thoroughly, and can explicate it clearly, I shall congratulate him for such happy

* *Nomina tu lapidis, qui quotidie tuis oculis observatur, formam, & Phyllida solus habeto.* Scal. contra Card.

py intellectuals, and be very ready to be informed by him. But since what the schools are wont to teach of the origin and attributes of substantial forms, is that, which, I confess, I cannot yet comprehend; and since I have some of the eminentest persons among the modern philosophers to join with me, though perhaps not for the same considerations, in the like confession, that it is not necessary the reason of my not finding this doctrine conceivable must be rather a defectiveness in my understanding, than the unconceivable nature of the thing itself; I, who love not (in matters purely philosophical) to acquiesce in what I do not understand, nor to go about to explicate things to others by what appears to me itself unexplicable, shall, I hope, be excused, if, leaving those, that contend for them, the liberty of making what use they can of substantial forms, I do, till I be better satisfied, decline employing them myself, and endeavour to solve those phenomena, I attempt to give an account of, without them; as not scrupling to confess, that those, that I cannot explicate, at least in a general way, by intelligible principles, I am not yet arrived to the distinct and particular knowledge of.

Now for our doctrine touching the origin of forms, it will not be difficult to collect it from what we formerly discoursed about qualities and forms together: for the form of a natural body being, according to us, but an essential modification, and as it were the stamp of its matter; or such a convention of the bigness, shape, motion, (or rest,) situation and contexture, (together with the thence resulting qualities) of the small parts, that compose the body, as is necessary to constitute and denominate such a particular body; and all these actions being producible in matter by local motion, it is agreeable to our hypothesis to say, that the first and universal, though not immediate cause of forms is none other but God, who put matter into motion, (which belongs not to its essence,) and established the laws of motion amongst bodies, and also, according to my opinion, guided it in divers cases at the beginning of things; and that, among second causes, the grand efficient of forms in local motion, which, by variously dividing, sequestering, transposing, and so connecting the parts of matter, produces in them those accidents and qualities, upon whose account the portion of matter they diversify, comes to belong to this or that determinate species of natural bodies, which yet is not so to be understood, as if motion were only an efficient cause in the generation of bodies, but very often (as in water, fire, &c.) it is also one of the chief accidents, that concur to make up the form.

But in this last summary account of the origin of forms, I think myself obliged to declare to you a little more distinctly what I just now intimated to be my own opinion. And this I shall do by advertising you, that though

I agree with our Epicureans, in thinking it probable, that the world is made up of an innumerable multitude of singly insensible corpuscles, endowed with their own sizes, shapes, and motions; and though I agree with the Cartesians, in believing (as I find that * *Anaxagoras* did of old) that matter hath not its motion from it self, but originally from God; yet in this I differ both from *Epicurus* and *Des Cartes*, that whereas the former of them plainly denies, that the world was made by any deity (for deities he owned,) and the latter of them, for aught I can find in his writings, or those of some of his eminentest disciples, thought, that God having once put matter into motion, and established the laws of that motion, needed not more particularly interpose for the production of things corporeal, nor even of plants or animals, which, according to him, are but engines: I do not at all believe, that either these Cartesian laws of motion, or the Epicurean casual concurrence of atoms, could bring mere matter into so orderly and well-contrived a fabrick as this world. And therefore I think, that the wise author of nature did not only put matter into motion, but, when he resolved to make the world, did so regulate and guide the motions of the small parts of the universal matter, as to reduce the greater systems of them into the order they were to continue in; and did more particularly contrive some portions of that matter into seminal rudiments or principles, lodged in convenient receptacles, (and, as it were, wombs,) and others into the bodies of plants and animals: one main part of whose contrivance did, as I apprehend, consist in this, that some of their organs were so framed, that supposing the fabrick of the greater bodies of the universe, and the laws he had established in nature, some juicy and spirituous parts of these living creatures must be fit to be turned into prolifick seeds, whereby they may have a power, by generating their like, to propagate their species. So that, according to my apprehension, it was at the beginning necessary, that an intelligent and wise agent should contrive the universal matter into the world, (and especially some portions of it into seminal organs and principles,) and settle the laws, according to which the motions and actions of its parts upon one another should be regulated: without which interposition of the world's architect, however moving matter may, with some probability (for I see not in the notion any certainty) be conceived to be able, after numberless occurrsions of its insensible parts, to cast it self into such grand conventions and convolutions as the Cartesians call *vortices*, and (as I remember) † *Epicurus* speaks of under the name of *ἠεροειδέεις, ἢ δινοίας*; yet I think it utterly improbable, that brute and unguided, though moving, matter should ever convene into such admirable structures, as the bodies of perfect animals. But the world being once framed, and the course of nature established, the naturalist

* *Aristotle* speaking of *Anaxagoras*, in the first chapter of the last book of his *Physicks*, hath this passage: *Dicit (Anaxagoras) cum omnia simul essent, atque quiescerent tempore infinito, mentem movisse ac segregasse.*

† *Epicurus* in his epistle to *Pythocles*.

turalist (except in some few cases, where God or incorporeal agents interpose,) has recourse to the first cause but for its general and ordinary support and influence, whereby it preserves matter and motion from annihilation or defition; and in explicating particular phænomena considers only the size, shape, motion, (or want of it,) texture, and the resulting qualities and attributes of the small particles of matter. And thus in this great automaton, the world, (as in a watch or clock,) the materials it consists of being left to themselves, could never at the first convene into so curious an engine: and yet when the skilful artist has once made and set it a going, the phænomena it exhibits are to be accounted for by the number, bigness, proportion, shape, motion (or endeavour,) rest, coaptation, and other mechanical affections of the spring, wheels, pillars, and other parts it is made up of: and those effects of such a watch, that cannot this way be explicated, must, for aught I know, be confessed not to be sufficiently understood.

BUT to return thither, whence my duty to the author of nature obliged me to make this short digression:

THE hitherto proposed hypothesis, touching the origination of forms, hath, I hope, been rendered probable by divers particulars in the past discourses, and will be both exemplified and confirmed by some of the experiments, that make the latter part of this present treatise, (especially the fifth and seventh of them,) which, containing experiments of the changing the form of a salt and a metal, do chiefly belong to the historical or experimental part of what we deliver touching the origin of forms. And indeed, besides the two kinds of experiments presently to be mentioned, we might here present you a third sort, consisting partly of divers relations of metalline transmutations, delivered upon their

own credit by credible men, that are not alchymists; and partly of some experiments (some made, some directed by us) of changing both bodies totally inflammable almost totally into water; and a good part even of distilled rain water without additament into earth; and distilled liquors, readily and totally mingleable with water, *pro parte* into a true oil, that will not mix with it. This sort of experiments, I say, I might here annex, if I thought fit, in this place, either to lay any stress upon those, that I cannot myself make out, or to transfer hither those experiments of changes amongst bodies not metalline, that belong to another * treatise. But over and above what the past notes and the experiments, that are to follow them, contain towards the making of what we teach concerning forms, we will here for further confirmation proceed to add two sorts of experiments, (besides the third already mentioned.) The one, wherein it appears, that bodies of very differing natures, being put together, like the wheels and other pieces of a watch, and by their connexion acquiring a new texture, and so new qualities, may, without having recourse to a substantial form, compose such a new concrete, as may as well deserve to have a substantial form attributed to it, by virtue of that new disposition of its parts, as other bodies, that are said to be endowed therewith: and the other, that a natural body being dissipated, and as it were taken in pieces like a watch, may have its parts so associated, as to constitute new bodies of natures very differing from its own, and from each other; and yet these dissipated and scattered parts, by being recollected and put together again like the pieces of a watch, in the like order as before, may recompose (almost, if not more than almost) such another body, as that they made up before they were taken asunder.

I. EXPERIMENTS *and* THOUGHTS *about the Production and Reproduction of FORMS.*

IT was not at random, that I spoke, when, in the foregoing notes about the origin of qualities, I intimated, that it was very much by a kind of tacit agreement, that men had distinguished the species of bodies, and that those distinctions were more arbitrary, than we are wont to be aware of. For I confess, that I have not yet, either in *Aristotle* or any other writer, met with any genuine and sufficient diagnostic and boundary for the discriminating and limiting the species of things; or, to speak more plainly, I have not found, that any naturalist has laid down a determinate number and sort of qualities or other attributes, which is sufficient and necessary to constitute all portions of matter, endowed with them, distinct

kinds of natural bodies. And therefore I observe, that most commonly men look upon these as distinct species of bodies, that have had the luck to have distinct names found out for them; though perhaps divers of them differ much less from one another than other bodies, which (because they have been huddled up under one name,) have been looked upon as but one sort of bodies. But not to lay any weight on this intimation about names, I found, that for want of a true characteristick or discriminating note, it hath been and is still both very uncertain as to divers bodies, whether they are of different species or of the same, and very difficult to give a sufficient reason, why divers bodies, wherein nature is assisted

* The Sceptical Chymist.

assisted by art, should not as well pass for distinct kinds of bodies, as others, that are generally reckoned to be so.

WHETHER (for instance) water and ice be not to be esteemed distinct kinds of bodies, is so little evident, that some, that pretend to be very well versed in *Aristotle's* writings and opinions, affirm him to teach, that water loses not its own nature by being turned into ice; and indeed I remember I have read a * text of his, that seems express enough to this purpose, and the thing it self is made plausible by the reducibleness of ice back again into water. And yet I remember, *Galen* is affirmed to make these two distinct species of bodies; which doctrine is favoured by the differing qualities of ice and water: for not only the one is fluid, and the other solid, and even brittle, but ice is also commonly more or less opacous in comparison of water, being also lighter than it in specie, since it swims upon it. To which may be added, that ice beaten with common salt will freeze other bodies, when water mingled with salt will not. And on this occasion I would propose to be resolved, whether must, wine, spirit of wine, vinegar, tartar, and vappa, be specifically distinct bodies? and the like questions I would ask concerning a hen's egg, and the chick, that is afterwards hatched out of it; as also concerning wood, ashes, soot, and likewise the eggs of silkworms, which are first small caterpillars, or (as some think them) but worms, when they are newly hatched, and then aurelia's, (or husked maggots,) and then butterflies; which I have observed with pleasure to be the successive production of the prolifick seed of silk-worms. And whether the answer to these queries be affirmative or negative, I doubt the reason, that will be given for either of the two, will not hold in divers cases, whereto I might apply it. And a more puzzling question it may be to some, whether a charcoal, being thoroughly kindled, do specifically differ from another charcoal? For, according to those I argue with, the fire has penetrated it quite through; and therefore some of the recent Aristotelians are so convinced of its being transmuted, that all the satisfaction I could find from a very subtle modern schoolman to the objection, that if the glowing coal were plunged into water, it would be a black coal again, was, that, notwithstanding that reduction, the form of a charcoal had been once abolished by the fire, and was reproduced by God, upon the regained disposition of the matter to receive it.

NOR is it very easy to determine, whether clouds, and rain, and hail, and snow, be bodies specifically distinct from water and from each other, and the writers of meteors are wont to handle them as distinct. And if such slight differences as those, that discriminate these bodies, or that, which distinguishes wind from exhalations, whose course makes it be sufficient to constitute differing kinds of bodies,

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it will be hard to give a satisfactory reason, why other bodies, that differ in more or more considerable particulars, should not enjoy the same privilege. And I presume, that snow differs less from rain, than paper doth from rags, or glass made of wood-ashes does from wood. And indeed men having by tacit consent agreed to look upon paper, and glass, and soap, and sugar, and brass, and ink, and pewter, and gunpowder, and I know not how many others, to be distinct sorts of bodies, I see not, why they may not be thought to have done it on as good grounds, as those, upon which divers other differing species of bodies have been constituted. Nor will it suffice to object, that these bodies are factitious; for it is the present nature of bodies, that ought to be considered in referring them to species, which way soever they came by that nature: for salt, that is in many countries made by boiling sea-water in cauldrons and other vessels, is as well true sea-salt, as that, which is made in the *Ile of Man*, (as navigators call it,) without any co-operation of man, by the bare action of the sun upon those parts of the sea-water, which chance to be left behind in hollow places, after a high spring-tide. And silk-worms, which will hatch by the heat of human bodies, and chickens, that are hatched in *Egypt* by the heat of ovens or dunghils, are no less true silkworms or chickens, than those, that are hatched by the sun or by hens.

As for what may be objected, that we must distinguish betwixt factitious bodies and natural, I will not now stay to examine, how far that distinction may be allowed: for it may suffice for our present purpose to represent, that whatever may be said of factitious bodies, where man does, by instruments of his own providing, only give figure, or also contexture to the sensible (not insensible) parts of the matter he works upon; as when a joiner makes a stool, or a statuary makes an image, or a turner a bowl: yet the case may be very differing in those other factitious productions, wherein the insensible parts of matter are altered by natural agents, who perform the greatest part of the work among themselves, though the artificer be an assistant, by putting them together after a due manner. And therefore I know not, why all the productions of the fire made by chymists should be looked upon, as not natural, but artificial bodies; since the fire, which is the grand agent in these changes, doth not, by being employed by the chymist, cease to be and to work as a natural agent. And since nature her self doth, by the help of the fire, sometimes afford us the like productions, that the alchymist's art presents us: as in *Aina*, *Vesuvius*, and other burning mountains, (some of whose productions I can shew you,) stones are sometimes turned into lime, (and so an alkalizate salt is produced,) and sometimes, if they be more disposed to be fluxed than cal-

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cined,

* See *Lib. 1. de Gen. & Corr. t. 80. Idem corpus* (says he there) *quoniam continuum, aliàs liquidum, aliàs concretum videmus, non divisione aut compositione hoc passum, aut conversione, aut altatione, sicuti Democritus asserit: nam neque transpositione, neque Naturæ demutatione (ὡς τὸ μεταβάλλον τὴν φύσιν) ἐκ liquido concretum evadere solet.*

cined, brought to vitrification ; metalline and mineral bodies are by the violence of the fire colligated into masses of very strange and compounded natures. Ashes and metalline flowers of divers kinds are scattered about the neighbouring places, and copious flowers of sulphur, sublimed by the internal fire, have been several times found about the vents, at which the fumes are discharged into the air : (as I have been assured by ingenious visitors of such places, whom I purposely inquired of, touching these *flores* ; for of these travellers more than one answered me, they had themselves gathered, and had brought some very good.) Not to add, that I have sometimes suspected, upon no absurd grounds, that divers of the minerals and other bodies, we meet with in the lower parts of the earth, and think to have been formed and lodged there ever since the beginning of things, have been since produced there by the help of subterranean fires or other heats, which may either by their immediate action, and exceedingly long application, very much alter some bodies by changing their texture ; as when lead is turned into minium, and tin into putty, by the operation of the fire in a few hours, or by elevating, in the form of exhalations or vapours, divers saline and sulphureous corpuscles or particles of unripe, or (to use a chymical term of art) embryonated minerals, and perhaps metals, which may very much alter the nature, and thereby vary the kind of other subterranean bodies, which they pervade, and in which they often come to be incorporated ; or else may, by convening among themselves, constitute particular concretions, as we see, that the fumes of sulphur and those of mercury unite into that lovely red mass, which in the shops they call vermilion, and which is so like to the mineral, whence we usually obtain mercury, that the Latins give them both the same name *Cinnabaris*, and in that are imitated by the French and Italians ; in whose favour I shall add, that if we suppose this mineral to consist of a stony concretion, penetrated by such mineral fumes, as I have been speaking of, the appellation may be better excused than perhaps you imagine ; since from *Cinnabaris nativa* not only I obtained a considerable quantity of good running mercury, (which is that, men are wont to seek for from it,) but to gratify my curiosity somewhat further, I tried an easy way, that came into my mind, whereby the *caput mortuum* afforded me no despicable quantity of good combustible sulphur. But this upon the by, being not obliged to set down here the grounds of my paradoxical conjecture about the effects of subterranean fires and heats, since I here lay no stress upon it, but return to what I was saying about *Ætna*, and other Volcanos. Since then these productions of the fire, being of nature's own making, cannot be denied to be natural bodies, I see not, why the like productions of the fire should be thought unworthy that name, only because the fire, that made the former, was kindled by chance in a hill, and that, which produced the latter, was kindled

by a man in a furnace. And if flower of sulphur, lime, glass, and colligated mixtures of metals and minerals are to be reckoned among natural bodies, it seems to be but reasonable, that, upon the same grounds, we should admit flower of antimony, lime, and glass, and pewter, and brass, and many other chymical concretes, (if I may so call them) to be taken into the same number ; and then it will be evident, that to distinguish the species of natural bodies, a concurrence of accidents will, without considering any substantial form, be sufficient.

BUT because I need not, on this occasion, have recourse to instances of a disputable nature, I will pitch, for the illustration of the mechanical production of forms, upon vitriol. For since nature herself, without the help of art, does oftentimes produce that concrete, (as I have elsewhere shewn by experience,) there is no reason, why vitriol, produced by easy chymical operations, should not be looked upon as a body of the same nature and kind. And in factitious vitriol, our knowing what ingredients we make use of, and how we put them together, enables us to judge very well how vitriol is produced. But because it is wont to be reckoned with salt-petre, sea-salt, and sal-gem, among true salts, I think it requisite to take notice, in the first place, that vitriol is not a mere salt, but that, which *Paracelsus* somewhere, and after him divers other Spagyristes call a *magistery*, which in their sense (for there are, that use it in another,) commonly signifies a preparation, wherein the body to be prepared has not its principles separated ; as in distillation, incineration, &c. but wherein the whole body is brought into another form, by the addition of some salt or menstruum, that is united *per minima* with it. And agreeably to this notion we find, that from common vitriol, whether native or factitious, may be obtained (by distillation and reduction) an acid saline spirit, and a metalline substance, as I elsewhere mention, that from blue vitriol copper may be (by more than one way) separated. And I the rather give this advertisement, because that as there is a vitriol of iron, which is usually green, and another of copper, which is wont to be blue, and also a white vitriol, about which it is disputed what it holds, (though that it holds some copper, I have found ;) and yet of all these are without scruple reputed true vitriols, notwithstanding that they differ so much in colour, and (as I have discovered) in several other qualities ; so I see no reason, why the other minerals, being reduced by their proper menstrua into salt like magisteries, may not pass for the vitriols of those metals, and consequently for natural bodies : which, if granted, will add some confirmation to our doctrine, though its being granted is not necessary to make it out. For to confine ourselves to vitriol, it is known among chymists, that if upon the filings of *Mars* one put a convenient quantity of that acid distilled liquor, which is (abusively) wont to be called oil of vitriol, diluting the mixture with rain or with common water, it

is easy by filtrating the solution, by evaporating the aqueous superfluity of it, and by leaving the rest for a competent while in a cellar, (or other cold place) to crystallize; it is easy, I say, by this means to obtain a vitriol of iron; which agrees with the other vitriol of vitriol-stones or marchasites, presented us by nature, without the help of any other menstruum, than the rain, that falls upon them from the clouds, in I know not how many qualities, part obvious, and part of them occult: as, (of the first sort) in colour, transparency, brittleness, easiness of fusion, styptical taste, reducibleness to a red powder by calcination, and other qualities more obvious to be taken notice of; to which may be annexed divers qualities of the second sort, (I mean the more abstruse ones,) as the power to turn in a trice an infusion of galls, made in ordinary water, (as also to turn a certain clear mineral solution, elsewhere mentioned,) into an inky colour; to which, in all probability, we may add a faculty of causing vomits even in a small dose, when taken into the stomach of a man, and that remarkable property of being endowed with as exact and curious a shape or figure, as those, for which salts have been, by modern philosophers especially, so much admired. But, that no scruple might arise from hence, that in the *vitriolum martis* wont to be made by chymists, the menstruum, that is employed, is the oil of common vitriol, which may be suspected to have retained the nature of the concrete whence it proceeded; and so this factitious vitriol may not be barely a new production, but partly a recorporification, as they speak, of the vitriolate corpuscles contained in the menstruum: to prevent this scruple, I say, (which yet perhaps would not much trouble a considering chymist) I thought fit to employ a quite other menstruum, that would not be suspected to have any thing of vitriol in it. And though aqua fortis and spirit of nitre, however they corrode *Mars*, are unfit for such a work; yet having pitched upon spirit of salt instead of oil of vitriol, and proceeding the same way, that has been already set down, it answered our expectation, and afforded us a good green vitriol. Nor will the great disposition I have observed in this our vitriol to resolve, by the moisture of the air, into a liquor, make it essentially differing from other vitriols, since it has been observed, and particularly by *Guntberus Belichius* more than once, that even the common vitriol he used in *Germany*, will also, though not so easily as other salts, run (as the chymists phrase it) *per deliquium*. And to make the experiment more compleat, though we did not find either oil of vitriol, or spirit of salt, good menstrua to make a blue venereal vitriol out of copper, (however filed or thinly laminated,) and though upon more trials than one, it appeared, that aqua fortis and spirit of nitre, which we thought fit to substitute to the above mentioned liquors, did indeed make a solution of copper, but so unctuous a one, that it was very hard to bring any part of it to dryness, without

spoiling the colour and shape of the desired body: yet repeating the experiment with care and watchfulness, we, this way, obtained one of the loveliest vitriols, that hath perhaps been seen, and of which you yourself may be the judge by a parcel of it I keep by me for a rarity.

To apply now these experiments, especially that, wherein spirit of salt is employed, to the purpose, for which I have mentioned them, let us briefly consider these two things; the one, that our factitious vitriol is a body, that, as well as the natural, is endowed with many qualities, (manifest and occult,) not only such as are common to it with other salts, as transparency, brittleness, solubleness in water, &c. but such as are properties peculiar to it, as greenness, easiness of fusion, stypticity of taste, a peculiar shape, a power to strike a black with infusion of galls, an emetick faculty, &c.

THE other thing we are to consider is, that though these qualities are in common vitriol believed to flow from the substantial form of the concrete; and may as justly as the qualities, whether manifest or occult, of other inanimate bodies, be employed as arguments to evince such a form: yet in our vitriol, made with spirit of salt, the same qualities and properties were produced by the associating and juxtaposition of the two ingredients, of which the vitriol was compounded; the mystery being no more but this, that the steel being dissolved in the spirit, the saline particles of the former, and the metalline ones of the latter having each their determinate shapes, did, by their association, compose divers corpuscles of a mixed or compounded nature, from the convention of many whereof there resulted a new body of such a texture, as qualified it to affect our sensories, and work upon other bodies, after such a manner as common vitriol is wont to do. And indeed in our case, not only it cannot be made appear, that there is any substantial form generated anew, but that there is not so much as an exquisite mixture, according to the common notion the schools have of such a mixture. For both the ingredients retain their nature, (though perhaps somewhat altered,) so that there is, as we were saying, but a juxtaposition of the metalline and saline corpuscles; only they are associated so, as by the manner of their coalition to acquire that new texture, which denominates the magistery they compose, vitriol. For it is evident, that the saline ingredient may either totally, or for much the greatest part be separated by distillation, the metalline remaining behind. Nay, some of the qualities we have been ascribing to our vitriol, do so much depend upon texture, that the very beams of the sun (converged) will, as I have purposely tried, very easily alter its colour, as well as spoil its transparency, turning it at first from green to white; and, if they be concentrated by a good burning-glass, making it change that livery for a deep red.

DOUBTS and EXPERIMENTS touching the curious Figures of SALTS.

AND here let me take notice, that though the exact and curious figures, in which vitriol and other salts are wont to shoot, be made arguments of the presence, and great instances of the plastick skill of substantial forms and seminal powers; yet, I confess, I am not so fully satisfied in this matter, as even the modern philosophers appear to be. It is not, that I deny, that *Plato's* excellent saying, *γεωμετρει ὁ θεός*, may be applied to these exquisite productions of nature. For though God has thought fit to make things corporeal after a much more facile and intelligible way, than by the intervention of substantial forms; and though the plastick power of seeds, which in plants and animals I willingly admit, seem not in our case to be needful; yet is the divine architect's geometry (if I may so call it) nevertheless to be acknowledged and admired. For having been pleased to make the primary and insensible corpuscles of salts and metals of such determinate, curious, and exact shapes, that as they happen to be associated together, they should naturally produce concretions; which, though differing in figure, according to the respective natures of their ingredients, and the various manners of their convening, should yet be all of them very curious, and seem elaborate in their kinds. How little I think is fit to be allowed, that the bodies of animals, which consist of so many curiously framed and wonderfully adapted organical parts, (and whose structure is a thousand times more artificial than that of salts and stones, and other minerals,) can be reasonably supposed to have been produced by chance, or without the guidance of an intelligent author of things, I have elsewhere largely declared. But I confess I look upon these figures we admire in salts, and in some kinds of stones, (which I have not been incurious to collect,) as textures so simple and slight, in comparison of the bodies of animals, and oftentimes in comparison of some one organical part, that I think it cannot be in the least inferred, that because such slight figurations need not be ascribed to the plastick power of seeds, it is not necessary, that the stupendous and incomparably more elaborate fabrick and structure of animals themselves should be so. And this premised, I shall add, that I have been inclined to the conjecture about the shapes of salts, that I lately proposed by these considerations.

FIRST, That by a bare association of metalline and saline corpuscles, a concrete, as finely figured as other vitriols, may be produced, as we have lately seen.

SECONDLY, Because that the figures of these salts are not constantly in all respects the same, but may in divers manners be somewhat varied, as they happen to be made to shoot more hastily or more leisurely, and

as they shoot in scander or fuller proportion of liquor. This may be easily observed by any, that will but with a little attention consider the difference, that may be found in vitriolate crystals or grains, when quantities of them were taken out of the great coolers, as they call them, wherein that salt, at the works where it is boiled, is wont to be set to shoot. And accordingly where the experienced mineralist *Agricola* describes the several ways of making vitriol in great quantities, he does not only more than once call the great grains or crystals, into which it coagulates, cubes; but speaking of the manner of their concretion about the cords or ropes, that are wont (in *Germany*) to be hanged from certain cross-bars into the vitriolate water or solution for the vitriol to fasten it self to, he compares the concretions indifferently to cubes or clusters of grapes: *Ex his* (says he, speaking of the cross-bars) *pendent restes lapillis extentæ, ad quos humor spissus adhaerescens densatur in translucentes atramenti sutorii vel cubos, vel acinos, qui uvæ speciem gerunt* *. I remember also, that having many years since a suspicion, that the reason, why alkalies, such as salt of tartar and pot-ashes, are wont to be obtained in the form of white powders or calces, might be the way, wherein the water or the lixiviums, that contain them, is wont to be drawn off; I fancied, that by leaving the saline corpuscles a competent quantity of water to swim in, and allowing them leisure for such a multitude of occurrences, as might suffice to make them hit upon more congruous coalitions than is usual, I might obtain crystals of them, as well as of other salts: conjecturing this, I say, I caused some well purified alkalies dissolved in clear water to be slowly evaporated, till the top was covered with a thin ice-like crust; then taking care not to break that, lest they should (as in the ordinary way, where the water is all forced off,) want a sufficient stock of liquor, I kept them in a very gentle heat for a good while; and then breaking the above mentioned ice-like cake, I had, as I wished, divers figured lumps of crystalline salt shot in the water, and transparent almost like white sugar-candy.

I LIKEWISE remember, that having on several occasions distilled a certain quantity of oil of vitriol with a strong solution of sea-salt, till the remaining matter was left dry, that saline residue being dissolved in fair water, filtered, and gently evaporated, would shoot into crystals, sometimes of one figure, sometimes of another, according as the quantity or strength of the oil of vitriol and other substances determined. And yet these crystals, though sometimes they would shoot into prism-like figures, as roched petre; and sometimes into shapes more like to allom or vitriol; nay, though oftentimes the same

* *Georg. Agricola de re metall. lib. 12. p. 462.*

caput mortuum dissolved would in the same glass shoot into crystals, whereof some would be of one shape, some of another; yet would these differing grains or crystals appear for the most part more exquisitely figured, than oftentimes vitriol does. From spirit of urine and spirit of nitre, when I have suffered them to remain long together before coagulation, and freed the mixture from the superfluous moisture very slowly, I have sometimes obtained fine long crystals (some of which I can shew you) so shaped, that most beholders would take them for crystals of salt-petre. And I have likewise tried, that whereas silver is wont to shoot into plates exceeding thin, almost like those of *Moscovia* glass, when I have dissolved a pretty quantity of it in aqua fortis or spirit of nitre, and suffered it to shoot very leisurely, I have obtained lunar crystals, (several of which I have yet by me,) whose figure, though so pretty as to have given some wonder even to an excellent geometrician, is differing enough from that of the thin plates formerly mentioned; each crystal being composed of many small and finely shaped solids, that stick so congruously to one another, as to have one surface, that appeared plain enough, common to them all.

THIRDLY, That insensible corpuscles of different, but all of them exquisite shapes, and endowed with plain, as well as smooth sides, will constitute bodies variously, but all very finely figured; I have made use of several ways to manifest. And first, though harts-horn, blood, and urine, being resolved, and (as the chymists speak) analyzed by distillation, may well be supposed to have their substantial forms (if they had any) destroyed by the action of the fire; yet in regard the saline particles they contain, are endowed with such figures as we have been speaking of, when in the liquor, that abounds with either of these volatile salts, the dissolved particles do leisurely shoot into crystals, I have divers times observed in these many masses, (some bigger and some less,) whose surfaces had plains, some of figures, as to sense, exactly geometrical, and others very curious and pleasant. And of these finely shaped crystals of various sizes, I have pretty store by me. And because, (as it may be probably gathered from the event) the saline corpuscles of stillatitious acid liquors, and those of many of the bodies they are fitted to dissolve, have such kind of figures as we have been speaking of, when the solutions of these bodies, upon the recess of the superfluous moisture, shoot into crystals; these, though they will some times be differing enough, according to the particular natures of the dissolved bodies, and the menstruum, yet either the crystals themselves, or their surfaces, or both, will oftentimes have fine and exquisite figures; as I have tried by a menstruum, wherewith I was able to dissolve some gems, as also with a solution of coral made with spirit of verdigrease, to omit other examples. And for the same reason,

when I tried, whether the particles of silver, dissolved in aqua fortis, would not, without coagulating with the salts, convene, upon the account of their own shapes, into little concretions of smooth and flat surfaces, I found, that having (to afford the metalline corpuscles scope to move in) diluted one part of the solution with a great many parts of distilled rain-water, (for common water will often-times make such solutions become white or turbid,) a plate of copper being suspended in the liquor, and suffered to lie quiet there a while, (for it need not be long) there would settle all about it swarms of little metalline and undiaphanous bodies, shining in the water like the scales of small fishes, but formed into little plates extremely thin, with surfaces not only flat, but exceeding glossy: and among those, divers of the larger were prettily figured at the edges. And as for gold, its corpuscles are sufficiently disposed to convene with those of fit or congruous salts into concretions of determinate shapes, as I have found in the crystals I obtained from gold dissolved in aqua regis, and after having been suffered to lose its superfluous moisture, kept in a cold place; and not only so, but also when, by a more powerful menstruum, I had subdivided the body of gold into such minute particles, that they were sublimable, (for that I can assure you is possible;) these volatile particles of gold, with the salts, wherewith they were elevated, afforded me (sometimes) store of crystals, which, though not all of them near of the same bigness, resembled one another in their shape, which was regular enough, and a very pretty one. But of this more elsewhere.

§ I REMEMBER I have also long since taken pleasure to dissolve two or more of those saline bodies, whose shapes we know already, in fair water, that by a very gentle evaporation I might obtain concretions whose shapes should be, though curious, yet differing from the figure of either of the ingredients. But we must not expect, that in all cases the salts dissolved together should be totally compounded: for oftentimes they are of such different natures, that one will shoot much sooner than another, and then it frequently happens, that a good proportion of that will be first crystallized in its own shape; as is conspicuously to be observed in the refining of that impure petre, (which from the country, that affords it, the purifiers call *Barbary* nitre,) from the common salt it abounds with: and (also) as *Agricola* observes*, that in some cases, where a vitriolate matter is mingled with that, which yields allom, those two kinds of salts will shoot separately in the same large vessel; (which the trials I have made with the compounded solutions of those two salts do not discountenance.) Now in such cases all, that can be expected, or needs be desired, is, that the remaining part of the mixture, or some portion of it, afford crystals or grains of compounded solid figures. Though the Venetian borax, wont to be sold in shops, be known to be a factitious

tious body, compounded of several salts, that I shall not now stay to enumerate; and though, when we buy it, we usually find it to consist of lumps and grains misshapen enough, yet when I dissolved some of it in a good quantity of fair water, and made it coagulate very leisurely, I had crystals, upon whose surfaces I could perceive very exquisite, and, as to sense, regular and geometrical figures. And one thing I must not here by any means pretermitt, which is, that though the *caput mortuum* of common aqua fortis consists of bodies of very differing natures, (for such are nitre and vitriol,) and has been exposed to a great violence of the fire; yet I have sometimes admired the curiousness of those figures, that might be obtained barely by frequent solutions and coagulations of the saline particles of this *caput mortuum* in fair water. But because the glasses, wherein my concretions were made, were too little to afford great crystals, and they ought to shoot very slowly; I chose rather to shew the curious some large crystals, which I took out of the laboratory of an ingenious person, who, without minding the figures, had upon my recommendation made great quantity of that salt in large vessels for a medicine; (it being the *Panacea duplicata*, so famous in *Holstein*.) For divers of these crystals have not only triangles, hexagons, and rhomboides, and other figures exquisitely cut on their smooth and specular surfaces, and others, bodies of prismatical shapes: but some of them are no less accurately figured than the finest nitre or vitriol I remember myself to have observed, and some also terminate in bodies almost like pyramids, consisting of divers triangles, that meet in one vertical point, and are no less admirably shaped, than the fairer sort of Cornish diamonds, that have been brought me for rarities. Besides the producing of salts of new shapes by compounding of saline bodies, I have found it to be practicable not only in some gross, or, as they speak, corporal salts, such as sea-salt, salt-petre, but also in some natural and some chymical salts dissolved together, and which perhaps you will think more considerable in saline spirits made by distillation: not that all of them are fit for this purpose, but that I have found divers of those, that work upon one another with ebullition, to be so. For in that consist the saline corpuscles come to be associated to one another, and thereby, or by their newly acquired figure, whilst their coalition lasts, to lose much of their former volatility: so that upon evaporation of the superfluous liquor, they will not fly as otherwise they might, but concoagulate into finely shaped crystals, as I have tried, among other saline liquors, with spirit of urine, and spirit of nitre, and with oil of vitriol, and spirit of fermented urine, with spirit of sheep's blood, and spirit of salt, and also with the spirits of salt and urine; which last experiment I the rather mention, because it shews, by the difference of the crystals, afforded by those two liquors from the crystals

resulting from one of them, namely, the spirit of urine, (or, if you please, the volatile salt wherewith it abounds,) concoagulated with a fit dose of oil of vitriol, how much those compounded emergent figures depend upon the more simple figures of the saline corpuscles, that happen to convene into those new concretes. For the spirit of urine, satiated with spirit of salt, and both very gently, and not too far evaporated, often afforded me crystals, that differed exceedingly in shape from those, which I obtained from the same spirit of urine, satiated either with oil of vitriol, or with spirit of nitre. For, (to add that upon the by,) that salt, compounded of the two spirits of urine and of common salt, is wont to be very prettily figured, consisting of one long beam as it were, whence on both sides issue out far shorter crystals, sometimes perpendicular to that, and parallel to one another like the teeth in a comb, and sometimes so inclining as to make the whole appear almost like a feather; which is the more remarkable, because I have (many years ago) observed, that common sal-armoniack, that is made of urine and common salt, both crude, with a proportion of foot, will, if warily dissolved and coagulated, shoot into crystals of the like shape. How far the unknown figure of a salt may possibly (for I fear it will not easily) be guessed at by that of the figure, which it makes with some other salt, whose figure is already known, I leave to geometricians to consider; having, I fear, insisted too long on this subject already. But yet I must add one particular more, which will as well illustrate and confirm much of what has been said above touching the origination of vitriol, as shew, that the shape of vitriol depends upon the texture of the bodies whereof it is composed.

FOURTHLY, then, when I considered, that (as I formerly noted) vitriol being but a magistery, made by the concoagulation of the corpuscles of a dissolved metal with those of the menstruum, the magisteries of other metals might, without inconvenience, be added, as other vitriolate concretes, to the green, the blue, and white vitriol, that are without scruple referred to the same species: and when I considered, that oil of vitriol was not a fit menstruum to dissolve divers of the metals, nor even all those, that it will corrode, and that the like unfitness also is to be found in common spirit of salt; I pitched upon aqua fortis, or spirit of nitre, as that menstruum, which was likeliest to afford variety of vitriols. And accordingly I found, that besides the lovely vitriol of copper formerly mentioned, that liquor would with quicksilver afford one sort of crystals, with silver another, and with lead a third; all which crystals of vitriol, as they differed from each other in other qualities, (upon which score you will find this experiment elsewhere mentioned,) so they did very manifestly and considerably differ in shape; the crystals of silver shooting in exceeding thin plates, and those of lead and quicksilver obtaining

taining figures, though differing enough from each other, yet of a far greater depth and thickness, and less remote from the figure of common vitriol or sea-salt: and yet all these vitriols, especially that of crude lead, when it was happily made, had shapes curious and elaborate, as well as those we admire in common vitriol or sea-salt.

If then these curious shapes, which are believed to be of the admirablest effects, and of the strongest proofs of substantial forms, may be the results of texture; and if art can produce vitriol itself as well as nature, why may we not think, that in ordinary phænomena, that have much less of wonder, recourse is wont to be had to substantial forms without any necessity? (matter, and a convention of accidents being able to serve the turn without them;) and why should we wilfully exclude those productions of the fire, wherein the chymist is but a servant of nature, from the number of natural bodies? And indeed, since there is no certain diagnostick agreed on, whereby to discriminate natural and factitious bodies, and constitute the species of both; I see not, why we may not draw arguments from the qualities and operations of several of those, that are called factitious, to shew how much may be ascribed to, and performed by the mechanical characterization, or stamp of matter; of which we have a noble instance in gun-powder, wherein, by a bare comminution and blending the ingredients, nitre, charcoal, and brimstone, which have only a new, and that an exceeding slight contexture, each retaining its own nature, in the mixture, so that there is no colour afforded to the pretence of a substantial form; there is produced a new body, whose operations are more powerful and prodigious than those of almost any body of nature's own compounding. And though glass be but an artificial concrete, yet, besides that it is a very noble and useful one, nature herself has produced very few, if enough to make up a number more lasting and more unalterable. And indeed divers of those factitious bodies, that chymistry is able to afford us, are endowed with more various and more noble qualities than many of those, that are unquestionably natural. And if we admit these productions into the number of natural bodies, they will afford us a multitude of instances, to shew, that bodies may acquire many and noble qualities, barely by having mechanical affections introduced by outward agents into the matter, or destroyed there. As, though glass be such a noble body, as we have lately taken notice of, yet since its fusibility, transparency, and brittleness, that are its only constituent attributes, we can in less than an hour (or perhaps half that time,) turn an opacous body into transparent glass, without the addition of any other visible body, by a change of texture made in the same matter, and by another change of texture, made without addition,

as formerly, we can in a trice reduce glass into, or obtain from it, a body not glassy, but opacous, and otherwise of a very differing nature, as it had been before. And here let me add what may not a little conduce to our present design, that even those, that embrace *Aristotle's* principles, do unawares confess, that a slight change of texture, without the introduction of a substantial form, may not only make a specific difference betwixt bodies, but so vast a one, that they shall have differing genius's, and may (as the chymists speak) belong to different kingdoms. For coral, to pass by all other plants of that kind, that may be mentioned to the same purpose, whilst it grows in the bottom of the sea, is a real plant, and several times (which suffices for my present scope) hath been there found by an acquaintance of mine, as well as by other enquirers, soft and tender like another plant: nay, I elsewhere * bring very good and recent authority to prove, that it is oftentimes found very succulent, and does propagate its species as well as other shrubs; and yet coral, being gathered and removed into the air by the recess of its soul, no new lapidifick form being so much as pretended to, turns into a concretion, that is by many eminent writers and others reckoned among lapideous ones: as indeed coral does not burn like wood, nor obey distillation like it; and not only its calx is very differing from the ashes of vegetables, and is totally soluble in divers acid liquors, and even spirit of vinegar, but the uncalcined coral itself will be easily corroded by good vinegar, after the same manner as I have seen *lapis stellaris*, and other unquestionably mineral stones dissolved, some by that liquor, and some by the spirit of it. A much stranger thing may be seen in the East-India island of *Sombrero*, not very far from *Sumatra*, if we may believe our countryman *Sir James Lancaster*, who relates it as an eye-witness, for which reason, and for the strangeness of the thing, I shall add the story in his own words. *Here* († says he, speaking of the coast of *Sombrero*) *we found upon the sand, by the sea-side, a small twig growing up to a young tree; and offering to pluck up the same, it shrunk down into the ground, and sinketh, unless you hold very hard. And being plucked up, a great worm is the root of it: and look how the tree groweth in greatness, the worm diminisheth. Now as soon as the worm is wholly turned into the tree, it rooteth in the ground, and so groweth to be great. This transformation was one of the greatest wonders I saw in all my travels. This tree being plucked up a little, the leaves stripped off, and the peel, by that time it was dry, turned into a hard stone, much like to white coral. So that* (concludes he) *this worm was twice transformed into different natures: of these we gathered, and brought home many.* The industrious *Piso*, in his excellent history of *Brasil*, vouches a multitude of witnesses (not having opportunity to

* In the Essays about things supposed to be spontaneously generated.

† *Purchas. Pilgr.* Part the first, p. 152.

to be one himself) for the ordinary transformation of a sort of animals (not much unlike grasshoppers) into vegetables, at a certain season of the * year.

BUT since I set down this relation of Sir *John Lancaster*, I have met with another, whose strangeness may much countenance it, in a small tract newly published by a Jesuit, *F. Michael Boym*, whom a good critick much commended to me. For this author doth, as an eye-witness, affirm, that which is little less to my present purpose: † *Je vis, &c.* i. e. *I saw in a small fresh-water and shallow lake of the island Hainan (which belongs to China) crabs or craw-fishes, which, as soon as they were drawn out of the water, did in a moment lose both life and motion, and became petrified, though nothing appeared to be changed either in the external or internal figure of their bodies.* What he further adds of these fishes, is but of their virtues in physick, which not concerning our subject, I shall, *Pyrophilus*, willingly pretermitt it; and even, as to our countryman's relation, hoping, by means of an ingenious correspondent in the *East Indies*, to receive a further information about the strange plant he mentions, I shall at present urge only what has been taken notice of concerning coral, to countenance the observation, for whose sake these nar-

ratives have been alledged. And so likewise as to what I was saying of glass and gunpowder, our receiving of those, and the generality of factitious bodies, into the catalogue of natural bodies, is not (which I formerly also intimated) necessary to my present argument: whereto it is sufficient, that vitriol is granted on all hands to be a natural body, though it be also producible by art. And also to the argument it affords us, we might add that memorable experiment delivered by *Helmont*, of turning oil of vitriol into allom, by the odour (as he calls it) of mercury, if, however it be not despicable, we had found it fit to be relied on. But reserving an account of that for another place, we shall substitute the instance presented us by our author, about the production of salt-petre: for if, having dissolved pot-ashes in fair water, you coagulate the filtrated solution into a white salt, and on that pour spirit of nitre, till they will not hiss any longer; there will shoot, when the superfluous water is evaporated, crystals, that proclaim their nitrous nature by their prismatical (or at least prism-like) shape, their easy fusion, their accension, and deflagration, and other qualities, partly mentioned by our author, and partly discoverable by a little curiosity in making trials.

II. EXPERIMENTAL ATTEMPTS *about the* REDINTEGRATION *of* BODIES.

THE former of those two arguments, *Pyrophilus*, by which I proposed to confirm the origin of forms, was, as you may remember, grounded upon the manner, by which such a convention of accidents, as deserves to pass for a form, may be produced: and that having been hitherto prosecuted, it now remains, that we proceed to the second argument, drawn not (as the former) from the first production, but from the reproduction of a physical body. And though both these arguments are valid, yet if this latter could, in spite of the difficulties intervening in making of the experiments, that belong to it, be as clearly made out as the former, you would, I suppose, like it much the better of the two. For if we could reproduce a body, which has been deprived of its substantial form, you would, I presume, think it highly probable, if not more than probable, that (to borrow our author's expression) that, which is commonly called the form of a concrete, which gives it its being and denomination, and from whence all its qualities are in the vulgar philosophy, by I know not what inexplicable ways, supposed to flow, may be in some bodies but a

characterization or modification of the matter they consist of; whose parts, by being so and so disposed in relation to each other, constitute such a determinate kind of body, endowed with such and such properties: whereas if the same parts were otherwise disposed, they would constitute other bodies, of very differing natures from that of the concrete, whose parts they formerly were, and which may again result or be produced after its dissipation, and seeming destruction, by the reunion of the same component particles, associated according to their former disposition.

BUT though it were not impossible to make an adequate redintegration of a chymically analyzed body, because some of the dissipated parts will either escape through the junctures of the vessels, (though diligently closed) or, if they be very subtle, will fly away upon the disjoining of the vessels, or will irrecoverably stick to the inside of them: yet I see not why such a reproduction, as is very possible to be effected, may not suffice to manifest what we intend to make out by it. For even in such experiments it appears, that when the form of a natural body is abo-

* The passage, which is long, I do not here transcribe, having had occasion to do it elsewhere. It is extant, *lib. 5. cap. 21.* and at the close of his narrative he subjoins, *Non est, quod quisquam de veritate dubitet, cum infinitos testes habeat Brasilia, &c.*

† *Flora Sinensis, ou Traite des Fleurs, &c.* under the Title *Lorimeoques.*

lished, and its parts violently scattered, by the bare re-union of some parts after the former manner, the very same matter the destroyed was before made of, may, without addition of other bodies, be brought again to constitute a body of the like nature with the former, though not of equal bulk. And indeed the experiment recorded by our author about the reproduction of salt-petre, as it is the best and successfulest I have ever been able to make upon bodies, that require a strong heat to dissipate them; so I hope it will suffice to give you those thoughts about this matter, that the author designed in alledging it; and therefore, though having premised thus much, I shall proceed to acquaint you with the success of some attempts he intimates (in that essay) his intention of making for the redintegration of some bodies; yet doing it out of some historical notes, I find among my loose papers, that, which I at present pretend to, is but partly to shew you the difficulty of such attempts, which, since our author's essay was communicated, have been represented (I fear, by conjecture only) as very easy to be accurately enough done; and partly because our author does not, without reason, intimate the usefulness of redintegrations; in case they can be effected; and does not causelessly intimate, that such attempts, though they should not perfectly succeed, may increase the number of noble and active bodies, and consequently the inventory of mankind's goods.

UPON such considerations we attempted the dissipation and re-union of the parts of common amber; and though chymists, for fear of breaking their vessels, are wont, when they commit it to distillation, to add to it a *caput mortuum* (as they speak) of sand, brick, &c. (in whose room we sometimes chuse to substitute beaten glass;) which hinders them to judge of and employ the remanence of the amber, after the distillation is finished; yet we supposed, and found, that if the retort were not too much filled, and if the fire were slowly and warily enough administered, the addition of any other body would be needless. Wherefore, having put into a glass retort four or five ounces of amber, and administered a gentle and gradual heat, we observed the amber to melt and bubble, (which we therefore mention, because ingenious men have lately questioned, whether it can be melted,) and having ended the operation, and sever'd the vessels, we found, that there was come over in the form, partly of oil, partly of spirit and phlegm, and partly of volatile salt, near half the weight of the concrete: and having broken the retort, we found in the bottom of it a cake of coal-black matter, than whose upper surface I scarce remember to have seen in my whole life any thing more exquisitely polished; insomuch, that, notwithstanding the colour, as long as I kept it, it was fit to serve for a looking-glass: and this smooth mass being broken, (for it was exceeding brittle,) the larger fragments of it appeared adorned with an excellent lustre.

All those parts of the amber, being put together into a glass body, with a blind head luted to it, were placed in sand; to be incorporated by a gentle heat: but whilst I slept aside to receive a visit, the fire having been increased without my knowledge, the fumes ascended so copiously, that they lifted up the vessel out of the sand, whereupon falling against the side of the furnace, it broke at the top, but being seasonably called, we saved all but the fumes; and the remaining matter looks not unlike tar, and with the least heat may be poured out like a liquor, sticking, even when it is cold, to the fingers. Yet this opened body doth not easily communicate so much as a tincture to spirit of wine, which therefore seems somewhat strange, because another time presuming, that this would be a good way to obtain a solution of some of the resinous parts of amber, we did by pouring spirit of wine, that (though rectified) was not of the very best, upon the re-united parts of amber, lightly digested into a mass, easily obtain a clear yellow solution, very differing from the tincture of amber, and abounding (as I found by trial) in the dissolved substance of the amber: but in oil of turpentine we have, in a short time, dissolved it into a blood-red balsam, which may be of good use (at least) to chirurgeons. And having again made the former experiment with more wariness than before, we had the like success in our distillation, but the re-united parts of the amber being set to digest in a large bolt-head, the liquor, that was drawn off, did in a few hours, from its own *caput mortuum*, extract a blood-red tincture, or else made a solution of some part of it, whereby it obtained a very deep red; but having been, by intervening accidents, hindered from finishing the experiment, we missed the satisfaction of knowing to what it may be brought at last.

AND as for what our author tells us of this design to attempt the redintegration of vitriol, turpentine, and some other concretes, wherein it seemed not unpracticable, he found in it more difficulty than every one would expect. For the bodies, on which such experiments are likeliest to succeed, seem to be alum, sea-salt, and vitriol. And as for alum, he found it a troublesome work to take (as a Spagyrist would speak) the principles of it asunder, in regard, that it is inconvenient to distil it with a *caput mortuum*, (as chymists call any fixed additament) lest that should hinder the desired redintegration of the dissipated parts. And when he distilled it by itself, without any such additament, he found, that with a moderate heat the allum would scarce part with any thing but its phlegm; and if he urged it with a strong fire, he found it would so swell, as to endanger the breaking of the retort, or threaten the boiling over into the receiver. (Yet having once been able very warily to abstract as much phlegm and spirit, as I conveniently could, from a parcel of rock-allum, and having poured it back upon that pulverized *caput mortuum*, and left the vessel long in a

quiet place, I found, that the corpuscles of the liquor, having had time, after a multitude of occurrences, to accommodate and reunite themselves to the more fixed parts of the concrete, did, by that association (or dissolution) recompose, at the top of the powder, many crystalline grains of finely figured salt, which increasing with time, made me hope, that, at the length, the whole or the greatest part would be reduced into alum, which yet a mischance, that robbed me of the glass, hindered me to see. So likewise of sea-salt, if it be distilled, as it is usual, with thrice its weight of burned clay, or beaten brick, it will prove inconvenient in reference to its redintegration: and if it be distilled alone, it is apt to be fluxed by the heat of the fire, and whilst it remains in fusion, will scarce yield any spirit at all. And as for vitriol, though the redintegration of it might seem to be less hopeful than that of the other salts, in regard that it consists, not only of a saline, but of a metalline body, whence it may be supposed to be of a more intricate and elaborate texture; yet because there needs no *caput mortuum* in the distillation of it, we did, to pursue our author's intimated designs, make two or three attempts upon it, and seemed to miss of our aim, rather upon the account of accidental hindrances, than of any insuperable difficulty in the thing itself. For once we, with a strong fire, drew off from a parcel of common blue vitriol the phlegm and spirit, and some quantity of the heavy oil, (as chymists abusively call it:) these liquors, as they came over without separation, we divided into several parts, and the remaining very red *caput mortuum* into as many. One of these parcels of liquor we poured over night upon its correspondent portion of the newly mentioned red powder. But having left it in a window, and the night proving very bitter, in the morning I found the glass cracked in many places, by the violence of the frost, and the liquor seemed to have been soaked up by the powder, and to have very much swelled it. This mixture then I took out, and placing it in an open-mouthed glass in a window, I found, after a while, divers grains of pure vitriol upon the other matter, and some little swellings, not unlike those we shall presently have occasion to speak of. I took likewise a much larger parcel of the fore-mentioned liquor, and its correspondent proportion of *caput mortuum*; and having leisurely mixed them in a large glass basin, I obtained divers phenomena, that belong not to this place, but may be met with where they will more properly fall in. In this basin (which I laid in the window, and kept from agitation,) I perceived, after a while, the liquor to acquire a bluish tincture, and after ten or twelve weeks, I found the mixture dry, (for it seems it was too much exposed to the air;) but the surface of it adorned in divers places with grains of vitriol very curiously figured.

AND besides these, there were store of protuberances, which consisted of abundance of small vitriolate particles, which seemed in

the way to a coalition; for having let the basin alone for four or five months longer, the matter appeared crusted over, partly with very elevated saline protuberances, partly with lesser parcels, and partly also with considerable broad cakes of vitriol, some of above half an inch in breadth, and proportionably long: and indeed the whole surface was so oddly diversified, that I cannot count the trouble these trials have put me to, mispent. Another time, in a more slender and narrow-mouthed glass, I poured back upon the *caput mortuum* of vitriol the liquors, I had by violence of the fire forced from it; so that the liquid part did swim a pretty height above the red calx, and remained a while limpid and colourless: but the vessel having stood for some time unstopped in a window, the liquor after a while acquired by degrees a very deep vitriolate colour, and not long after there appeared, at the bottom, and on the top of the calx, many fair and exquisitely figured grains of vitriol, which covered the surface of the calx, and the longer the vessel continued in the window, the deeper did this change, made upon the upper part of the powder, seem to penetrate: so that I began to hope, that, in process of time, almost (if not more than almost) the whole mixture would be reduced to perfect vitriol. But an accident robbed me of my glass, before I could see the utmost of the event.

And, on this occasion, I must not pretermitt an odd experiment I lately made, though I dare not undertake to make it again. I elsewhere relate, how I digested, for divers weeks, a quantity of powdered antimony, with a greater weight by half of oil of vitriol; and how having at length committed this mixture to distillation, and thereby obtained, besides a little liquor, a pretty quantity of combustible antimonial, or antimonio-vitriolate sulphur; there remained, in the bottom of the retort, a somewhat light and very friable *caput mortuum*, all the upper part of which was at least as white as common wood-ashes, and the rest looked like a cinder. And now I must tell you, what became of this *caput mortuum*, whereof I there make no further mention. We could not well foresee what could be made of it, but very probable it was, that it would afford us some new discovery, by being exposed to the fire, in regard of the copious sulphur, whereof it seemed to have been deprived; provided it were urged in close vessels, where nothing could be lost. Whereupon committing it to a naked fire in a small glass retort, well coated and accommodated with a receiver, we kept it there many hours, and at length severing the vessels, we found (which need not be wondered at) no antimonial quicksilver, and much less of sulphur sublimed than we expected: wherefore greedily hastening to the *caput mortuum*, we found it fluxed into a mass, covered with a thin cake of glass, whose fragments being held against the light, were not all coloured, as antimonial glass is wont to be, but were as colourless as common white glass.

glafs. The lump above mentioned being broken, was found, somewhat to our wonder, to be perfect black antimony, adorned with long shining streaks, as common antimony is wont to be: only this antimony seemed to have been a little refined by the sequestration of its unnecessary sulphur; which ingredient seems by this experiment, as well as by some other observations of ours, to be more copious in some particular parcels of that mineral, than is absolutely requisite to the constitution of antimony. Though in our case it may be suspected, that the reduction of part of the mass to a colourless glass was an effect of the absence of so much of the sulphur, and might in part make the remaining mass some amends for it. What we further did with this new or reproduced concrete, is not proper to be here told you: only for your satisfaction we have kept a lump of it, that you may with us take notice of what some philosophers would call the mindfulness of nature; which, when a body was deprived of a not inconsiderable portion of its chief ingredient, and had all its other parts dissipated and shuffled, and discoloured, so as not to be knowable, was able to rally those scattered and disguised parts, and marshal or dispose them into a body of the former consistence, colour, &c. though (which is not here to be overlooked) the contexture of antimony, by reason of the copious shining

striae, that enoble the darker body, be much more elaborate, and therefore more uneasy to be restored, than that of many other concretes.

BUT among all my trials about the redintegration of bodies, that, which seemed to succeed best, was made upon turpentine: for having taken some ounces of this, very pure and good, and put it into a glass retort, I distilled so long with a very gentle fire, till I had separated it into a good quantity of very clear liquor, and a *caput mortuum* very dry and brittle; then breaking the retort, I powdered the *caput mortuum*, which, when it was taken out, was exceeding sleek, and transparent enough, and very red, but being powdered, appeared of a pure yellow colour. This powder I carefully mixed with the liquor, that had been distilled from it, which immediately dissolved part of it into a deep red balsam; but by further digestion, in a large glass exquisitely stopp'd, that colour began to grow fainter, though the remaining part of the powder, (except a very little, proportionable to so much of the liquor, as may be supposed to have been wasted by evaporation and transfusion out of one vessel into another,) be perfectly dissolved, and so well reunited to the more fugitive parts of the concrete, that there is scarce any, that by the smell, or taste, or consistence, would take it for other than good and laudable turpentine.



C O N S I D E R A T I O N S
A N D
E X P E R I M E N T S,
T O U C H I N G T H E
O r i g i n o f Q U A L I T I E S a n d F O R M S.
T H E H I S T O R I C A L P A R T.

S E C T I O N I.

Containing the observations.

IN the foregoing notes I have endeavoured with as much clearness as the difficulty of the subject and the brevity I was confined to permitted, to give a scheme or summary of the principles of the corpuscularian philosophy, as I apprehended them, by way of a short introduction to it, at least as far as I judged necessary for the better understanding of what is contained in our notes and experiments, concerning the productions and changes of particular qualities. But though, I hope, I have not so affected brevity as to fall into obscurity, yet since these principles are built upon the phænomena of nature, and devised in order to the explication of them, I know not what I can do more proper to recommend them, than to subjoin some such natural phænomena, as either induce me to take up such notions, or which I was directed to find out by the notions I had embraced. And since I appeal to the testimony of nature to verify the doctrine I have been proposing about the origin and production of qualities, (for that of forms will require a distinct discourse;) I think it very proper to set down some observations of what nature does, without being over-ruled by the power and skill of man, as well as some experiments, wherein nature is guided, and as it were mastered by art, that so she may be made to attest the truth of our doctrine, as well when she discloses her self freely, and, if I may so speak, of her own accord, as when she is as it were cited to make her depositions by the industry of man. The observations will be but the more suitable to our design for being common and familiar as to the phænomena, though perhaps new enough as to the application to our purpose. And as for the experiments, because those, that belong more immediately to this or that particular quality, may be met with in the notes, that treat of it, I thought it not amiss, that the experiments should be both few in number, and yet so pregnant, that every one of them should afford such differing phænomena, as may make it applicable to more than one quality.

I.

THE observation I will begin with shall be fetched from what happens in the hatching of an egg. For as familiar and obvious a

thing as it is, (especially after what the learned *Fabricus ab Aquapendente*, and a recent anatomist have delivered about them,) that there is a great change made in the substance of the egg, when it is by incubation turned into a chick; yet, as far as I know, this change hath not been taken notice of for the same purpose, to which I am about to apply it.

I CONSIDER then, that in a prolific egg (for instance, that of a hen,) as well the liquor of the yolk, as that of the white is a substance; as to sense, similar. For upon the same account, that anatomists and physicians call several parts of the human body, as bones, membranes, &c. similar, that is such, as that every sensible part of it hath the same nature or denomination with the whole, as every splinter of bone is bone, as every shred of skin is skin.

AND though I find by distilling the yolks and whites they seem to be dissimilar bodies, in regard that the white of an egg (for example) will afford substances of a very differing nature, as phlegm, salt, oil, and earth; yet (not now to examine, whether, or how far these may be esteemed productions of the fire, that are rather obtained from the white of the egg, than were præ-existent in it; not to mention this, I say,) it doth not appear by distillation, that the white of an egg is other than a similar body in the sense above delivered. For it would be hard to prove, that one part of the white of an egg will not be made to yield the same differing substances by distillation, that any other part does; and bones themselves, and other hard parts of a human body, that are confessedly similar, may by distillation be made to afford salt, and phlegm, and spirit, and oil, and earth, as well as the white of an egg.

THIS being thus settled in the first place, we may in the next consider, that by beating the white of an egg well with a whisk, you may reduce it from a somewhat tenacious, into a fluid body, though this production of a liquor be, as we elsewhere noted, effected by a divulsion, agitation, &c. of the parts; that is, in a word, by a mechanical change of the texture of the body.

IN the third place I consider, that, according to the exactest observations of modern anatomists, which our own observations do not contradict, the rudiments of the chick, lodged in

in the cicatricula or white speck upon the coat of the yolk, is nourished, till it have obtained to be a great chick, only by the white of the egg; the yolk being by the providence of nature reserved as a more strong and solid aliment, till the chick have absorbed the white, and be thereby grown great and strong enough to digest the yolk: and in effect you may see the chick furnished not only with all the necessary, but divers other parts, as head, wings, legs, and beak, and claws, whilst the yolk seems yet as it were untouched. But whether this observation about the entireness of the yolk be precisely true, is not much material to our present purpose, nor would I be thought to build much upon it; since the yolk itself, especially at that time, is wont to be fluid enough, and to be a liquor perhaps no less so than the white was, and that is enough for my present purpose.

FOR in the last place I consider, that the nutritive liquor of an egg, which is in itself a body so very soft, that by a little agitation it may be made fluid, and is readily enough dissolvable in common cold water; this very substance, I say, being brooded on by the hen, will within two or three weeks be transmuted into a chick, furnished with organical parts, as eyes, ears, wings, legs, &c. of a very differing fabric, and with a good number of similar ones, as bones, cartilages, ligaments, tendons, membranes, &c. which differ very much in texture from one another; besides the liquors, as blood, chyle, gall, &c. contained in the solid parts. So that here we have out of the white of an egg, which is a substance similar, insipid, soft, (not to call it fluid,) diaphanous, colourless, and readily dissoluble in cold water; out of this substance, I say, we have, by the new and various contrivement of the small parts it consisted of, an animal, some of whose parts are not transparent, but opacous; some of them red, as the blood; some yellow or greenish, as the gall; some white, as the brain; some fluid, as the blood, and other juices; some consistent, as the bones, flesh, and other stable parts of the body; some solid and frangible, as the bones; others tough and flexible, as the ligaments; others soft and loosely coherent, as the marrow; some without springs, as many of the parts; some with springs, as the feathers; some apt to mingle readily with cold water, as the blood, the gall; some not to be so dissolved in it, as the bones, the claws, and the feathers; some well tasted, as the flesh and blood; some very ill tasted, as the gall; (for that I have purposely and particularly observed.) In a word, we have here produced out of such an uniform matter as the white of an egg,

FIRST, new kind of qualities, as (besides opacity) colours, (whereof a single feather will sometimes afford us variety,) odours, tastes, and heat in the heart and blood of the chick, hardness, smoothness, roughness, &c.

SECONDLY, divers other qualities, that are wont to be distinguished from sensible ones, as fluidity (in the blood and aqueous humour of the eye,) consistency in the gristles, flesh, &c.

hardness, flexibility, springiness, toughness; unfitness to be dissolved in cold water, and several others. To which may probably be added,

THIRDLY, some occult properties, as physicians observe, that some birds, as young swallows, young magpies afford specifick or at least noble medicines in the falling-sickness, hysterical fits, and divers other distempers.

FOURTHLY, I very well foresee it may be objected, that the chick with all its parts is not a mechanically contrived engine, but fashioned out of matter by the soul of the bird, lodged chiefly in the cicatricula, which by its plastick power fashions the obsequious matter, and becomes the architect of its own mansion. But not here to examine, whether any animal, except man, be other than a curious engine; I answer, that this objection invalidates not what I intend to prove from the alledged example. For let the plastick principle be what it will, yet still, being a physical agent, it must act after a physical manner; and having no other matter to work upon but the white of the egg, it can work upon that matter but as physical agents, and consequently can but divide the matter into minute parts of several sizes and shapes, and by local motion variously context them, according to the exigency of the animal to be produced, though from so many various textures of the produced parts there must naturally emerge such differences of colours, tastes, and consistencies, and other qualities, as we have been taking notice of. That, which we are here to consider, is not what is the agent or efficient in these productions, but what is done to the matter to effect them. And though some birds by an inbred skill do very artificially build their curious nests, yet cannot nature, that teaches them, enable them to do any more than select the materials of their nests, and by local motion divide, transport, and connect them after a certain manner. And when man himself, who is undoubtedly an intelligent agent, is to frame a building or an engine, he may indeed, by the help of reason and art, contrive his materials curiously and skilfully; but still all he can do, is but to move, divide, transpose, and context the several parts, into which he is able to reduce the matter assigned him.

NOR need we imagine, that the soul of that hen, which having first produced the egg, does after a while sit on it, hath any peculiar efficiency in hatching of a chick: for the egg will be well hatched by another hen, though that, which laid it, be dead. And, which is more, we are assured by the testimony of very good authors, as well as of recent travellers, that in some places, especially in *Aegypt*; there needs no bird at all to the production of a chick out of an egg, since they hatch multitudes of eggs by the regulated heat of ovens or dunghills. And indeed, that there is a motion or agitation of the parts of the egg by the external heat, whereby it is hatched, is evident of it self, and not (as far as I know) denied by any; and that also the white substance is absorbed, and contexted or contrived into the body of the chick, and its

its several parts, is manifest to sense; especially if one hath the curiosity to observe the progress of the chick's formation and increment. But as it is evident, that these two things, the substance of the white, and the local motion, wherein the external heat necessary to incubation puts its parts, do eminently concur to the production of the chick, so that the formative power (whatever that be) doth any more than guide these motions, and thereby associate the fitted particles of matter after the manner requisite to constitute a chick, is that, which I think will not easily be evinced. And I might, to what I said of the egg, add several things touching the generation of viviparous animals, which the learned *Fabricius ab Aquapendente*, as well as some of the ancient philosophers, would have to be generated from an imperfect kind of eggs: but I take the eggs of birds to be much fitter to instance in, because they are things, that we have more at command, and wherewith we can conveniently make more trials and observations; and especially because in perfect eggs the matter to be transmuted is more closely locked up, and being kept from any visible supply of matter, confined to be wrought upon by the external heat, and by its own vital principle within.

II.

WATER being generally esteemed an elementary body, and being at least far more homogeneous than bodies here below are wont to be, it may make very much for our present purpose to shew, that water itself, that is fluid, tasteless, inodorous, diaphanous, colourless, volatile, &c. may, by a differing texture of its parts, be brought to constitute bodies of attributes very distant from these. This I thought

ht be done, by nourishing vegetables with simple water. For in case I could do so, all or the greatest part of that, which would accrue to the vegetable thus nourished would appear to have been materially but water, with what exotick quality soever it may afterwards, when transmuted, be endowed.

THE ingenious *Helmont* indeed mentions an experiment somewhat of this nature, though not to the same purpose, which he made by planting a branch of willow into a pot full of earth, and observing the increase of weight he obtained after divers years, though he fed the plant but with rain-water. And some learned modern naturalists have conjectured at the easy transmutableness of water, by what happens in gardens and orchards, where the same showers or rain after a long drought makes a great number of differing plants to flourish. But though these things be worthy of their authors, yet I thought they would not be so fit for my purpose, because it may be speciously enough objected, that the rain-water does not make these plants thrive and flourish, by immediately affording them the aliments they assimilate into their own substance, but by proving a vehicle, that dissolves the saline, and other alimental substances of the earth, and dilutes both them and the nutritive juice, which, in a part of the plant it self, it may find too much thickned

by the drought or heat of the ambient air, and by this means it contributes to the nourishment of the plant, though it self be insensibly afterwards exhaled into vapours. And indeed experience shews us, that several plants, that thrive not well without rain-water, are not yet nourished by it alone, since when corn in the field, and fruit-trees in orchards, have consumed the saline and sulphureous juices of the earth, they will not prosper there, how much rain soever falls upon the land, till the ground by dung or otherwise be supplied again with such assimilable juices. Wherefore I rather chose to attempt the making of plants grow in phials filled with water, not only to prevent the fore-mentioned objection, and also to make the experiment less tedious, but that I might have the pleasure of seeing the progress of nature in the transmutation of water: and my observations of this kind as novelties, unmentioned by any other writer, I shewed divers ingenious friends, who having better opportunities than I of staying in one place, have attempted the like, and made successful trials, which I suppose will not be concealed from the publick. Of my observations about things of this kind, I can at present find but few among my *Adversaria*, but in them I find enough for my present turn. For they and my memory inform me, that *vinca pervinca*, *raphanus aquaticus*, *spear-mint*, and even *ranunculus* it self, did grow and prosper very well in phials filled with fair water, by whose necks the leaves were supported, and the plant kept from sinking: some of these were only cuttings without roots, diverse of them were left in the water all the autumn, and great part of the winter, and at the end of *January* were taken out verdant and with fair roots, which they had shot in the water. And besides I find, that particularly a branch or sprig of *raphanus aquaticus* was kept full nine months, and during that time withered not the whole winter, and was taken out of the water with many fibrous roots, and some green buds, and an increase of weight; and that a stump of *ranunculus* did so prosper in the water, that in a month's time it had attained to a pretty deal more than double the weight it had, when it was put in. And the next note, which I find concerning these plants, informs me, that the above mentioned *crow's-foot* being taken out again at six months after it was put in, weighed a drachm and a half wanting a grain and a half, that is, somewhat above thrice as much as it did at first. This last circumstance (of the increase of weight) I therefore thought fit particularly to make trial of, and set down upon this account among others, that having doubted the roots and leaves, that seemed produced out of the water, might really be so by an oblongation and an expansion of the plants, (as I have purposely tried, that an onion weighed and laid up in the spring, though after some weeks keeping in the air it shot blades, whereof one was five inches long, instead of incorporating the air or terrestrial effluvia with itself, and consequently thereby growing heavier, had lost nine grains of its former weight;) it might by this circumstance appear, that

that there may be a real assimilation and transmutation of water into the substance of the vegetable, as I elsewhere also shew by other proofs. For this being made out, from thence I infer, that the same corpuscles, which, convening together after one manner, compose that fluid, inodorous, colourless, and insipid body of water, being contexted after other manners, may constitute differing concretes, which may have firmness, opacity, odours, smells, tastes, colours, and several other manifest qualities, and that too very different from one another. And besides all this, these distinct portions of transmuted water may have many other qualities, without excepting those, that are wont to be called specific or occult; witness the several medicinal virtues attributed by authors to spearmint, and to periwinkle, to majorane, and to raphanus aquaticus. And as for ranunculus, that plant being reckoned among poisonous ones, and among those, that raise blisters, it will be easily granted, that it hath, as other poisons, an occult deleterial faculty: and indeed it somewhat deserves our wonder, that so insipid and innocent a thing as fair water, should be capable of being turned into a substance of such a piercing and caustic nature, as by contact to raise blisters on a human body. And yet perhaps that is no less strange, which we elsewhere relate, that a plant consisting chiefly of transmuted water, did by distillation afford us a true oil, that would not mingle with water, and consequently was easily convertible into fire. But whether or no this experiment, or any such like, prove, that almost all things may be made of all things, not immediately, but by intervention of successive changes and dispositions, is a question, to which we elsewhere say something, but are not willing in this place to say any thing. And if it be here objected, that the solid substance, that accrues to a plant rooted in water, proceeds not at all from the water itself, but from the nitrous, fat, and earthy substances, that may be presumed to abound even in common water; not here to repeat what I elsewhere say about this objection, I shall at present reply, that though as to divers plants, that flourish after rain, I am apt to think, as I intimated above, that they may in part be nourished as well by the saline and earthy substances, to which the rain usually proves a vehicle, as by the rain itself; yet as to what the objection holds forth about the plants, that grow not in the ground, but in glasses filled with water, it should not be barely said, but proved; which he will not perhaps think easy to be done, that considers how vast a quantity of fair water is requisite to be exhaled away, to obtain as much as one ounce of dry residue, whether saline or earthy.

III.

THAT a plant growing in the earth doth by the faculties of its vegetative soul attract the juices of the earth, that are within its reach, and selecting those parts, that are congruous to its nature, refuse the rest, is the general opinion of philosophers and physicians: and therefore

many naturalists are not wont much to marvel, when they see a tree bear a fruit, that is sour or bitter, because they presume, that nature hath in the root of the tree culled out such parts of the alimental juice of the earth, as being made to convene into one fruit, are fit to make it of such a quality. But it is worth observing for our present purpose, what happens both in ordinary graftings, and especially in that kind of infusion (taking the word in a large sense) which is commonly called inoculation. For though we may presume, that the root of a white-thorn (for instance) may electively attract its aliment from the earth, and choose that, which is fittest to produce the ignoble fruit, that is proper for that plant; yet we cannot reasonably suppose, that it should, in its attraction of aliment, have any design of providing an appropriate nutriment for a pear: and yet the known experience of gardeners, and our own observations manifest, that the cyons of a pear-tree will take very well upon a white-thorn-stock, and bring forth a well-tasted fruit, very differing in many qualities from that of the white-thorn. I have also learned from those that are expert, that though apples and pears, being but vulgar fruit, are seldom propagated but by grafting; yet they may be propagated likewise by inoculation, (which seems to be but a kind of grafting with a bud.) Now in the inoculations, that are made upon fruit-trees, it is very observable, and may much countenance what we are endeavouring to prove, that a little vegetable bud, (that is no seed properly so called) not so big oftentimes as a pea, should be able so to transmute all the sap that arrives at it, that though this sap be already in the root, and in its passage upwards determined by nature's intention, as men are wont to speak, to the production of the fruit, that is natural to the stock; yet this sap should by so small a vegetable substance as a bud, (whether by the help of some peculiar kind of strainer, or by the operation of some powerful ferment lodged in it, or by both these, or some other cause) be so far changed and over-ruled, as to constitute a fruit quite otherwise qualified than that, which is the genuine production of the tree, and which is actually produced by those other portions of the like sap, which happened to nourish the prolific buds, that are the genuine offspring of the stock; so that the same sap, that in one part of a branch constitutes (for instance) a cluster of haws, in another part of the same branch may constitute a pear. And that which is further remarkable to our present purpose, is, that not only the fruits made of the same sap do often differ from one another in shape, bigness, colour, odour, taste, and other obvious qualities, as well as occult ones: but that though the sap itself be (oftentimes) a waterish and almost insipid liquor, that appears to sense homogeneous enough, and even by distillation affords very little besides phlegm; yet this sap is not only convertible by buds of several natures into differing fruits, but in one and the same fruit the transmuted sap shall, by differing textures, be made to exhibit very differing and sometimes contrary qualities.

As when (for instance) a peach-bud does not only change the sap, that comes to it into a fruit, very differing from that, which the stock naturally produceth, but in the skin of the peach it must be red, in the kernel white, and in other parts, of other colours; the flesh of it must be fragrant, the stone inodorous, the flesh soft and yielding, the stone very hard and brittle, the meat pleasantly tasted, the kernel bitter; not to mention, that peach-blossoms, though produced also by the bud, are of a colour and texture very differing from that of the fruit, and are ennobled with an occult quality, which the fruit hath not, I mean, a purgative virtue: so that from inoculations we may learn, that a phlegmatic liquor, that seems homogeneous enough, and but very slenderly provided with other manifest qualities than common water, may, by being variously contexted by the buds of trees, be transmuted into bodies endowed with new and various considerable scents, colours, tastes, solidity, medicinal virtues, and divers other qualities manifest and occult.

If it be here said, that these qualities are the productions of the plastic power residing in prolific buds, which indeed (to me) seem to be but very minute boughs; I shall return the same answer, that I did to the like objection, when it was proposed in the first observation.

HITHERTO I have only argued from vulgar inoculations, but there may be others, as well more considerable, as less ordinary: and I remember I have seen a tree, whereof, though the stock was of one sort of good fruit, there were three more and differing kinds of stone-fruit, that had been made to take by inoculation, and two of those inoculated boughs had actually fruit on them; and the third, though it had as yet no fruit, because the season for that sort of plants to bear was not yet come, yet the shoot was so flourishing, that we concluded, that the blossoms would in due time be succeeded by fruit. And since I have been speaking of the differing qualities of the parts of the same fruit, I am content to add two things: the one, that *Garcias ab Horto*, a classic author, (and physician to the *Indian* viceroy) affirms* with some solemnity, (as wondering that a learned man should write otherwise) that though the fruit we call cassia fistula be very commonly used, both here and in the *Indies*, as a purging medicine, yet the seeds of this solutive cassia are astringent. The other, that of late years there have been often brought into *England* from the *Caribbe* islands certain kernels of a fruit, which those, that have seen it grow, liken to a white pear-plumb; these are so strongly purgative and also emetic, that the ingenious *Mr. Lygon* † tells us, that five of them wrought with him a dozen times upwards, and above twenty downwards; and yet the same author assures us, (which is likewise here a received tradition among them that are curious of this fruit,) that in the kernel, in the parting of it into halves, (as when our hazle-nuts in *England* part in the middle longways) you shall

find a thin film, which looks of a faint carnation, (which colour is easily enough discerned, the rest of the kernel being perfectly white,) and that taking out the film, you may eat the nut safely, without feeling any operation at all, and it is as sweet as a *Jordan* almond. [A learned man, that practised physic in *America*, being inquired of by me concerning the truth of this relation, answered, that though he had divers times given those nuts as cathartic remedies, yet he had not that curiosity to take out the films, finding it the universal belief, that the purgative faculty consisted therein.] And I remember, that the famous ‡ *Monardes* doth somewhat countenance this tradition, where, speaking of another purging fruit, that also comes from *America*, (from *Cartagena*, and *Nombre de Dios*) he takes notice, that these purging beans (which are like ours, but smaller) have a thin skin, that divides them through the middle, which must (together with the external rind) be cast away, else they will work so violently both upwards and downwards, as to bring the taker into hazard of his life: whereas he commends these beans, rightly prepared, not only as a pleasant medicine, that doth without trouble purge both choler, phlegm, and gross humours, for which it is celebrated among the *Indians*.

To these stories of our countrymen and *Monardes*, I shall subjoin another, which I find related by that great Rambler about the world, *Vincent le Blanck*, who giving us an account of a public garden, which he visited in *Africa*, in the territories of the Lord of *Casima*, not far from the borders of *Nubia*, which he represents as the curiousest garden he saw in all the East, he mentions this among other rarities: 'There were (says he) other sorts of fruit, which I never saw but there, and one among the rest, leaved like a sycamore, with fruit like the golden apple, but no gall more bitter, and within five kernels, as big as almonds, the juice whereof is sweet as sugar; betwixt the shell and the nut there grows a thick skin of a carnation colour, which taken before they be thoroughly ripe, they preserve with date vinegar, and make an excellent sweatmeat, which they present to the king as a great curiosity.'

IV.

THE fourth and last observation I shall at present mention, is afforded me by the consideration of rotten cheese. For if we take notice of the difference betwixt two parts of the same cheese, whereof the one continues sound by preserving its texture, and the other hath suffered that impairing alteration of texture we call rottenness; we may often see a manifest and notable change in the several portions of a body, that was before similar. For the rotten part will differ from the sound in its colour, which will be sometimes livid, but most commonly betwixt green and blue; and its odour, which will be both strong and offensive; and its taste, which will be very piquant, and to

* *Aromat. Hist. lib. 1. cap. 29. de Cassia solutiva.*

† *Lygon's History of Barbados pag. 67, 68.*

‡ See *Nicholaus Monardes* under the title, *Faba purgativa.*

some men much more pleasant than before, but to most men odious; and in divers other qualities, as particularly its consistence, it will be much less solid and more friable than before; and if with a good microscope we look upon the moulded parts of many cheeses, we shall quickly discover therein some swarms of little

animals, (the mites) furnished with variety of parts of differing sizes, shapes, textures, &c. and descry a yet greater diversity, both as to manifest qualities (nor probably is it inferior as to occult ones) betwixt the mouldy part of the cheese and the untainted, than the unassisted eye could otherwise have discovered.

ADVERTISEMENTS about the Ensuing SECTION II.

THE author would not have the reader think, that the following experiments are the sole ones, that he could have set down to the same purpose with them. For they are not the only, that he had actually laid aside for this occasion, till judging the ensuing ones sufficient for his present scope, he thought it fitter to reserve others for those notes about the production of particular qualities, to which they seemed properly to belong. Perhaps also it will be requisite for me (because some readers may think the omission a little strange) to excuse my having left divers particulars unmentioned in more than one of the ensuing experiments. And I confess, that I might easily enough both have taken notice of more circumstances in them, and made far more reflexions on them, if I would have expatiated on the several experiments, according to the directions delivered in other * papers. But though there, where it was my design to give employment to the curiosity and diligence of as many votaries to nature, as (for want of better instructions) had a mind to be so set on work, it was fit the proposed method should be suitable; yet here, where I deliver experiments not so much as part of natural history, as instances to confirm the hypotheses and discourses they are annexed to, it seemed needless and improper (if not impertinent) to set down circumstances, cautions, inferences, hints, applications, and other particulars, that had no tendency to the scope, for which the experiments were alledged.

AND as for the kind of experiments here made choice of, I have the less scrupled to pitch upon chymical experiments rather than others on this occasion; not only because of those advantages, which I have ascribed to such experiments in the latter part of the † preface to my Specimens, but because I have been encouraged by the success of the attempt made in those discourses. For as new as it was, when I made it four or five years ago, and as unusual a thing as it could seem to divers Atomists and Cartesians, that I should take upon me to confirm and illustrate the notions of the Particularian philosophy (if I may so call it) by the help of an art, which many were pleased to think cultivated but by illiterate operators or whimsical fanatics in philosophy, and useful only to make medicines or disguise metals: yet these endeavours of ours met with much less opposition, than new attempts are most commonly fain to struggle with. And in so short a time I have had the happiness to engage both

divers chymists to learn and relish the notions of the corpuscular philosophy, and divers eminent embracers of that to endeavour to illustrate and promote the new philosophy, by addicting themselves to the experiments, and perusing the books of chymists. And I acknowledge, it is not unwelcome to me to have been (in some little measure) instrumental to make the corpuscularian philosophy, assisted by chymistry, preferred to that, which has so long obtained in the schools. For (not here to consider, which I elsewhere do, how great an advantage that philosophy hath of this, by having an advantage of it in point of clearness) though divers learned and worthy men, that knew no better principles, have, in cultivating the Peripatetick ones, abundantly exercised and displayed their own wit; yet I fear they have very little, if at all, improved their reader's intellect, or enriched it with any true or useful knowledge of nature; but have rather taught him to admire their subtlety, than understand hers. For to ascribe all particular phenomena, that seem any thing difficult, (for abundance are not thought so, that are so,) to substantial forms, and but nominally understood qualities, is so general and easy a way of resolving difficulties, that it allows naturalists, without disparagement, to be very careless and lazy, if it do not make them so; as in effect we may see, that in about two thousand years since Aristotle's time, the adorers of his physicks, at least by virtue of his peculiar principles, seem to have done little more than wrangle, without clearing up (that I know of) any mystery of nature, or producing any useful or noble experiment: whereas the cultivators of the particularian philosophy, being obliged by the nature of their hypothesis, and their way of reasoning, to give the particular accounts and explications of particular phenomena of nature, are also obliged, not only to know the general laws and course of nature, but to inquire into the particular structure of the bodies they are conversant with, as that, wherein, for the most part, their power of acting and disposition to be acted on does depend. And in order to this, such inquirers must take notice of abundance of minute circumstances; and to avoid mistaking the causes of some of them, must often make and vary experiments; by which means nature comes to be much more diligently and industriously studied, and innumerable particulars are discovered and observed, which in the lazy Aristotelian way of philosophizing would not be heeded. But to return to that

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* Containing some advices and directions for the writing of an experimental natural history

† The preface here mentioned, is that premised to the tract intitled, — *Some Specimens of an attempt to make Chymical Experiments useful to illustrate the notions of the Corpuscular Philosophy.*

decade of instances, to which these advertisements are premised; I hope I need not make an apology for making choice rather of chymical experiments, than others, in the second and concluding section of the historical part of the present treatise. But though I prefer that kind of instances, yet I would not be thought to overvalue them in their kind, or to deny, that some artists may (for aught I know) be found, to whose chymical arcana these experiments may be little better than trifles. Nor perhaps are these the considerablest, that I my self could easily have communicated; (though these them-

selves would not be now divulged, if I would have been ruled by the dissuasions of such, as would have nothing of chymical made common, which they think considerable.) But things of greater value in themselves, and of noble use in physick, may be less fit for our present purpose, (which is not to impart medicinal, or alchymistical processes, but illustrate philosophical notions,) than such experiments as these; which, besides that they contain variety of phænomena, do not (for the most part) require either much time, or much charge, or much skill.

SECTION II.

Containing the EXPERIMENTS.

Experiment I.

TAKE good and clear oil of vitriol, and cast into it a convenient quantity of good camphire grossly beaten; let it float there a while, and, without the help of external heat, it will insensibly be resolved into a liquor, which, from time to time, as it comes to be produced, you may, by shaking the glass, mingle with the oil of vitriol; whereunto you may by this means impart first a fine yellow, and then a colour, which though it be not a true red, will be of kin to it, and so very deep, as to make the very mixture almost quite opacous. When all the camphire is perfectly dissolved by incorporating with the menstruum, if you hit upon good ingredients, and upon a right proportion, (for a slight mistake in either of them may make this part of the experiment miscarry) you may probably obtain such a mixture, as I have more than once had; namely, such a one, as not only to me, whose sense of smelling is none of the dullest, but also to others, that knew not of the experiment, seemed not at all to have an odour of the camphire. But if into this liquor you pour a due quantity of fair water, you will see (perhaps not without delight) that, in a trice, the liquor will become pale, almost as at the first, and the camphire, that lay concealed in the pores of the menstruum, will immediately disclose itself, and immerse in its own nature and pristine form of white floating and combustible camphire, which will fill not the phial only, but the neighbouring part of the air with its strong and diffusive odour.

Now the phænomena of this experiment may, besides the uses we elsewhere make of it, afford us several particulars pertinent to our present purpose.

I. For (first) we see a lighter and consistent body brought by a comminution into particles of a certain figure, to be kept swimming and mixed with a liquor, on which it floated before, and which is, by great odds, heavier than itself: so that as by the solution of gold in *aqua regis* it appears, that the ponderouslest of bodies, if it be reduced to parts minute enough, may be kept from sinking in a liquor much lighter than itself; so this experiment of ours manifests, what I know not whe-

ther hitherto men have proved, that the corpuscles of lighter bodies may be kept from emerging to the top of a much heavier liquor. Which instance being added to that of the gold, may teach us, that when bodies are reduced to very minute parts, we must as well consider their particular texture, as the received rules of the hydrostaticks, in determining whether they will sink, or float, or swim.

II. THIS experiment also shews, that several colours, and even a very deep one, may soon be produced by a white body and a clear liquor, and that without the intervention of fire or any external heat.

III. AND that yet this colour may, almost in the twinkling of an eye, be destroyed, and as it were annihilated; and the latent whiteness, as many would call it, may be as suddenly restored by the addition of nothing but fair water, which has no colour of its own; upon whose account it might be surmised to be contrary to the perishing colour, or to heighten the other into a predominancy: nor does the water take into it self either the colour it destroyed, or that it restores. For

IV. THE more than semi-opacity of the solution of camphire and oil of vitriol does presently vanish; and that menstruum, with the water, make up (as soon as the camphorate corpuscles come to be afloat) one transparent and colourless liquor.

V. AND 'tis worth noting, that upon the mixture of a liquor, which makes the fluid much lighter, (for so water is in respect of vitriol) a body is made to emerge, that did not so, when the fluid was much heavier. This experiment may serve to countenance what we elsewhere argue against the schools, touching the controversy about mistion. For whereas though some of them dissent, yet most of them maintain, that the elements always lose their forms in the mixed bodies they constitute: and though, if they had dexterously proposed their opinion, and limited their assertions to some cases, perhaps the doctrine might be tolerated; yet since they are wont to propose it crudely and universally, I cannot but take notice, how little it is favoured by this experiment; wherein even a mixed body (for such is camphire) doth in a further mistion retain

tain its form and nature, and may be immediately so divorced from the body, to which it was united, as to turn, in a trice, to the manifest exercise of its former qualities. And this experiment being the easiest instance I have devised of the preservation of a body, when it seems to be destroyed, and of the recovery of a body to its former conditions, I desire it may be taken notice of, as an instance I shall after have occasion to have recourse to and make use of.

VI. BUT the notablest thing in the experiment is, that odours should depend so much upon texture; that one of the subtlest and strongest-scented drugs, that the East it self, or indeed the world affords us, should so soon quite lose its odour, by being mixed with a body, that has scarce, if at all, any sensible odour of its own; and this, while the camphorate corpuscles survive undestroyed in a liquor, from whence one would think, that less subtle and fugitive bodies than they should easily exhale.

VII. NOR is it much less considerable, that so strong and piercing a scent as that of camphire should be, in a moment, produced in a mixture, wherein none of it could be perceived before, by such a liquor as water, that is quite devoid of any odour of its own: which so easy and sudden restauration of the camphire to its native scent, as well as other qualities, by so languid a liquor as common water, doth likewise argue, that the union or texture of the two ingredients, the camphire and the oil of vitriol, was but very slight, upon which nevertheless a great alteration in point of qualities depended. And to confirm, that divers of the preceding phenomena depend upon the particular texture of the liquors employed to exhibit them, I shall add, that if instead of oil of vitriol you cast the concrete into well-dephlegmed spirit of nitre, you will obtain no red nor dark, but a transparent and colourless solution. And when to the above mentioned red mixture I put, instead of fair water, about two or three parts of duely rectified spirit of wine, there would ensue no such changes, as those formerly recited; but the spirit of wine, that dissolved the concrete, when it was by it self, without losing its diaphaneity, or acquiring any colour, did, when it dissolved the mixture, dissolve it with its new adventitious colour, looking like a gross red wine, somewhat turbid, or not yet well freed from its lees: so that this colour appeared to reside in the mixture as such, since neither of the two ingredients dissolved in, or mingled with the spirit of wine, would have afforded that colour, or indeed any other. But if to this liquor, that looked like troubled wine, we poured a large proportion of fair water, the redness would immediately vanish, and the whole would, as to sense, become white throughout: I say, as to sense, because the whiteness did not indeed appertain properly to the whole mixture, but to a huge multitude of little corpuscles of the revived concrete, whereof some or other, which at first swam confusedly to and fro, left no sensible portion of the

liquor unfurnished with some of them; whereas when the camphirate corpuscles had leisure to emerge, as they soon did, they floated in the form of a white powder or froth at the top of the liquor, leaving all the rest as clear and colourless as the common water.

BUT we have not yet mentioned all the use we designed to make of our mixture; for by prosecuting the experiment a little further, we made it afford us some new phenomena.

VIII. For having kept the mixture in a moderately warm place, (which circumstance had perhaps no influence on the success,) and having distilled it out of a glass retort, the event answered our expectation, and the liquor, that came over, had a scent; which, though very strong, was quite differing both from that of the mixture, and that of the camphire; and in the remaining body, though the liquor and the camphire it consisted of, were either both transparent, or the one transparent as a liquor, and the other white, as transparent colourless bodies are wont to be made by confusion: yet the remaining mass, which amounted to a good part of the mixture, was not only opacous, but as black as coal, in some places looking just like polished jet; which is the more considerable, because, that though vegetable substances, that are not fluid, are wont to acquire a blackness from the fire, yet neither do liquors, that have already been distilled, obtain that colour upon redistillation; neither have we, upon trial purposely made, found, that camphire, exposed to fire in a retort, fitted with a receiver, (which was the case of the present experiment) would at all acquire a jetty colour, but would either totally ascend white, or afford *stoes* and a *caput mortuum* (as a vulgar chymist would call the remains) of the same colour, both in respect of one another, and in respect of the camphire.

IX. AND our experiment afforded this notable phenomenon, that though oil of vitriol be a distilled liquor, and though camphire be so very fugitive a substance, that being left in the air it will of itself fly all away, and therefore physicians and druggists prescribe the keeping it in linseeds or millium, or other convenient bodies, to hinder its avolation; yet, by our experiment, its fugacity is so restrained, that not only the *caput mortuum*, newly mentioned, endured a good fire in the retort, before it was reduced to that pitchy substance we were lately mentioning; but having taken some of that substance out of the retort, and ordered it by a careful workman to be kept in a closely covered crucible during some time in the fire, when it was brought me back, after the pot had been kept red-hot above half an hour, there remained a good quantity of the matter, brittle, without any smell of camphire, and as black as ordinary charcoal: so much do the fixity and volatility of bodies depend upon texture.

Experiment II.

AMONG those experiments of mine, *Pyrophilus*, which tend to manifest, that new qualities may be produced in bodies, as the effects of new textures; I remember, some years ago,

Considerations and Experiments touching

ago, I writ for a friend a whole set of trials, that I had made about the changes I could produce in metals and minerals by the intervention of sublimate. But though the whole tract, wherein they are recited, might be pertinent enough to our present subject, yet reserving other passages of it for other places, (especially for our notes upon those particular qualities, which they are most proper to illustrate,) it may at this time suffice me to send you a transcript of what that account contains relating to copper and silver, the one a mean and fugitive, and the other a noble and fixed metal. For those changes in colour, consistence, fusibleness, and other qualities, which you will meet with in these experiments, will afford us divers phenomena, to shew what great changes may be made, even in bodies scarce corruptible, by one or more of those three catholic ways of nature's working according to the corpuscular principles; namely, the access, the recess, and the transposition of the minute particles of matter.

As for my method of changing the texture of copper, I confess it hath oftentimes seemed strange to me, that chymists, plainly seeing the notable effect, that sublimate distilled from antimony has upon that mineral, by opening it and volatilizing it, (as we see it do in the making of what they are pleased to call *Mercurius vitæ*) should not have the curiosity to try, whether or no sublimate might not likewise produce, if not the same, yet a considerable change in other mineral bodies; there appearing no reason, or at least there having been none given, that I know of, why the refering operation (if I may so speak) of sublimate should be confined to antimony. Upon these considerations, we were invited to endeavour to supply the neglect we had observed in chymists of improving the experiment of *Butyrum Antimonii*: and though an indisposition in point of health, which beset us before we had made any great progress in our inquiries, made us so shy of fumes of sublimate and minerals, that we neither did make all our trials so accurately, nor prosecute them so far as we would have done, had we been to deal with more innocent materials; yet we suppose it will not be unwelcome to you to receive from us a naked, but faithful, narrative of our proceedings; being apt to think, that you will therein find inducements to carry on this experiment further than we have done, and to compleat what we have but begun.

FIRST then, we took half a pound of copper plates, of about an inch broad, and the thickness of a grain of wheat, (which we after found was too great) and of an arbitrary length; then casting a pound of grossly beaten Venetian sublimate into the bottom of a somewhat deep glass retort, we cast in the copper plates upon it, that the fumes of the sublimate might, in their ascension, be compelled to act upon the incumbent metal: and then placing this retort as deep as we well could in a sand furnace, and adapting to it a small receiver, we administered a gradual fire seven or eight hours, and at length for a while increased the heat, as much as we well could do in such a furnace.

The success of this operation was as follows.

1. THERE came little or no liquor at all over into the receiver, but the neck and upper part of the retort were candied on the inside, by reason of the copious sublimate adhering to them, which sublimate weighed above ten ounces: in the retort we found about two ounces and a quarter of running mercury, which had been suffered to revive by the acid salts, which corroding the copper, forsook the quicksilver, whereto they had been in the sublimate united.

2. UPON the increase of the fire there was plainly heard a noise, made by the melting matter in the retort, not unlike that of a boiling pot, or of vitriol, when, being committed to a calcining fire, it is first brought to flow. And this noise we found to be a more constant circumstance of this experiment, than the revivification of part of the mercury contained in the sublimate: for upon another trial made with the former proportion of copper plates and sublimate, we observed, during a very long while, such a noise as hath been already mentioned; but the operation being finished, we scarce found so much as a few grains of running mercury either in the retort or receiver.

3. WE found the metalline lump in the bottom of the retort to have been increased in weight somewhat more than (though not half an ounce above) two ounces; some of the copper plates, lying at the bottom of the mass, retained yet their figure and malleableness, which we ascribe to their not having been thin enough to be sufficiently wrought upon by the sublimate: the others, which were much the greater number, had wholly lost their metalline form, and were melted into a very brittle lump which I can compare to nothing more fitly than a lump of good benjamin. For this mass, though ponderous, was no less brittle, and being broken, appeared of divers colours, which seemed to be almost transparent, and in some places it was red, in others of a high and pleasant amber colour, and in other parts of it colours more darkish and mixt might be discerned.

4. BUT this strange mass, being broken into smaller lumps, and laid upon a sheet of white paper in a window, was by the next morning, where-ever the air came at it, all covered with a lovely greenish blue, or rather bluish green, almost like that of the best verdigreese; and the longer it lay in the air, the more of the internal parts of the fragments did pass into the same colour: but the white paper, which in some places they stranded, seem dyed of a green colour inclining unto yellow. And here we had occasion to take notice of the insinuating subtilty of the air; for having put some pieces of this cupreous gum (if I may so call it) into a little box, to shut out the air, which we have found it possible to exclude by other means, we found, that notwithstanding our care those included fragments were, as well as the rest already mentioned, covered with the powder as it were of *viride æris*.

5. WE must not on this occasion omit to tell you, that having the last year made some trials in reference to this experiment, we observed

ferred in one of them, that some little copper-plates, from which sublimate had been drawn off, retained their pristine shape and metalline nature, but were whitened over like silver, and continued so for divers months; (though we cannot precisely tell you how long, having at length accidentally lost them.) And to try whether this whiteness were only superficial, we purposely broke some of these flexible plates, and found, that this silver colour had penetrated them throughout, and was more glorious in the very body of the metal, than on its surface; which made us suspect, that the sublimate by us employed had been adulterated with arsenick, (wherewith the sophistators of metals are wont to make blanchers for copper, but not to mention, that the malleableness continued, which arsenick is wont to destroy) we discovered not by trial, that the sublimate was other than sincere.

6. In this metalline gum the body of the copper appeared so changed and opened, that we were invited to look upon such a change as no ignoble experiment, considering the difficulty, which the best artists tell us there is, and which those, that have attempted it, have found; I say, not to unlock the sulphur of Venus, but to effect less changes in its texture, than was hereby made. For this gum, cast upon a quick coal and a little blown, will partly melt and flow like rosin, and partly flame and burn like a sulphur, and with a flame so lasting, if it be rekindled as often as it leaves off burning, that we observed it, not without some wonder; and so inflammable is this opened copper, that being held to the flame of a candle or a piece of lighted paper, it would almost in a moment take fire, and send forth a flame like common sulphur, but only that it seemed to us to incline much more to a greenish colour, than the bluer flame of brimstone is wont to do.

To these phenomena of our experiment, as it was made with copper, my notes enable me to subjoin some others, exhibited; when he made it with sublimate and silver.

THERE were taken of the purest sort of coined silver we could get, half a score of thin plates, on which was cast double the weight of sublimate in a small and strongly-coated retort. This matter being sublimed in a naked fire, we found, (having broken the vessel) that the sublimate was almost totally ascended to the top and neck of the retort; in the latter of which, appeared in many places some revived mercury; in the bottom of the retort we found a little fluxed lump of matter, which it was scarce possible to separate from the glass; but having, with much ado, divorced them, we found this mass to be brittle, of a pale yellowish colour, of near about the weight of the metal, on which the sublimate had been cast. And in the thicker part of this lump there appeared, when it was broken, some part of the silver plates, which, though brittle, seemed not to have been perfectly dissolved. This resin of silver did, like that of copper, but more slowly, imbibe the moisture of the air, and within about twenty-four hours, was covered

with a somewhat greenish dust, concerning which we durst not determine, whether it proceeded from that mixture of copper, which is generally to be met with in coined silver, or from the compounded metal. For the more curious sort of painters do, as they inform us, by corroding coined silver with the fretting steams of saline bodies, or with corrosive bodies themselves, turn it into a fine kind of azure, as we may elsewhere have opportunity more particularly to declare. I shall now only add, that some small fragments of our resin being cast upon red-hot coals, did there waste themselves in a flame, not very differing in colour from that of the former mentioned resin of copper, but much more durable, than would have been easily expected from so small a quantity of matter.

THIS is all the account I can give you of our first trial; but suspecting, that the copper wont to be mixed as an alloy with our coined silver might have too much influence on the recited event, coming afterwards into a place, where we could procure refined silver, we took an ounce of that, and having laminated it, we cast it upon twice its weight of beaten sublimate, which being driven away from it with a somewhat strong fire, we took out of the bottom of the glass retort a lump of matter, which in some places, where it lay next the glass, was as it were silvered over very finely, but so very thinly, that the thickness of the silver scarce equalled that of fine white paper; the rest of the metal (except a little, that lay undissolved almost in the middle of the mass, because, as we supposed, the plates had not been beaten, till they were sufficiently and equally thin) having been, by the saline part of the sublimate, that stuck to it, colliquated into a mass, that looked not at all like silver, or so much as any other metal or mineral.

AND it is remarkable, that though silver be a fixed metal, and accounted indestructible, yet it should by so slight an operation, and by but about a quarter of its weight of additament, (as appeared by weighing the whole lump) be so strangely disguised, and have its qualities so altered.

FOR (first) though an eminent whiteness be accounted the colour, which belongs to pure silver, and though beaten sublimate be also eminently white; yet the mass we are speaking of was partly of a lemon or amber colour, or a deep amethystine colour, and partly of so dark an one, as it seemed black: and it was pretty, that sometimes in a fragment, that seemed to be one continued and entire piece, the upper part would be of a light yellow, which abruptly ending, the lower was of a colour so obscure, as scarce to challenge any name distinct from black.

NEXT, Whereas silver is one of the most opacous bodies in nature, and sublimate a white one, the produced mass was in great part transparent, though not like glass, yet like good amber.

THIRDLY, The texture of the silver was exceedingly altered; for our mass, instead of being malleable and flexible, as that metal is

very much, appeared, if you went about to cut it with a knife, like horn, yet otherwise easily apt to crack and break, though not at all to bend.

FOURTHLY, Whereas silver will endure ignition for a good while, before it be brought to fusion, our mixture will easily melt, not only upon quick coals, but in the flame of a candle; but this resin, or gum (if I may so call it) of our fixed metal did not, like that we formerly described of copper, tinge the flame of a candle, or produce with the glowing coals, on which it is laid, either a green or bluish colour.

AND, *Pyrophilus*, to discover, how much these operations of the sublimate upon copper and silver depend upon the particular textures of these bodies, I took two parcels of gold, the one common gold thinly laminated, and the other very well refined, and having cast each of these in a distinct urinal upon no less than thrice its weight of grossly beaten sublimate, I caused this last named substance to be in a sand-furnace elevated from the gold, but found not, that either of the two parcels of that metal was manifestly altered thereby: whether in case the gold had been reduced to very minute particles, some kind of change (perhaps, if any, differing enough from those lately recited to have been made in the copper and the silver) might have been made in it, I am not so absolutely certain; but I am confident, that by what I reserve to tell you hereafter of sublimate's operation upon some other minerals, especially tin, it will appear, that that operation depends very much upon the particular texture of the body, from whence that sublimate is elevated.

BEFORE I dismiss this subject, *Pyrophilus*, I must not conceal from you, that in the papers, whence these experiments made with sublimate have been transcribed, I annexed to the whole discourse a few advertisements, whereof the first was, that I was reduced in those experiments to employ, for want of a better, a sand-furnace, wherein I could not give so strong a fire as I desired; which circumstance may have had some influence upon the recited phenomena; and among other advertisements there being one, that will not be impertinent to my present design, and may possibly afford a not unsuccessful hint, I shall subjoin it in the words, wherein I find it delivered.

THE next thing, of which I am to advertise you, is this, that this experiment may probably be further improved by employing about it various and new kinds of sublimate; and that several other things may be sublimed up together either with crude mercury or with common sublimate, he, that considers the way of making vulgar sublimate, will not, I suppose, deny. To give you only one instance, I shall inform you, that, having caused about equal parts of common sublimate and sal armoniack to be well powdered and incorporated, by subliming the mixture in strong and large urinals placed in a sand-furnace, we obtained a new kind of sublimate, differing from the former, which we manifested *ad oculum*, by dissolving a little of it and a little of common sub-

limate severally in fair water: for dropping a little resolved salt of tartar upon the solution of common sublimate, it immediately turned of an orange-tawny colour; but dropping the same liquor upon the solution of the armoniack sublimate, if I may so call it, it presently turned into a liquor, in whiteness resembling milk. And having from four ounces of copper-plates drawn six ounces of this new sublimate after the already often recited manner, we had indeed in the bottom of the retort a cupreous resin, not much unlike that, made by copper and common sublimate; and this resin did, like the other, in the moist air soon begin to degenerate into a kind of verdigreefe. But that, which was singular in this operation, was, that not only some of the sublimate had carried up, to a good height, enough of the copper to be manifestly coloured by it of a fine bluish green, but into the receiver there was passed near an ounce of liquor, that smelt almost like spirit of sal armoniack, and was tinged like the sublimate, so that we supposed the body of the *Venus* to have been better wrought upon by this, than by the former sublimate. And yet I judged not this way to be the most effectual way of improving common sublimate, being apt to think, upon grounds not now to be mentioned, that it may by convenient liquors be so far enriched and advanced, as to be made capable of opening the compact body of gold itself, and of producing in it such changes, (which yet perhaps will enrich but men's understandings) as chymists are wont very fruitlessly to attempt to make in that almost indestructible metal. But of this, having now given you a hint, I dare here say no more.

Experiment III.

THERE is, *Pyrophilus*, another experiment, which many will find more easy to be put in practice, and which yet may, as to silver, be made a kind of succedaneum to the former, and consequently may serve to shew, how the like qualities in bodies may be effected by differing ways, provided a like change of texture be produced by them. Of this I shall give you an example in that preparation of silver, that some chymists have called *Luna Cornea*, which I shall not scruple to mention particularly, and apply to my present purpose; because though the name of *Luna Cornea* be already to be met with in the writings of some alchymists, yet the thing itself, being not used in physick, is not wont to be known by those, that learn chymistry in order to physick; and the way that I use in making it is differing from that of alchymists, being purposely designed to shew some notable phenomena, not to be met with in their way of proceeding.

WE take then refined silver, and having beaten it into thin plates, and dissolved it in about twice its weight of good aqua fortis, we filtrate it carefully to obtain a clear solution, (which sometimes we evaporate further, till it shoot into crystals, which we afterwards dry upon brown paper with a moderate heat.)

UPON the abovementioned solution we drop good spirit of salt, till we find, that it will no more

more curdle the liquor it falls into, (which will not happen so soon, as you will be apt at first to imagine;) then we put the whole mixture in a glass funnel lined with cap-paper, and letting the moisture drain through, we dry with a gentle heat the substance, that remains in the filtre, first washing it (if need be) from the loosely adhering salts, by letting fair water run through it several times, whilst it yet continues in the filtre. This substance being well dried, we put it into a glass phial, which being put upon quick coals first covered with ashes, and then freed from them, we melt the contained substance into a mass, which, being kept a while in fusion, gives us the *Luna Cornea* we are now to consider.

IF to make this factitious concrete, we first reduce the silver into crystals, and afterwards proceed with spirit of salt, as we have just now taught you to do with the solution, we have the exceedingly opacous, malleable, and hardly fusible body of silver, by the convenient interposition of some saline particles, not amounting to the third part of the weight of the metal, reduced into crystals, that both shoot in a peculiar and determinate figure, differing from those of other metals, and also are diaphanous and brittle, and by great odds more easily fusible than silver it self, besides other qualities, wherein having elsewhere taken notice, that these crystals differ both from silver and from aqua fortis, we shall not now insist on them, but pass to the qualities, that do more properly belong to the change of the solution of silver into *Luna Cornea*.

FIRST then we may observe, that though spirit of salt be an highly acid liquor, and though acid liquors and alkalies are wont to have quite contrary operations, the one precipitating what the other would dissolve, and dissolving what the other would precipitate; yet in our case, as neither oil of tartar *per deliquium*; nor spirit of salt will dissolve silver, so both the one and the other will precipitate it; which I desire may be taken notice of against the doctrine of the vulgar chymists, and as a proof, that the precipitation of bodies depends not upon acid or alkalizate liquors as such, but upon the texture of the bodies, that happen to be confounded.

2. WE may here observe, that whiteness and opacity may be immediately produced by liquors, both of them diaphanous and colourless.

3. THAT, on the other side, a white powder, though its minute parts appear not transparent, like those of beaten glass, resin, &c. which, by comminution, are made to seem white, may yet, by a gentle heat, be presently reduced into a mass indifferently transparent, and not at all white, but of a fair yellow.

4. WE may observe too, that though silver require so strong a fire to melt it, and may be long kept red-hot, without being brought to fusion; yet by the association of some saline particles conveniently mingled with it, it may be made so fusible, as to be easily and quickly melted, either in a thin phial, or at the flame of a candle, where it will flow almost like wax.

5. IT may also be noted, that though the lu-

nar solutions and the spirit of salt would, either of them apart, have readily dissolved in water; yet when they are mingled, they do, for the most part, coagulate into a substance, that will lie undissolved in water, and is scarce, if at all, soluble either in aqua fortis or in spirit of salt.

6. AND remarkable it is, that the body of silver being very flexible and malleable, (especially if the metal be, as ours was, refined) it should yet, by the addition of so small a proportion of salt, (a body rigid and brittle) as is associated to it in our experiment, be made of a texture so differing from what either of its ingredients was before, being wholly unlike either a salt or a metal, and very like in texture to a piece of horn. And to satisfy my self how much the toughness of this metalline horn depended upon the texture of the *composition*, resulting from the respective textures of the several ingredients, I precipitated a solution of silver with the distilled saline liquor commonly called oil of vitriol, instead of spirit of salt; and having washed the precipitate with common water, I found, agreeably to my conjecture, that this precipitate, being fluxed in a moderate heat, afforded a mass, that looked like enough to the concrete we have been discoursing of, but had not its toughness, being brittle enough to be easily broken in pieces. But the two considerablest phenomena of our experiment do yet remain unmentioned.

FOR, 7thly, it is odd, that whereas a solution of silver is, as we have often occasion to note, the bitterest liquor we have ever met with, and the spirit of salt far sourer than either the sharpest vinegar, or even the spirit of it, these two so strongly and offensively tasted liquors should be so easily and speedily, without any other thing to correct them, be reduced into an insipid substance, (at least so far insipid, that I have licked it several times with my tongue, without finding it otherwise, though perhaps with much rolling it to and fro in the mouth, it may at length afford some unpleasant taste, but exceedingly different from that of either of the liquors, that composed it;) and this, though the salts, that made both the silver and the precipitating spirit so strongly tasted, remain associated with the silver.

8. AND lastly, it is very strange, that though the saline corpuscles, that give the efficacy both to good aqua fortis and the like spirit of salt, be not only so volatile, that they will easily be distilled with a moderate fire, but so fugitive, that they will in part fly away of themselves in the cold air, (as our noses can witness to our trouble, when the phials, that contain such liquors, are unstopped;) yet by virtue of the new texture they acquire by associating themselves with the corpuscles of the silver and with one another, these minute particles of salt lose so much of their former lightness, and acquire such a degree of fixedness, that they will endure melting with the metal they adhere to, rather than suffer themselves to be driven away from it. Nor do I remember, that when I melted this mass in a thin phial, I could perceive any sensible evaporation of the matter: nay, having afterwards put a parcel of

it upon a quick coal, though that were blown to intend the heat; yet it suffered fusion, and so ran off from the coal, without appearing, when it was taken up again, to be other than *Luna Cornea*, as it was before.

Experiment IV.

I AM now, *Pyrophilus*, about to do a thing, contrary enough both to my custom and inclination; that is, to discourse upon the phenomena of an experiment, which I do not teach you to make. But since I cannot as yet, without some breach of promise, plainly disclose to you what I must now conceal, your equity assures me of your pardon. And as because the qualities of the salt I am to speak of are very remarkable, and pertinent to my present purpose, I am unwilling to pass them by unmentioned; so I hope, that, notwithstanding their being strange, I may be allowed to discourse upon them to you, who, I presume, know me too well to suspect I would impose upon you in matters of fact, and to whom I am willing (if you desire it) to shew the anomalous salt it self, and ocular proofs of the chief properties I ascribe to it.

I SHALL not then scruple to tell you, that discoursing one day with a very ingenious traveller and chymist, who had had extraordinary opportunities to acquire secrets, of a certain odd salt I had thought upon and made, which was of so differing a kind from other salts, that though I did not yet know what feats I should be able to do with it, yet I was confident it must have noble and unusual operations: this gentleman, to requite my frankness, told me, that I had lighted on a greater jewel than perhaps I was aware of; and that if I would follow his advice, by adding something, that he named to me, and prosecuting the preparation a little further, I should obtain a salt exceedingly noble. I thanked him, as I had cause, for his advice, and when I had opportunity, followed it. And though I found the way of making this salt so nice and intricate a thing, that if I would, I could scarce easily describe it, so as to enable most men to practise it; yet having once made it, I found, that besides some of the things I had been told it would perform, I could do divers other things with it, which I had good cause to believe the gentleman of whom I was speaking did not think of; and I doubt not, but I should have done much more with it, if I had not unfortunately lost it soon after I had prepared it.

SEVERAL of the phenomena I tried to produce with it, which are not so proper for this place, are reserved for another; but here I shall mention a few, that best fit my present purpose.

FIRST then, though the several ingredients, that composed this salt, were all of them such, as vulgar chymists must, according to their principles, look upon as purely saline, and were each of them far more salt than brine, or more four than the strongest vinegar, or more strongly tasted than either of those two liquors; yet the compound, made up of only such bodies, is so far from being eminently salt, or

four, or insipid, that a stranger being asked what taste it had, would not scruple to judge it rather sweet, than of any other taste; though its sweetness be of a peculiar kind, as there is a difference even among bodies sweet by nature; the sweetness of sugar being diverse from that of honey, and both of them differing from that of the sweet vitriol of lead. And this is the only instance I remember I have hitherto met with of salts, that, without the mixture of insipid bodies, compose a substance really sweet. I say, really sweet, because chymists oftentimes term the calces of metals, and other bodies dulcified, if they be freed from all corrosive salts and sharpness of taste, sweet, though they have nothing at all of positive sweetness in them; and by that licence of speaking do often enough impose upon the unskilful.

ANOTHER thing considerable in our anomalous salt is, that though its odour be not either strong or offensive, (both which that of volatile salts is wont to be;) yet if it be a little urged with heat, so as to be forced to evaporate hastily and copiously, I have known some, that have been used to the powerful stink of aqua fortis, distilled urine, and even spirit of sal armoniack itself, that have complained of this smell as more strong, and upon that account more unsupportable than these themselves: and yet when these fumes settle again into a salt, their odour will again prove mild and inoffensive, if not pleasant.

THIRDLY, Whereas all the volatile and acid and lixivate salts, that we know of, are of so determinate and specificated a nature, if I may so speak, that there is no one sort of the three, but may be destroyed by some one or other of the other two salts, if not by both; as spirit of urine, which is a volatile salt, being mingled with spirit of salt or aqua fortis or almost any other strong and acid spirit, will make a great ebullition, and lose its peculiar taste, and several of its other qualities; and, on the other side, salt of tartar and other alkalies, (that is, salts produced by incineration of mixed bodies) will be destroyed with ebullition by aqua fortis, spirit of salt, or almost any other strong spirit of that family: and spirit of salt, aqua fortis, &c. will be (as they speak) destroyed both by animal volatile salts, and by the fixed salts of vegetables; that is, will make an effervescence with either sort of salts, and compose with them a new liquor or salt, differing from either of the ingredients, and, as to taste, smell, odour, and divers other qualities, more languid and degenerate: whereas, I say, each of these three families of salts may be easily destroyed by the other two, our anomalous salt seems to be above the being thus wrought upon by any of all the three, and is the only body I know; (which is no small privilege, or rather prerogative:) For I did not find, that a solution of it, made with as little water as I could, which is the way whereby we usually make it fluid, would make any ebullition either with oil of tartar *per deliquium*, or spirit of sal armoniack, or strong spirit of salt, or even oil of vitriol, but would calmly and silently

lently mix with these differing liquors, and continue as long as I had patience to look upon them, without being precipitated by them. But this is not the only way I employed, to examine, whether our salt belonged to any of the three abovementioned comprehensive families of salts. For I found not, that the strongest solution of it would turn syrup of violets either red, as acid spirits do, or green, as both fixed and volatile salts will do. Nor would our solution turn a clear one of sublimate made in common water either white, as spirit of urine, sal armoniack, or others of the same family, or into an orange-tawny, like salt of tartar, and other alkalies; but left the solution of sublimate transparent, without giving it any of these colours, mingling itself very kindly with it, as it had done with the four lately mentioned liquors. And to satisfy myself a little further, I not only tried, that an undischoloured mixture of syrup of violets and our solution would immediately be turned red by two or three drops of spirit of salt, or green by as much oil of tartar; but to prosecute the experiment, I let fall a drop or two of a mixture made of our anomalous solution, and spirit of salt well shaken together, upon some syrup of violets; which was thereby immediately turned red, and a little of the same anomalous solution, being shaken together with oil of tartar *per deliquium*, turned another parcel of the same syrup of violets into a delightful green; which, happening as I expected, seemed to argue, that our solution, though as to sense it were exquisitely mingled in the several mixtures, to which I had put it, did, as it left them their undestroyed respective natures, retain its own: and yet this salt is so far from being a languid or an insignificant thing, that aqua fortis, and oil of vitriol themselves, as operative and as furious liquors as they are, are unable in divers cases to make such solutions, and perform such other things, as our calm but powerful menstruum can, though but slowly, effect.

FOURTHLY, Though this salt be a volatile one, and requires no strong heat to make it sublime into finely figured crystals without a remanence at the bottom; yet being dissolved in liquors, you may make the solution, if need be, to boil, without making any of the salt sublime up, before the liquor be totally or almost totally drawn off; whereas the volatile salt of urine, blood, hartshorn, &c. are wont to ascend before almost any part of the liquor they are dissolved in, which is in many cases very inconvenient.

AND though this be a volatile salt, yet I remember not, that I have observed any fixed salt, (without excepting salt of tartar itself) that runs near so soon *per deliquium*, as this will do; but by abstraction of the adventitious moisture, it is easily restored to its former saline form, and yet differs from salt of tartar, not only in fixedness and taste, and divers other qualities, but also in this, that, whereas salt of tartar requires a vehement fire to flux it, a gentler heat, than one would easily imagine, will melt our salt into a limpid liquor.

AND whereas spirit of wine will dissolve some bodies, as sanderick, mastick, gum-lac, &c.

and water, on the other side, dissolves many, that spirit of wine cannot, and oils will dissolve some, for which neither of the other liquors are good solvents; our salt will readily dissolve both in fair water, in the highest rectified spirit of wine, (and that so little, as not to weigh more than the salt) and in chymical oils themselves, with which it will associate itself very strictly, and perhaps more too, than I have yet found any other consistent salt to do.

Experiment V.

THE experiment I am, *Pyrophilus*, now about to deliver, though I have not yet had opportunity to perfect what I designed, when some notions, that I have about fire and salt, suggested it to me, is yet such, as may far more clearly, than almost any of the experiments commonly known to chymists, serve to shew us, how near to a real transmutation those changes may prove, that may be effected even in inanimate, and, which is more, scarce corruptible bodies, by the recess of some particles, and the access of some others, and the new texture of the residue. The experiment I have made several ways, but one of the latest and best I have used is this: Take one part of good sea-salt well dried and powdered, and put to it double its weight of good aqua fortis or spirit of nitre; then having kept it (if you have time) for some while in a previous digestion, distil it over with a slow fire in a retort or a low body, till the remaining matter be quite dry, and no more: for this substance, that will remain in the bottom of the glass, is the thing, that is sought for.

THIS operation being performable in a moderate fire, and the bodies themselves being almost of an incorruptible nature, one would scarce think, that so slight a matter should produce any change in them; but yet I found, as I expected, these notable mutations of qualities effected by so unpromising a way.

FOR in the first place, we may take notice, that the liquor, that came over, was no longer an aqua fortis, or spirit of nitre, but an aqua regis, that was able to dissolve gold; which aqua fortis will not meddle with, and will not dissolve silver, as it would have done before; but will rather, as I have purposely tried, precipitate it out of aqua fortis, if that menstruum have already dissolved it. But this change belonging not so properly to the substance it self I was about to consider, I shall not here insist on it.

2. THEN, the taste of this substance comes by this operation to be very much altered. For it hath not that strong saltiness, that it had before, but tastes far milder; and though it relish of both, affects the palate much more like salt-petre, than like common salt.

3. NEXT, whereas this last-named body is of very difficult fusion, our factitious salt imitates salt-petre in being very fusible; and it will, like nitre soon melt, by being held in the flame of a candle.

4. BUT to proceed to a more considerable phenomenon, it is known, that sea-salt is a body, that doth very much resist the fire; when once, by being brought to fusion, it hath been

forced to let go that windy substance, that makes unbeaten salt crackle in the fire, and so by blowing it accidentally increase it. It is also known, that acid spirits, as those of salt, vitriol, nitre, vinegar, &c. are not only not inflammable themselves, but hinderers of inflammation in other bodies; and yet my conjecture leading me to expect, that by this operation I should be able to produce out of two unflammable bodies a third, that would be easily inflammable, I found upon trial not only that small lumps of this substance, cast upon quick and well-blown coals, though they did not give so blue a flame as nitre, did yet, like it, burn away with a copious and vehement flame. And, for further trial, having melted a pretty quantity of this transmuted sea-salt in a crucible, by casting upon it little fragments of well-kindled charcoal, it would, like nitre, presently be kindled, and afford a flame so vehement and so dazzling, that one, that had better eyes than I, and knew not what it was, complained, that he was not able to support the splendour of it. Nor were all its inflammable parts consumed at one deflagration: for by casting in more fragments of well-kindled coal, the matter would fall a puffing, and flame afresh for several times consecutively, according to the quantity, that had been put into the crucible.

5. BUT this itself was not the chief discovery I designed by this experiment. For I pretended hereby to devise a way of turning an acid salt into an alkali, which seems to be one of the greatest and difficultest changes, that is rationally to be attempted among durable and inanimate bodies. For it is not unknown to such chymists, as are any thing inquisitive and heedful, how vast a difference there is between acid salts, and those, that are made by the combustion of bodies, and are sometimes called fixed, sometimes alkalizate. For whereas strong lixiviums (which are but strong solutions of alkalies) will readily enough dissolve common sulphur, and divers other bodies abounding with sulphur, even those highly acid liquors, aqua fortis and aqua regis, though so corrosive, that one will dissolve silver and the other gold itself, will let brimstone lie in them undissolved I know not how long; though some say, that in process of time there may be some tincture drawn by the menstruum from it, which yet I have not seen tried, and though it were true, would yet sufficiently argue a great disparity betwixt those acid spirits and strong alkalizate solutions, which will speedily dissolve the very mass of common sulphur. Besides, it is observed by the inquisitive chymists, nor does my experience contradict it, that the bodies, that are dissolved by an acid menstruum, may be precipitated by an alkalizate; and on the contrary, solutions made by the latter may be precipitated by the former. Moreover, as litharge dissolved in spirit of vinegar will be precipitated by the oil of tartar *per deliquium*, or the solution of its salt; and, on the contrary, sulphur or antimony dissolved in such a solution will be precipitated out of it by the spirit of vinegar, or even common vinegar: Moreover, acids and alkalizates do also differ

exceedingly in taste, and in this greater disparity, that the one is volatile, and the other fixed, besides other particulars not necessary here to be insisted on. And indeed if that were true, which is taught in the schools, that there is a natural enmity, as well as disparity betwixt some bodies, as between oily and waterish ones, the chymists may very speciously reach, (as some of them do) that there is a strange contrariety betwixt acid and alkalizate salts; as when there is made an affusion of oil of tartar upon aqua regis or aqua fortis, to precipitate gold out of the one, and silver out of the other, their mutual hostility seems manifestly to shew itself, not only by the noise, and heat, and fume, that are immediately excited by their conflict, but by this most of all, that afterwards the two contending bodies will appear to have mutually destroyed one another, both the four spirit and the fixed salt having each lost its former nature in the scuffle, and degenerated with its adversary into a certain third substance, that wants several of the properties both of the four spirit and the alkali. Now to apply all this to the occasion, on which I mentioned it, how distant and contrary soever the more inquisitive of the latter chymists take acid and fixed salts to be; yet I scarce doubted, but that, by our experiment, I should from acid salts obtain an alkali; and accordingly having, by casting in several bits of well-kindled coal, excited in the melted mass of our transmuted salt, as many deflagrations as I could, and then giving it a pretty strong fire to drive away the rest of the more fugitive parts, I judged, that the remaining mass would be (like the fixed nitre I have elsewhere mentioned) of an alkalizate nature; and accordingly having taken it out, I found it to taste, not like sea-salt, but fiery enough upon the tongue, and to have a lixivate relish. I found too, that it would turn syrup of violets into a greenish colour, that it would precipitate a limpid solution of sublimate, made in fair water, into an orange-tawny powder. I found, that it would, like other fixed salts, produce an ebullition with acid spirits, and even with spirit of salt it self, and concoagulate with them. Nor are these themselves all the ways I took to manifest the alkalizate nature of our transmuted sea-salt.

I DID indeed consider at first, that it might be suspected, that this new alkalizateness might proceed from the ashes of the injected coals, the ashes of vegetables generally containing in them more or less of a fixed salt. But when I considered too, that a pound of charcoal, burned to ashes, is wont to yield so very little salt, that the injected fragments of coal (though they had been, which they were not) quite burned out in this operation would scarce have afforded two or three grains of salt, (perhaps not half so much) I saw no reason at all to believe, that in the whole mass I had obtained, (and which was all, that was left me of the sea-salt, I had first employed,) it was nothing but so inconsiderable a proportion of ashes, that exhibited all the phenomena of an alkali.

AND for further confirmation both of this, and what I said a little before, I shall add, that

that to satisfy my self yet more, I poured upon a pretty quantity of this lixiviate salt a due proportion of aqua fortis, till the hissing and ebullition ceased, and then leaving the fluid mixture for a good while to coagulate, (which it did very slowly) I found it at length to shoot into saline crystals; which, though they were not of the figure of nitre, did yet, by their inflammability and their bigness, sufficiently argue, that there had been a conjunction made betwixt the nitrous spirit, and a considerable proportion of alkali.

I considered also, that it might be suspected, that in our experiment it was the nitrous corpuscles of the aqua fortis, that, lodging themselves in the little rooms deserted by the saline corpuscles of the sea-salt, that passed over into the receiver, had afforded this alkali; as common salt-petre, being handled after such a manner, would leave in the crucible a fixt or alkalizate salt. But to this I answer, that as the sea-salt, which was not driven over by so mild a distillation, and seemed much a greater part than that which had passed over, was far from being of an alkalizate nature; so the nitrous corpuscles, that are presumed to have staid behind, were, whilst they composed the spirit of nitre, of an highly volatile and acid nature, and consequently of a nature directly opposite to that of alkalies. And if by the addition of any other substance, that were no more alkalizate than sea-salt, an alkali could be obtained out of spirit of nitre of aqua fortis, the producibility of an alkali out of bodies of another nature might be rightly thence inferred: so that however it appears, that by the intervention of our experiment, two substances, that were formerly acid, are turned into one, that is manifestly of an alkalizate nature; which is that we would here evince.

Perhaps it may, *Pyrophilus*, be worth while to subjoin, that to prosecute the experiment by inverting it, we drew two parts of strong spirit of salt from one of purified nitre, but did not observe the remaining body to be any thing near so considerably changed as the sea-salt, from which we had drawn the spirit of nitre; since though the spirit of salt, that came over, did (as we expected) bring over so many of the corpuscles of the nitre, that being heated, it would readily enough dissolve foliated gold; yet the salt, that remained in the retort, being put upon quick coals, did flash away with a vehement and halituous flame, very like that of common nitre.

Experiment VI.

I Come now, *Pyrophilus*, to an experiment, which, though in some things it be of kin to that, which I have already taught you concerning the changing of sea-salt by aqua fortis, will yet afford us divers other instances, to shew, how upon the change of texture in bodies there may arise divers new qualities; especially of that sort, which, because they are chiefly produced by chymistry, and are wont to be considered by chymists, if not by them only, may in some sense be called chymical.

THE body, which, partly whilst we were

preparing it, and partly when we had prepared it, afforded us these various phenomena; either is the same, that *Glauberus* means by his *sal mirabilis*, or at least seems to be very like it: and whether it be the same or no, its various and uncommon properties make it very fit to have a place allowed it in this treatise; though of the many trials I made with it, I can at present find no more among my loose papers, than that following part of it, that I wrote some years ago to an ingenious friend, who I know will not be displeas'd, if, to save my self some time and the trouble of examining my memory, I annex the following transcript of it.

[To give you a more particular account of what I writ to you from *Oxford* of my trials about *Glauber's* salt, though I dare not say, that I have made the self-same thing, which he calls his *sal mirabilis*, because he has described it so darkly and ambiguously, that it is not easy to know with any certainty what he means; yet whether or no I have not made salt, that, as far as I have yet tried it, agrees well enough with what he delivers of his, and therefore is like to prove either his *sal mirabilis*, or almost as good a one, I shall leave you to judge by this short narrative.

THE strange things, that the industrious *Glauber's* writings have invited men to expect from his *sal mirabilis*, in case he be indeed possessed of such a thing, and the enquiries of divers eminent men, who would fain learn of me what I thought of its reality and nature, invited me, the next opportunity I got, to take into my hands his *Pars altera miraculi mundi*, whose title you know promises a description of this *sal artis mirificum*, as he is pleas'd to call it. But, I confess, I did not read it near all over, because a great part of it is but a transcription of several intire chapters out of *Paracelsus*, and I perceived, that much of the rest did, according to the custom of chymical writings, more concern the author than the subjects: wherefore looking upon his process of making his *sal mirabilis*, I soon perceived he had no mind to make it common, since he only bids us upon two parts of common salt dissolved in common water to pour *A*, without telling us what that *A* is. Wherefore reading on in the same process, and finding, that he tells us, that with *B* (which he likewise explains not at all, nor determines the quantity of it) one may make an aqua fortis, it presently called into my mind, that some years before having had occasion to make many trials, mentioned in other tracts of mine, with oil of vitriol and salt-petre, I did among other things make a red spirit of nitre, by the help only of oil of vitriol: Remembring this, I say, I resorted to one of my *Carneades's* dialogues*, and reviewing that experiment, as I have set it down, I concluded, that though I had not dissolved the salt-petre in water, as *Glauber* doth his common salt; yet since on the other side I made use of external fire, it was probable I might this way also get a nitrous spirit, though not so strong. And though by calling the liquor, that must make an aqua fortis, *B*; whereas he had called that, which is

to

* See the Sceptical Chymist.

to make his spirit of salt and *sal mirabilis*, A, he seem'd plainly to make them different things; yet relying on the experiment I had made, and putting to a solution of nitre as much of the oil of vitriol as I had taken last, though that be double the quantity he prescribes for the making of his *sal mirabilis*, I obtained out of a low glass body and head in sand an indifferent good *spiritus nitri*, that even before rectification would readily enough dissolve silver, though it were diluted with as much of the common water, wherein salt-petre had been dissolved, as amounted at least to double or treble the weight of the nitrous parts. The remaining matter being kept in the fire, till it was dry, afforded us a salt easily reducible (by solution in fair water and coagulation) into crystalline grains, of a nature very differing both from crude nitre, and from fixt nitre, and from oil of vitriol. For it coagulated into pretty big and well-shaped grains, which, you know, fixed nitre and other alkalizate salts are not wont to do; and these grains were not, like the crystals of salt-petre it self, long and hexaëdricall, but of another figure, not easy nor necessary to be here described.

BESIDES, this vitriolate nitre (if I may so call it) would not easily, if at all, flow in the air as fixt nitre is wont to do: moreover, it was easily enough fusible by heat, whereas fixt nitre doth usually exact a vehement fire for its fusion: and though crude salt-petre also melts easily, yet to satisfy you, how differing a substance this of ours was from that, we cast quick coals into the crucible, without being at all able to kindle it. Nay, and when for further trial we threw in some sulphur also, though it did flame away it self, yet it did not seem to kindle the salt, that was hot enough to kindle it; much less did it flash, as sulphur is wont on such occasions to make salt-petre do. Add to all this, that a parcel of this white substance, being without brimstone made to flow for a while in a crucible with a bit of charcoal for it to work upon, grew manifestly and strongly scented of sulphur, and acquired an alkalizate taste, so that it seem'd almost a coal of fire upon the tongue, if it were licked before it imbibed any of the air's moisture, and (which many perhaps will, though I do not, think stranger) obtained also a very red colour; which recalled to my mind, that *Glauber* mentions such a change observable in his salt made of common salt, upon whose account he is pleas'd to call such a substance his *Carbunculus*.

BEING invited by this success to try, whether I could make his *sal mirabilis*, notwithstanding his intimating, as I lately told you, that it is done with a differing menstruum from that, wherewith the salt-petre is to be wrought upon; I observ'd, that where he points at a way of making his salt in quantity without breaking the vessels, he prescribes, that the materials be distilled in vessels of pure silver: whence I conjectured, that it was not aqua fortis or spirit of nitre, that he employ'd to open his sea-salt; and that consequently, since common spirit of salt was too weak to effect

so great a change as the experiment requires, it was very probable, that he employ'd oil of sulphur or of vitriol, which will scarce at all fret unalloyed silver. And however I concluded, that whatsoever the event should prove, it could not but be worth the while to try, what operation such a menstruum would have upon sea-salt, as I was sure had such a notable one upon salt-petre. And I remember, that formerly making some experiments about the differing manners of dissolution of the same concrete by several liquors, I found, that oil of vitriol dissolves sea-salt in a very odd way, (which you will find mentioned among my promiscuous experiments:) wherefore pouring upon a solution of bay-salt made in but a moderate proportion of water, oil of vitriol to the full weight of the dry salt, and abstracting the liquor in a glass cucurbite placed in sand, I obtain'd, without stress of fire, besides phlegm, good store of a liquor, which by the smell and taste seem'd to be spirit of salt. And to satisfy my self the better, mingling a little of it with some of the spirit of nitre lately mentioned, I found the mixture, even without the assistance of heat, to dissolve crude gold. And having for further trial's sake poured some of it upon spirit of fermented urine, till the affusion ceased to produce any conflict, and having afterwards gently evaporated away the superfluous moisture, there did, as I expected, shoot in the remaining liquor a salt figur'd like combs and feathers, thereby disclosing it self to be much of the nature of sal armoniack, such as I elsewhere relate my having made, by mingling spirit of urine with spirit of common salt made the ordinary way.]

THIS, *Pyrophilus*, is all I can find at present of that account, of which I hop'd to have found much more: but you will be the more unconcerned, for my not adding divers other things, that, I remember, I tried, as well before and after the writing the above transcribed paper, (as particularly, that I found the experiment sometimes to succeed not ill, when I distilled the oil of vitriol and sea-salt together, without the intervention of water, whereby much time was saved, and also when I employ'd oil of sulphur, made with a glass bell, instead of oil of vitriol) if I inform you, that afterwards I found, that *Glauber* himself, in some of his subsequent pieces, had deliver'd more intelligibly the way of making what he, without altogether so great a brag, as most think, calls his *sal mirabilis*, (which yet some very ingenious readers of his writings have come to us to teach them) and that those experiments of his about it, which I was able to make succeed, (for some I was not, and some I did not think fit to try) you will find, together with those of my own, in more proper places of other papers. Only, to apply what hath been above related to my present purpose, I must not here pretermitt a couple of observations.

AND first, we may take notice of the power, that mixtures, though they seem but very slight, and consist of the smallest number of ingredients, may, if they make great changes of texture,

texture, have, in altering the nature and qualities of the compounding bodies. For in our (above recited) case, though sea-salt being a body considerably fixed requir's a naked fire to be elevated even by the help of copious additaments of beaten bricks or clay, &c. to keep it from fusion, yet the saline corpuscles are distilled over in a moderate fire of sand; whilst the oil of vitriol, by whose intervention they acquire this volatility, though it be not (like the other) a gross, or as the same chemist speaks, corporeal salt, but a liquor, that has been already distilled, is yet by the same operation so fixed, as to stay behind not only in the retort, but, as I have sometimes purposely tried, in much considerabler heats than that needs in this experiment be exposed to. Nor only is the oil of vitriol made thus far fixed, but it is otherwise also no less changed. For when the remaining salt has been exposed to a competent heat, that it may be very dry and white, to be sure of which I several times do, when the distillation is ended, keep the remaining mass (taken out of the retort and beaten) in a crucible among quick coals, you shall have a considerable quantity (perhaps near as much as the sea-salt you first employed) of a substance, which, though not insipid, has not at all the taste of sea-salt, or any other pungent one, and much less the highly corrosive acidity of oil of vitriol.

AND the mention of this substance leads me to the second particular I intended to take notice of, which is a phenomenon to confirm what I formerly intimated, that notwithstanding the regular and exquisite figures of some salts, they may, by the addition of other bodies, be brought to constitute crystals of very differing, and yet of curious, shapes. For if you dissolve the hitherto mentioned *caput mortuum* of sea-salt (after you have made it very dry, and freed it from all pungency of taste) in a sufficient quantity of fair water, and having filtrated the solution, suffer the dissolved body leisurely to coagulate, you will probably obtain, as I have often done, crystals of a far greater transparency, than the cubes, wherein sea-salt is wont to shoot, and of a shape far differing from theirs, though oftentimes no less curious than that of those cubes: and, which makes mainly for my present purpose, I have often observed those finely-figured crystals to differ as much in shape from one another, as from the grains of common salt. And indeed I must not on this occasion conceal from you, that whether it be to be imputed to the peculiar nature of sea-salt, or (which I judge much more probable) to the great disparities to be met with in liquors, that do all of them pass for oil of vitriol, whether (I say) it be to this or to some other cause, that the effect is to be imputed, I have found my attempts to make the best sort of *sal mirabilis* subject to so much uncertainty, that though I have divers times succeeded in them,

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I have found so little uniformity in the success, as made me reckon this experiment amongst contingent ones, and almost weary of meddling with it.

Experiment VII*.

I Remember, *Pyrophilus*, I once made an experiment, which if I had had the opportunity to repeat, and had done so with the like success, I should be tempted to look upon it, though not as a luciferous experiment, (for it is the quite contrary) yet as so luciferous a one, as, how much soever it may serve to recommend chemistry itself, may no less displease envious chemists, who will be troubled, both that one, who admits not their principles, should devise such a thing; and that, having found it, he should not (chemist like) keep it secret.

BUT to give you a plain and naked account of this matter, that you may be able the better to judge of it, and, if you please, to repeat it, I will freely tell you, that supposing all metals, as well as other bodies, to be made of one catholick matter common to them all, and to differ but in shape, size, motion, or rest, and texture of the small parts they consist of, from which affections of matter the qualities, that difference particular bodies, result, I could not see any impossibility in the nature of the thing, that one kind of metal should be transmuted into another; (that being in effect no more, than that one parcel of the universal matter, wherein all bodies agree, may have a texture produced in it, like the texture of some other parcel of the matter common to them both.)

AND having first supposed this, I further considered, that in a certain menstruum, which according to vulgar chemists doctrine, must be a worthless liquor, according to my apprehension, there must be an extraordinary efficacy in reference to gold, not only to dissolve and otherwise alter it, but to injure the very texture of that supposedly immutable metal.

THE menstruum then I chose to try, whether it could not dissolve gold with, is made by pouring on the rectified oil of the butter of antimony, as much strong spirit of nitre, as would serve to precipitate out of it all the *bezoarticum minerale*; and then with a good smart fire distilling off all the liquor, that would come over, and (if need be) cohobating it upon the antimonial powder. For though divers chemists, that make this liquor, throw it away, upon presumption, that because of the ebullition, that is made by the affusion of the spirit to the oil and the consequent precipitation of a copious powder, the liquors have mutually destroyed or disarmed each other; yet my notions and experience of the nature of some such mixtures invite me to prize this, and give it the name of *menstruum peracutum*.

HAVING then provided a sufficient quantity of this liquor, (for I have observed, that

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* Though this VIIth experiment, being considerable and very pertinent, the author thought fit to mention it, such as it is here delivered, when he writ but to a private friend; yet after he was induced to publish these papers, it was the (now raging) plague, which drove him from the accommodation requisite to his purpose, that frustrated the design he had of first repeating that part of the experiment, which treats of the destruction of gold: for as for that part, which teaches the volatilization of it, he had tried that often enough before.

gold ordinarily requires a more copious solvent than silver,) we took a quantity of the best gold we could get, and melted it with three or four times its weight of copper, which metal we choose rather than that, which is more usual among refiners, silver, that there may be the less suspicion, that there remained any silver with the gold after their separation: this mixture we put into good aqua fortis, or spirit of nitre, that all the copper being dissolved, the gold might be left pure and finely powdered at the bottom; this operation with aqua fortis being accounted the best way of refining gold, that is yet known, and not subject like lead to leave any silver with it, since the aqua fortis takes up that metal. And for greater security, we gave the powder to an ancient chemist to boil some more of the menstruum upon it, without communicating to him our design. This highly refined gold being, by a competent degree of heat, brought, as is usual, to its native colour and lustre, we put to it a large proportion of the *menstruum peracutum*, (to which we have sometimes found cause to add a little spirit of salt, to promote the solution) wherein it dissolves slowly and quietly enough; and there remained at the bottom of the glass a pretty quantity (in shew, though not in weight) of white powder, that the menstruum would not touch; and, if I much misremember not, we found it as indissolvable in aqua regis too. The solution of gold being abstracted, and the gold again reduced into a body did, upon a second solution, yield more of the white powder, but not (if I remember aright) so much as at the first: now having some little quantity of this powder, it was easy with borax or some other convenient flux to melt it down into a metal, which metal we found to be white like silver, and yielding to the hammer, if not to a less pressure, and some of it being dissolved in aqua fortis, or spirit of nitre, did, by the odious bitterness it produced, sufficiently confirm us in our expectation, to find it true silver.

I DOUBT not but you will demand, *Pyrophilus*, why I did not make other trials with this factitious metal, to see in how many other qualities I could verify it to be silver: but the quantity I recovered after fusion was so small, some of it perhaps being left either in the flux, or in the crucible, that I had not wherewithal to make many trials; and being well enough satisfied by the visible properties and the taste peculiar to silver, both that it was a metal, and rather silver than any other, I was willing to keep the rest of it for a while, as a rarity, before I made further trials with it; but was so unfortunate, as with it to lose it in a little silver box, where I had something of more value, and possibly of more curiosity.

You will also ask, why I repeated not the experiment? To which I shall answer, that, besides that one may easily enough fail in making the menstruum fit for my purpose, I did, when I had another opportunity, (for I was long without it) make a second attempt; and having, according to the above mentioned method, brought it so far, that there remained

nothing but the melting of the white powder into silver, when having washed it, I had laid it upon a piece of white paper by the fire's side to dry, being suddenly called out of my chamber, an ignorant maid, that in the mean time came to dress it up, unluckily swept this paper, as a foul one, into the fire: which discouragement, together with a multiplicity of occasions, have made me suspend the pursuit of this experiment till another opportunity. But in the mean time, I was confirmed in some part of my conjecture by these things.

THE first, by finding, that with some other menstrua, which I tried, and even with good aqua regis itself, I could obtain from the very best gold I dissolved in them some little quantity of such a white powder, as I was speaking of; but in so very small a proportion to the dissolved gold, that I had never enough of it at once to think it worth prosecuting trials with.

THE other was this, that a very experienced mineralist, whom I had acquainted with part of what I had done, assured me, that an eminently learned and judicious person, that he named to me, had, by dissolving gold in a certain kind of aqua regis, and after by reduction of it into a body, re-dissolving it again, and repeating this operation very often, reduced a very great, if not much the greater part, of an ounce of gold into such a white powder.

AND the third thing, that confirmed me, was the proof given me by some trials, that I purposely made, that the *menstruum peracutum* I employed had a notable operation upon gold, and would perform some things (one of which we shall by and by mention) which judicious men, that play the great criticks in chemistry, do not think feasible; so that there seems no greater cause to doubt, that the above-mentioned silver was really obtained out of the pure gold, than only this, that men have hitherto so often in vain attempted to make a real transmutation of metals, (for the better or for the worse,) and to destroy the most fixed and compacted body of gold, that the one is looked upon as an unpracticable thing, and the other as an indestructible metal.

To reflect then a little upon what we have been relating, if we did not mistake nor impose upon our selves, (I say upon our selves, the project being our own, and pursued without acquainting any body with our aim,) it may afford us very considerable consequences of great moment.

AND in the first place, it seems probably reducible from hence, that however the chemists are wont to talk irrationally enough of what they call *tinctura auri*, and *anima auri*; yet, in a sober sense, some such thing may be admitted: I say, some such thing, because as on the one hand I would not countenance their wild fancies about these matters, some of them being as unintelligible, as the Peripatetics substantial forms; so, on the other hand, I would not readily deny, but that there may be some more noble and subtle corpuscles, that being duly conjoined with the rest of the matter, whereof gold consists, may qualify that matter

to look yellow, to resist aqua fortis, and to exhibit those other peculiar phænomena, that discriminate gold from silver; and yet these noble parts may either have their texture destroyed by a very piercing menstruum, or by a greater congruity with its corpuscles, than with those of the remaining part of the gold, may stick more close to the former, and by their means be extricated and drawn away from the latter. As when, (to explain my meaning by a gross example) the corpuscles of sulphur and mercury do, by a strict coalition, associate themselves into the body we call vermilion, though these will rise together in sublimentary vessels, without being divorced by the fire, and will act in many cases, as one physical body; yet it is known enough among chymists, that if you exquisitely mix with it a due proportion of salt of tartar, the parts of the alkali will associate themselves more strictly with those of the sulphur, than these were before associated with those of the mercury; whereby you shall obtain out of the cinnabar, which seemed intensely red, a real mercury, that will look like fluid silver. And this example prompts me to mind you, *Pyrophilus*, that, at the beginning of this paragraph, I said no more, than that the consequence, I have been deducing, might probably be inferred from the premises. For as it is not absurd to think, that our menstruum may have a particular operation upon some noble, and (if I may so call them) some tinging parts of the gold, so it is not impossible, but that the yellowishness of that rich metal may proceed not from any particular corpuscles of that colour, but from the texture of the metal; as in our lately-mentioned example, the cinnabar was highly red, though the mercury it consisted of, were silver-coloured, and the sulphur but a pale yellow; and consequently, the whiteness and other changes produced in the new metal we obtained, may be attributed, not to the extraction of any tinging particles, but to a change of texture, whereon the colour as well as other properties of the gold did depend. But that, which made me unwilling to reject the way I first proposed of explicating this change of colour, was, that a mineralist of great veracity hath several times assured me, that a known person in the relator's country, the *Netherlands*, got a great deal of money by the way of extracting a blue tincture out of copper, so as to leave the body white; adding, that he himself, having procured from a friend (to satisfy his curiosity) a little of the menstruum, (whose chief ingredients his friend communicated to him, and he to me) he did, as he was directed, dissolve copper in common aqua fortis, to reduce it into small parts; and then having kept the calx of the powder of this copper for some hours in this menstruum, he perceived, that the clear liquor, which was weak in taste, did not dissolve the body of the metal, but only extract a blue tincture, leaving behind a very white powder, which he quickly reduced by fusion into a metal of the same colour, which he found as malleable as before. Which I the less wonder at, be-

cause the experienced chymist *Johannes Agricola*, in his Dutch annotations upon *Poppius*, mentions the making of a white and malleable copper in good quantities upon his own knowledge; and that of such a kind of copper I have with pleasure made trial, I elsewhere relate. But of these matters we may possibly say more in a convenient place.

THE second thing, that seems deducible from our former narrative, is, that however most (for I say not all) of the judiciousest among the chymists themselves, as well as among their adversaries, believe gold too fixed and permanent a body to be changeable by art, insomuch that it is a received axiom amongst many eminent Spagyrist, that *facilius est aurum construere, quàm destruere*; yet gold itself is not absolutely indestructible by art, since gold being acknowledged to be an homogeneous metal, a part of it was, by our experiment, really changed into a body, that was either true silver, or at least a new kind of metal very different from gold. And since it is generally confessed, that among all the bodies we are allowed to observe near enough, and to try our skill upon, there is not any, whose form is more strictly united to its matter than that of gold; and since also the operation, by which the white powder was produced, was made only by a corrosive liquor, without violence of fire, it seems at least a very probable inference, that there is not any body of so constant and durable a nature, but that, notwithstanding its persisting inviolated in the midst of divers sensible disguises, its texture, and consequently its nature, may be really destroyed, in case this more powerful and appropriated agent be brought, by a due manner of application, to work upon the body, whose texture is to be destroyed.

BUT this matter we elsewhere handle, and therefore shall now proceed to the last and chief consecrations of our experiment.

THIRDLY then, it seems deducible from what we have delivered, that there may be a real transmutation of one metal into another, even among the perfectest and noblest metals, and that effected by factitious agents in a short time, and, if I may so speak, after a mechanical manner. I speak not here of projection, whereby one part of an aurifick powder is said to turn I know not how many hundred or thousand parts of an ignobler metal into silver or gold, not only because, though projection includes transmutation, yet transmutation is not all one with projection, but far easier than it: but chiefly because it is not in this discourse you are to expect what I can say, and do think, concerning what men call the philosophers stone. To restrain my self then to the experiment we are considering, that seems to teach us, that at least among inanimate bodies, the noblest and constantest sort of forms are but peculiar contrivances of the matter, and may, by agents, that work but mechanically, that is, by locally moving the parts, and changing their sizes, shape, or texture, be generated and destroyed; since we see, that in the same parcel of metal-line matter, which a little before was true and pure

pure gold, by having some few of its parts withdrawn, and the rest transposed, or otherwise altered in their structure, (for there appears no token, that the menstruum added any thing to the matter of the produced silver) or by both these ways together, the form of gold, or that peculiar modification, which made it yellow, indissoluble in aqua fortis, &c. is abolished; and from the new texture of the same matter there arises that new form or convention of accidents, from which we call a metal silver. And since ours was not only dissoluble in aqua fortis, but exhibited that excessively bitter taste, which is peculiar to silver, there seems no necessity to think, that there needs a distinct agent, or a peculiar action of a substantial form, to produce in a natural body the most peculiar and discriminating properties. For it was but the same menstruum, devoid of bitterness, that by destroying the texture of gold changed it into another, upon whose account it acquired at once both whiteness in colour, dissolubleness in aqua fortis, and aptness to compose a bitter body with it, and I know not how many other new qualities are attributed.

I KNOW it is obvious to object, that it is no very thrifty way of transmutation, instead of exalting silver to the condition of gold, to degrade gold to the condition of silver. But a transmutation is nevertheless more or less real, for being or not being luciferous; and since that may enrich a brain, that may impoverish a purse, I must look upon your humour as that of an alchymist, rather than of a philosopher, if I durst not expect, that the instructiveness in such an experiment will suffice to recommend it to you. And if I could have satisfied my self, that good authors are not mistaken about what they affirm of the transmutation of iron into copper, though, the charge and pains considered, it be a matter of no gain, yet I should have thought it an experiment of great worth, as well as the transmutation of silver into gold. For it is no small matter to remove the bounds, that nature seems very industriously to have set to the alterations of bodies; especially among those durable and almost immortal kinds, in whose constancy to their first forms nature seems to have designed the shewing her self invincible by art.

I SHOULD here, *Pyrophilus*, conclude what I have to say of the experiment, that hath already so long entertained us, by recommending to you the repetition of what I had not the opportunity to try above once from end to end, were it not, that I remember something I said about the *menstruum peracutum*, may seem to import a promise of communicating to you something of the efficacy of that liquor upon gold. And therefore partly for that reason, and partly to make sure, that the present discourse shall not be uninformative to you, I would add, that though not only the generality of refiners and mineralists, but divers of the most judicious cultivators of chymistry itself, hold gold to be so fixed a body, that it can as little be volatilized as destroyed, and that upon this ground, that the processes of subliming or di-

stillling gold to be met with in divers chymical books are either mystical, or unpracticable, or fallacious, (in which opinion I think them not much mistaken;) though this, I say, be the persuasion even of some critical chymists, yet, upon the just expectation I had to find my menstruum very operative upon gold, I attempted and found a way to elevate it to a considerable height, by a far less proportion of additament, than one, that were not fully persuaded of the possibility of elevating gold, would imagine; and though I have indeed found, by two or three several liquors, (especially the *aqua pugilum*, enigmatically described by *Basilius*) that the fixedness of gold is not altogether invincible, yet I found the effect of these much inferior to that of our mixture; touching which I shall relate to you the easiest and shortest, though not perhaps the very best, manner of employing it.

WE take then the finest gold we can procure, and having either granulated it or laminated it, we dissolve it in a moderate heat with a sufficient quantity of the *menstruum peracutum*, and having carefully decanted the solution into a conveniently sized retort, we very gently in a sand-furnace distil off the menstruum; and if we have a mind to elevate the more gold, we either pour back upon the remaining substance the same menstruum, or, which is better, re-dissolve it with fresh. The liquor being abstracted, we urge the remaining matter by degrees of fire, and in no stronger a one than what may easily be given in a sand-furnace, a considerable quantity of the gold will be elevated to the upper part of the retort, and either fall down in a golden-coloured liquor into the receiver, or, which is more usual, fasten itself to the top and neck in the form of a yellow and reddish sublimate; and sometimes we have had the neck of the retort enriched with good store of large thin crystals, not yellow but red, and most like rubies, very glorious to behold; (though even these being taken out, and suffered to lie a due time in the open air, would lose their saline form, and run *per deliquium* into a liquor.) Nor see I any cause to doubt, but that by the re-affusions of a fresh menstruum upon the dry calx of gold, that stays behind, the whole body of the metal may be easily enough made to pass through the retort, though for a certain reason I forbore to prosecute the experiment so far.

BUT here, *Pyrophilus*, I think my self obliged to interpose a caution, as well as to give you a further information about our present experiment. For first, I must tell you, that though even learned chymists think it a sufficient proof of a true tincture, that not only the colour of the concrete will not be separated by distillation, but the extracted liquor will pass over tinted into the receiver; yet this supposition, though it be not unworthy of able men, may in some cases deceive them. And next I must tell you, that whereas I scruple not in several writings of mine to teach, that the particles of solid and consistent bodies are not always unfit to help to make up
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fluid ones, I shall now venture to say further, that even a liquor made by distillation, how volatile soever such liquors may be thought, may in part consist of corpuscles of the most compact and ponderous bodies in the world.

Now to manifest both these things, and to shew you withal the truth of what I elsewhere teach, *That some bodies are of so durable a texture, that their minute parts will retain their own nature, notwithstanding variety of disguises, which may impose not only upon other men, but upon chymists themselves*; I will add, that to prosecute the experiment, I dropped into the yellow liquor afforded me by the elevated gold a convenient quantity of clean running mercury, which was immediately coloured with a golden coloured film, and shaking it to and fro, till the menstruum would gild no more, when I supposed the gold to be all precipitated upon the mercury, I decanted the clarified liquor, and mixing the remaining amalgam (if I may so call it) of gold and mercury with several times its weight of borax, I did as I expected; by melting them in a small crucible, easily recovered the scattered particles of the elevated metal, reduced into one little mass or bead of corporal or yellow (though perhaps somewhat palish) gold. But yet, whether the gold, that tinged the menstruum, might not, before the metal was reduced or precipitated out of it, have been more successfully applied to some considerable purposes than a bare solution of gold, that hath never been elevated, may be a question, which I must not in this place determine, and some other things, that I have tried about our elevated gold, I have elsewhere taken notice of; only this further use I shall here make of this experiment, that whereas I speak in other papers, as if there may be a volatile gold in some ores and other minerals, where the mine-men do not find any thing of that metal, I mention such a thing upon the account of the past experiment and some analogies. And therefore, as I would not be understood to adopt what every chymical writer is pleased to fancy concerning volatile gold; so I think judicious men, that are not so well acquainted with chymical operations, are sometimes too forward to condemn the chymists observations; not because their opinions have nothing of truth, but because they have had the ill luck not to be warily enough proposed. And to give an instance in the opinion, that some minerals have a volatile gold, (and the like may be said of silver) I think I may give an account rational enough of my admitting such a thing, by explicating it thus: that as in our experiment, though after the almost total abstraction of the menstruum, the remaining body being true gold, and consequently in its own nature fixed, yet it is so strictly associated with some volatile saline particles, that these being pressed by the fire, carry up along with them the corpuscles of the gold, which may be reduced into a mass by the admission of borax, or some other body fitted to divorce the corpuscles of the metal from those, that would elevate them, and to unite them into grains, too big and ponderous

to be sublimed: so in some mineral bodies there may be pretty store of corpuscles of gold so minute, and so blended with the unfixed particles, that they will be carried up together with them by so vehement a heat, as is wont to be employed to bring ores, and even metalline masses, to fusion. And yet it is not impossible, but that these corpuscles of gold, that in ordinary fusions fly away, may be detained and recovered by some such proper additament, as may either work upon, and (to use a chymical term) mortify the other parts of the mass, without doing so upon the gold; or, by associating with the volatile and ignobler minerals some way or other, disable them to carry away the gold with them, as they otherwise may do; or by its fixedness and cognation of nature make the dispersed gold imbody with it. On which occasion I remember, that a very ingenious man desiring my thoughts upon an experiment, which he and some others, that were present at it, looked upon as very strange; namely, that some good gold having for a certain trial been coupled with a great deal of lead, instead of being advanced in colour, as in goodness, was grown manifestly paler than before; my conjecture being, that so great a proportion of lead might contain divers particles of volatile silver, which meeting with the fixed body of the gold by incorporating therewith, was detained, was much confirmed, by finding upon inquiry, that the gold instead of losing its weight, had it considerably increased; which did much better answer my guess, than it did their expectation, that made the experiment, and were much surpris'd at the event. But this is no fit place to prosecute the consideration of the additaments, that may be used to unite and fix the particles of the nobler metals blended with volatile bodies; though perhaps what hath been said may afford some hint about the matter, as well as some apology for the chymical term, volatile gold: the possibility of which, I presume, we have evinced by the latter part of this experiment, (in which I am sorry I cannot remember the proportion of the remaining salts, that were able to elevate the gold) for that I have several times made, and therefore dare much more confidently rely on it, than I can press you to do on the former part (about the transmutation, or at least destruction of gold) till you or I shall have opportunity to repeat that trial.

Experiment VIII.

THOUGH, *Pyrophilus*, the experiment I am about to subjoin, may at the first glance seem only to concern the *production of tastes*, and be indeed one of the principal, that I devised concerning that subject, and that belongs to the notes I have made about those qualities; yet, if you do not of your self take notice of it, I may hereafter have occasion to shew you, that there are some particulars in this experiment, that are applicable to more than tastes. And since I had once thoughts (however since discouraged by the difficulties of the attempt) to make my notes extend even to divers qualities,

lities; which the operations of chymists and the practice of physicians have made men take notice of; (such as the powers of corroding, precipitating, fixing, purging, blistering, stupifying, &c.) I presume you will not dislike that one, who had thoughts to say something even of chymical and of medical qualities, if I may so call them, should give you here an experiment or two about more obvious, though particular affections of bodies, when there are several things in the experiment, that may be of a general import to the doctrine of the origin of qualities and forms.

WE took then an ounce of refined silver, and having dissolved it in aqua fortis, we suffered it to shoot into crystals, which being dried, we found to exceed the weight of the silver by several drachms, which accrued upon the concoagulation of the acid salts, that had dissolved and were united to the metal. These crystals we put into a retort, and distilled them in sand, with almost as great a heat as we could give in a hammered iron furnace, wherein the operation was made; but there came over only a very little sourish phlegm with an ill scent: wherefore the same retort being suffered to cool, and then coated, it was removed to another furnace, capable of giving a far higher degree of heat, namely, that of a naked fire, and in this furnace the distillation was pursued by the several degrees of heat, till at length the retort came to be red-hot, and kept so for a good while: but though even by this operation there was very little driven over, yet that sufficiently manifested what we aimed at shewing, namely, that a body extremely bitter might afford, as well as it consisted of, good store of parts, that are not at all bitter, but (which is a very differing taste) eminently sour. For our receiver being taken off even when it was cold, the contained spirit smoked out like rectified aqua fortis, and not only smelt and tasted like aqua fortis, to the annoyance of the nose and tongue; but being poured upon filings of crude copper, it fell immediately to corrode them with violence, making much hissing, and sending up thick fumes, and in a trice produced with the corroded copper a bluish colour, like that, which that metal is wont to give in good aqua fortis.

AFTERWARDS we took minium and aqua fortis, and made a solution, which being filtered and evaporated, left us a *saccharum Saturni* much like the common, made with spirit of vinegar. Then taking this sweet vitriol of lead, (as we elsewhere call it) we endeavoured in the formerly mentioned sand-furnace to drive it over in a retort; but finding that degree of fire incompetent to force over any thing, save a little phlegmatick liquor, we caused the retort to be coated and transferred to the other furnace, where being urged with a naked fire, it afforded at length a spirit somewhat more copious than the silver had done. This spirit smoked in the cold receiver as the other had, and did, like it, rankly smelt of aqua fortis, and was so far from retaining any of the sweetness of the concrete, that had yielded it, that it was offensively acid, and being poured up-

on minium, it did with noise and bubbles fall upon it, and quickly afforded us a liquor, which being filtered, did, by its sweetness, as well as other proofs, assure us, that there would have needed but a gentle evaporation (if we had leisure to make it) to obtain from it a true fugar of lead. And it is remarkable, that the concrete, which appeared white before distillation, remained, for the most part, behind in the retort in the form of a black *caput mortuum*, (sometimes we have had it in a yellowish lump) which was neither at all sweet, as the vitriol of lead it self had eminently been, nor at all sour, as the liquor distilled from it was in a high degree; but seemed rather insipid, and was indeed but a calx of lead, which the heat of the fire had in part reduced into true and manifest lead in the retort it self, as appeared by many grains of several sizes, that we met with in the *caput mortuum*; (the rest of which is easily enough reducible by fusion, with a convenient flux, into malleable lead it self.)

THERE are some phenomena of this experiment, that we may elsewhere have occasion to take notice of, as particularly, that notwithstanding silver be a body so fixed in the fire, that it will (as it is generally known) endure the cupel itself, and though in the dried crystals of silver, the salt, that adheres to the silver, increases the weight of the metal but about a fourth or a third part; yet this small proportion of saline corpuscles was able to carry up so much of that almost fixedest of bodies, that more than once we have had the inside of the retort, to a great height, so covered over with the metalline corpuscles, that the glass seemed to be silvered over, and could hardly, by long scraping, be freed from the copious and closely adhering sublimate.

BUT the phenomenon, that I chiefly desire to take notice of at present, is this, that not only aqua fortis, being concoagulated with differing bodies, may produce very differing concretes, but the same numerical saline corpuscles, that, being associated with those of one metal, had already produced a body eminent in one taste, may afterwards, being freed from that body, compose a liquor eminent for a very differing taste; and after that too, being combined with the particles of another metal, would with them constitute a body of a very eminent taste, as opposite as any one can be to both the other tastes; and yet these saline corpuscles, if, instead of this second metal, they should be associated with such a one as that they are driven from, would therewith exhibit again the first of the three mentioned tastes. To prove all this, we took crystals of refined silver made with aqua fortis, and though these crystals be, as we often note, superlatively bitter; yet having, by a naked fire extorted from them what spirit we could, and found that, as we expected, extremely acid, we put one part of it upon a few filings of silver, of which it readily made a solution more bitter than gall, and the other part of the distilled liquor we poured upon minium. And though whilst it had been an ingredient of the crystals

tals of silver committed to distillation, it did with that metal compose an excessively bitter substance, yet the same particles being loosened from that metal, and associated with those of the lead, did with them constitute a solution, which by evaporation afforded us a *saccharum Saturni*, or a vitriol sweet as sugar. And for further confirmation, we varied the experiment, having in a naked fire distilled some dried *saccharum Saturni* made with aqua fortis, the little liquor, that came over, in proportion to the body, that afforded it, was so strong a spirit of nitre, that for several hours the receiver was filled with the red fumes; and though the smoking liquor were hugely sharp, yet part of it, being poured upon a piece of its own *caput mortuum*, (in which we perceived not any taste) did at length (for it wrought but very slowly) exhibit some little grains of a saccharine vitriol; but the other part, being put upon filings of silver, fell upon it immediately with noise and store of smoke, and a while after concoagulated with part of it (which it had dissolved) into a salt excessively bitter.

Experiment IX.

THE artificial transmutation of bodies being, as the rarest and difficultest production, so one of the noblest and usefulest effects of human skill and power; not only the clear instances of it are to be diligently sought for and prized, but even the probabilities of effecting such an extraordinary change of bodies are not to be neglected; especially if the version hoped for, be to be made betwixt bodies of primordial textures, (if I may so call them) and such bodies, as by the greatness of their bulk, and by their being to be found in most of the mixed bodies here below, make a considerable part of those, that we men have the most immediately to do with. Invited by these considerations, *Pyrophilus*, I shall venture to give you the account of some observations and trials about the transmuting of water into earth, though it be not so perfect, as I wish, and as I hope by God's blessing to make it.

THE first occasion, afforded me to do any thing about this matter, was my being consulted by a gentleman, (an antient chymist, but not at all a philosopher) who relating to me, how much he had (with the wonted success of such attempts) laboured after the grand *Arcana*, complained to me, among other things, that, having occasion to employ great quantity of purified rain-water, he obtained from it much less than he wished of the substance, that he looked for, but a great deal of a certain whitish excrementitious matter, which he knew not what to make of. This gave me the curiosity first to desire a sight of it, in case he had not thrown it away, (which by good fortune he had not) and then, taking notice of the unexpected plenty, and some of the qualities of it, to ask him some questions, which were requisite and sufficient to persuade me, that this residue came not from accidental foulness of the water, nor of the vessels it was received in. This I afterwards often thought of, and indeed it might justly enough awaken some suspicions,

that the little motes, that have been sometimes observed to appear numerous enough in pure rain-water, whilst it is distilling, might not be merely accidental, but really produced, as well as exhibited by the action of the fire. I thought it then worth while to prosecute this matter a little farther; and having put a pretty quantity of distilled rain-water in a clean glass body, and fitted it with a head and a receiver, I suffered it to stand in a digestive furnace, till by the gentle heat thereof, the water was totally abstracted, and the vessel left dry: which being taken out of the sand, I found the bottom of the glass all covered over with a white (but not so very white) substance; which being scraped off with a knife, appeared to be a fine earth, in which I perceived no manifest taste, and which, in a word, by several qualities seemed to be earth.

THIS encouraged me to redistil the rain-water in the same glass body, whose bottom, when the water was all drawn off, afforded me more of the like earth: but though the repetition of the experiment, and my having, for greater caution, tried it all the while in a new glass, that had not been employed before to other uses, confirmed me much in my conjecture, that unless it could be proved, which I think will scarce be pretended, that so insipid a liquor as rain-water should, in so gentle a heat, dissolve the most close and almost indestructible body of glass it self, (which such corrosive menstruums as aqua fortis and aqua regis are wont to leave unharmed) the earthy powder, I obtained from already distilled rain-water, might be a transmutation of some parts of the water into that substance; yet having unhappily lost part of my powder, and consumed almost all the rest, (for I kept a little by me, which you may yet see) I should, till I had more frequently reiterated my experiments, (which then I had not opportunity to do, though I had thoughts of doing it also with snow-water, that I had put into chymical glasses for that purpose, and with liquor of melted hail, which I had likewise provided) and thereby also obtained some more of this virgin earth, (as divers chymists would call it) to make farther trials with, have retained greater suspicions, if I had not afterward accidentally fallen into discourse of this matter with a learned physician, who had dealt much in rain-water; but he much confirmed me in my conjecture, by assuring me, that he had frequently found such a white earth, as I mentioned, in distilled rain-water, after he had distilled the same numerical liquor, (carefully gathered at first) I know not how many times one after another; adding, that he did not find (any more than I had done) any cause to suspect, that if he had continued to redistil the same portion of water, it would have yielded him more earth.

BUT the oddness of the experiment still keeping me in suspense, it was not without much delight, that afterwards mentioning it to a very ingenious person, whom without his leave, I think not fit to name, well versed in chymical matters, and whom I suspected to have,

have, in order to some medicines, long wrought upon rain-water, he readily gave me such an account of his proceedings, as seemed to leave little scruple about the transmutation we have been mentioning: for he solemnly affirmed to me, that having observed, as I had done, that rain-water would, even after a distillation or two, afford a terrestrial substance, which may sometimes be seen swimming up and down in the limpid liquor, he had the curiosity, being settled and at leisure, to try how long he could obtain this substance from the water. And accordingly having freed rain-water, carefully collected from its accidental, and as it were feculent earthiness, which it will deposit at the first slow distillation, (and which is oftentimes coloured, whereby it may be distinguished from the white earth made by transmutation) he re-distilled it in very clean glasses, not only eight or ten times, but near two hundred, without finding that his liquor grew weary of affording him the white earth, but rather that the corpuscles of it did appear far more numerous, or at least more conspicuous in the latter distillation, than in the former. And when I expressed my curiosity to see this earth, he readily shewed me a pretty quantity of it, and presented me with some, which comparing with what I had remaining of mine, I found to be exceeding like it, save that it was more purely white, as having been for the main afforded by rain-water, that had been more frequently rectified. And to compare this welcome powder with that I made myself, I tried with this divers things, which I had before tried with my own, and (because the quantity presented me was less inconsiderable) some others too. For I observed in this new powder, as I had done with my own, that being put into an excellent microscope, and placed where the sun-beams might fall upon it, it appeared a white meal, or a heap of corpuscles so exceeding, not to say unimaginably small, that in two or three choice microscopes both I and others had occasion to admire it: and their extreme littleness was much more sensibly discerned by mingling some few grains of sand amongst them, which made a mixture, that looked like that of pebble stones, and of the finest flower. For our earth, even in the microscope, appeared to consist of as small particles, as the finest hair-powder to the naked eye. Nor could we discern this dust to be transparent, though, when the sun shined upon it, it appeared in the microscope to have some particles a little glistening, which yet appearing but in a glaring light, we were not sure to be no *deceptio visus*.

2. I FOUND, that our white powder being cast into water, would indeed for a while discolour it by somewhat whitening it, which is no more than spaud will do, and the fine dust of white marble and other stones, whose corpuscles, by reason of their minuteness, swim easily for a while in the water; but when it was once settled at the bottom, it continued there undissolved (for aught I could perceive) for some days and nights, as earth would have done.

3. HAVING weighed a quantity of it, and put it into a new clean crucible, with another inverted over it for a cover, I placed it among quick coals, and there kept the crucible red-hot for a pretty while, causing the fire afterward to be acuated with a blast of a bellows; but taking out the powder, I neither found it melted nor clotted into lumps, nor, when I weighed it again, did I see cause to conclude, that there was much of it wasted, besides what stuck to the sides of the crucible and to a little clay, wherewith I had luted on the cover, (and which, to shew you that the heat had not been inconsiderable, was in several places burnt red, by the vehemence of fire :) and when I afterwards kept this powder in an open crucible among glowing coals, neither I, nor one that I employed to assist me, perceived it at all to smoke; and having put a little upon a quick coal, and blown that too, I found that, which I had not blown away, to remain fixed (which some bodies will not do) upon quick coals, that will endure the fire in a red-hot crucible.

4. I FOUND this powder to be much heavier in specie, than water; for employing a nice pair of gold scales, and a method, that would be too long here to describe, I found, that this powder weighed somewhat (though not much) more than twice so much common water, as was equal to it in bulk. And lest some corollaries, that seem obviously contained in the common but groundless conceits of the Peripateticks, about the proportions of the elements in density, &c. should make you expect, that this powder ought to have been much more ponderous, I shall add, that having had the curiosity, which I wonder no body should have before me, to examine the gravity of the earth, which seems the most elementary of any we have, I took some sifted wood-ashes, which I had caused to be three or four times boiled in a plentiful proportion of water, to free them from salt, and having put them very dry into common water, I found them but little heavier than our newly mentioned powder, surpassing in weight water of the same bulk but twice, and a little more than a 6th part; (water and it being very little more than as 1 to 2 $\frac{1}{2}$.) And that you may the less doubt of this, I will yet subjoin, that examining the specific gravity of (white) glass itself, I found that compact body to be very little, if at all, more than two times and a half as heavy as water of equal bigness to it. So that the gravity of that powder, which, borrowing a chymical term, we have been calling virgin-earth, being added to its fixedness and other qualities, it may seem no great impropriety of speech to name it earth; at least if by earth we mean not the pure elementary earth of the schools, which many of themselves confess not to be found actually separate, but a body dry, cold, ponderous, induring the fire, and, which is the main, irresoluble by water and fire into other bodies specifically different.

[BUT to return to the guise of the powder; when I asked this learned man, whether he observed the glass he distilled in to have been fretted by the liquor, and whether this lost of its

its substance, according as it deposited more powder, he answered me (and he is a person of unsuspected credit) that he found not his glass to have been injured by the liquor, and that the water wasted (though he were careful it should not do so by evaporation and transfusions) by degrees so much, that there remained by his estimate but about an eighth part of the first quantity. And though for certain reasons he kept by him the liquor last distilled, yet he doubted not, but that it might be very nigh totally brought into earth, since out of an ounce of distilled rain-water he had already obtained near three quarters of an ounce, if not more, of the often mentioned earth.]

THESE several relations will, I suppose, persuade you, *Pyrophilus*, that this experiment is hopeful enough to be well worth your pursuing; if not, that perhaps none but such a scrupulous person as I, would think the prosecution of it other than superfluous. And if you do acquiesce in what hath been already done, you will, I presume, think it no mean confirmation of the corpuscularian principles and hypotheses. For if, contrary to the opinion, that is so much in request among the generality of modern physicians and other learned men, that the elements themselves are transmuted into one another, and those simple and primitive bodies, which nature is presumed to have intended to be the stable and permanent ingredients of the bodies she compounds here below, may be artificially destroyed, and (without the intervention of a feminal and plastick power) generated or produced: if, I say, this may be done, and that by such slight means, why may we not think, that the changes and metamorphoses, that happen in other bodies, which are acknowledged by the moderns to be far more liable to alterations, may proceed from the local motion of the minute or insensible parts of matter, and the changes of texture, that may be consequent, thereunto? Some bold atomists would here be determining, by what particular ways this strange transmutation of water into earth may be performed; and would perchance particularly tell you, how the continually but slowly agitated parts of the water, by their innumerable occurfions, may by degrees rub, and as it were grind themselves into such surfaces, as either to stick very close to one another by immediate contact, (as I elsewhere observe polished pieces of glass to do) or implicate and intangle themselves together so, as to make as it were little knots; which knots (he would add) or the newly mentioned clusters of coherent particles, being then grown too great and heavy to be supported by the water, must subside to the bottom in the form of a powder, which by reason of the same gravity of the moleculæ, and the strict union of the lesser particles, that compose them, obtain an indisposition to dissolve in water, and to be elevated or dissipated by the fire; as their insipidness may be accounted for by its being but the same with that of the liquor, whence they were made, and

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their transparency by that of the water they were made of, and by the multitude of the little surfaces, that belong to so fine a powder. But though in favour of such conjectures I could somewhat illustrate them, partly by applying to this occasion what I elsewhere observe of the reducing of the fluid body of quicksilver, by a bare circulation (which is but a repeated distillation) with a proportionable heat; into a real powder, which also will not so easily be raised by the fire, as the fluid body, whence by change of texture it was made; and partly by subjoining, among other things, how by the conjunction of two distilled liquors digested together I have obtained good store of an insipid substance; that would not melt in water, and that would long enough endure no inconsiderable degree of fire; though, I say, by these and other such particulars I could make our atomist's conjectures less improbable, yet the full disquisition of so difficult a subject is too long and intricate to be proper for this place.*

AND therefore, without here examining our atomist's explication of this metamorphosis, we will give him leave for a while to suppose the transmutation itself to be real, and thereupon to consider, whether the historical part of it do not much disfavour some of the chief doctrines of the chymists, and a fundamental one of *Helmont's*. For if the purest water may be turned into earth, it will not be easy to make it improbable, that the other ingredients of mixt bodies, which the chymists call their hypostatical principles, are capable of being transmuted into one another, which would overthrow one of the main foundations of their whole philosophy; and besides, if out of the simplest water itself a moderate fire can produce a large proportion of earth, that was not formerly præexistent in it, how shall we be sure, that in all the analyses, which the fire makes of mixed bodies, the substances thereby exhibited are obtained by separation only, without any transmutation? As for *Helmont*, it is well enough known, that he makes water to be the material principle of all bodies here below, which he would have to be either water itself, or but water disguised by those forms, which the seeds of things have given it. I will not here examine, whether this opinion, if he had restrained it to animals and vegetables, might not with some restriction and limitations be kept from appearing absurd, since my *Eleutherius* hath (though without absolutely adopting it) elsewhere pleaded for its not being so extravagant, as it hath been thought.

BUT whereas *Helmont's* grand argument from experience is grounded on this, that the alkahest doth, as he affirms, by being digested with and distilled from other tangible bodies, reduce them all at last into a liquor no way differing from rain-water, though we should grant the matter of fact, yet the experiment of our powder will warrant me to question their ratiocination. For if all mixed bodies be therefore concluded to be materially from water, because they are by the operation of

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* What is here delivered may be for the main verified by what the reader will meet with in the following Xth experiment, though that be not in which the author meant.

the fire and a menstruum, after having passed through divers previous changes, reduced at length into insipid water; by the same way of arguing (and with greater cogency) I might conclude, that all those bodies are materially but disguised earth, since without intervention of a seminal principle, (for *Helmont* will not allow that title to fire, which he styles the artificial death of things) water itself may be turned into earth. Indeed if that acute chymist were now alive, and had such an immortal liquor, as he describes his alkahest to be, I would gladly put him upon trying whether that menstruum would reduce our white earth into water. But there being no more probability of that, than that such reproduced water, being just what it was before, might be turned into earth again; it may be probably said, that since these bodies are mutually convertible into one another, (and as to the version of water into earth, by a seemingly slight operation) they are not either of them ingenerable and incorruptible elements, much less the sole matter of all tangible bodies, but only two of the primordial and of the most obvious schematisms of that, which is indeed the universal matter; which as it comes to have its minute particles associated after this or that manner, may, by a change of their texture and motion, constitute with the same corpuscles sometimes water and sometimes earth.

BUT, *Pyrophilus*, to leave these reflexions, to return to the bold conjectures, that they are grounded on; though if I had leisure and indulgence enough, I could, I confess, add many things in favour of some of those thoughts: * yet I would not have you wonder, that whilst I was mentioning the many particulars, that seem to evince the change of water into earth, I should let fall some words, that intimate a diffidence about it. For to disguise nothing unto you, I must confess, that having in spite of an unusual care unluckily lost a whole paper of the powder I had made my self, and having unexpectedly been obliged to remove from my furnaces, before I had made half the trials I judged requisite in so nice a case, I have not yet laid aside all my scruples.

FOR 1. I would gladly know, whether the untransmuted rain-water, by the deposition of so much terrestrial matter, were grown lighter in specie than before, or sharp in taste. Next I would be thoroughly satisfied, (which I confess I am not yet, notwithstanding all that the followers of *Angelus Sala* have confidently enough written) whether and how far insipid liquors (as rain-water is) may or may not work as menstrua upon stones or earthy bodies: not to question whether the particles of rain-water may not by their mutual attrition, or some other action upon one another, be reduced into shapes and sizes fit to compose such a menstruum as the liquor was not before; as in divers plants, that seemed to be nourished only with water, the sap endowed with a sharp taste and great penetrancy and activity of parts.

2. It were also fit to know, whether the glass body, wherein all the distillations are made, do lose of its weight any thing near so much as the obtained powder amounts to over and above the decrement of weight, which may be imputed to the action of the heat upon the substance of the glass, in case it appear by another glass, kept empty in an equal heat, and for the same time, that the glass loses by such operations any thing worth reckoning. And it were also not impertinent to try, whether the gravity of the obtained powder be the same in specie with that of the glass, wherein the distillations were made: (for that it differed but about a fifth part from the weight of crystalline glass, I lately mentioned.) Which scruple and some of the former I might have prevented, if I had had convenient metalline vessels, wherein to make the distillations instead of glass ones.

3. I could wish likewise, that it were more demonstrably determined, what is on all hands taken for granted, (as it appears indeed highly probable) that distilled rain-water is a perfectly homogeneous body; which if it be not, divers suspicions might be suggested about its transmutation into earth; and if it be, it will be, as a very strange thing, so a matter of very great difficulty to conceive, how a perfectly and exquisitely homogeneous matter should, without any addition or any seminal and plastick principle, be brought to afford great store of a matter of much more specific gravity than it self; since we see, that no aggregate we can make of bodies, but equiponderant in specie with water, doth by virtue of their convention grow specifically heavier than it.

4. HAVING had the curiosity to try, whether corrosive liquors would work upon our white powder, I found, that not only good oil of vitriol would corrode it, but strong and dephlegmed spirit of salt did readily work upon part of it, and that without the assistance of heat, though not without hissing and exciting great store of bubbles; as I have known such menstrua do, when put upon *Lapis Stellaris* or *Ossifragus*, or some such soft stone; as if that so much defecated rain-water, actuated by heat, had resolved some of the looser corpuscles of the sand or stone, that together with some salts compose common glass, as I have observed in some petrifying water, that some of the bodies I took up, and which were presumed to be petrified, were but crusted over with stone, that seemed generated but by the successive apposition of stony particles, that lying invisibly mingled with the running water, stuck in their passage to the conveniently disposed bodies, that lay in the stream's way. But yet I must not omit, that when I suffered this mixture to settle, as much of the powder, as seemed to be a very great part of it, remained in the lower part of the liquor, as if that had rather fretted than dissolved it; and that not because the menstruum was overcharged or glutted, as I found by putting in afterwards several fresh parcels of powder, which it readily fell

* Of the possible ways of turning liquors into consistent bodies, by bending, breaking, twisting, and by otherwise changing the texture of the liquor, see more particularly the *History of Fluidity and Firmness*, published by the author.

fell upon, not without noise and froth. Nor must I forget, that sometimes I have excited such an ebullition, by pouring the same liquors upon the earthy part of wood-ashes, several times washed in boiling water, (though, I confess, I afterwards somewhat suspected there might remain some little adhering alkali, which might occasion those bubbles, notwithstanding that both I and another, whom I also invited to taste it, took the earth to be quite saltless :) I might, *Pyrophilus*, add, that sometimes also methought I found this powder (which yet likewise sometimes happened to me with the lately mentioned earth of wood-ashes) somewhat gritty between my teeth, and subjoin divers other particulars, if it were not too tedious to mention to you all the doubts and considerations, that have occurred to me about the recited change of water into earth: which yet are not such as ought to hinder me from giving you the historical account I have set down, since to some of my scruples I could here give plausible answers, but that I cannot do it in few words. And if any part of our white powder prove to be true earth, no body perhaps yet knows to what the experiment may lead sagacious men: and whether in a strict sense it be true earth or no, yet the phenomena, that are exhibited in the production of it, are sufficient to give this ninth experiment a place among the others (of the same deced) with which it is associated. For since out of a substance, that is universally acknowledged to be elementary and homogeneous, and which manifestly is fluid, transparent, much lighter in specie than earth, moist and fugitive, there is artificially generated or obtained a substance consistent, white, and consequently opacous, comparatively ponderous, dry, and not at all fugitive; the alteration is so great, and effected in so simple a way, that it cannot but afford us a considerable instance of what the varied texture of the minute parts may perform in a matter confessedly similar. And if frequently distilled rain-water should not be allowed homogeneous, our experiment will at least shew us, better than perhaps any hath yet done, how little we are bound to believe what the chymists and others tell us, when they pretend manifestly to exhibit to us homogeneous principles, and elementary bodies; and how difficult it is to be certain, when a body is absolutely irresoluble into specifically differing substances, and consequently what is the determinate number of the perfectly simple ingredients of bodies: (supposing that such there are.) Though I must confess, that my only aim is not to relate what hath been done, but to procure the prosecution of it. For if the obtained substance be, by the rain-water, dissolved out of the glass, this will both prove a noble and surprizing instance of what may be done by insipid menstruums, even upon bodies, that are justly reckoned among the compactest and most indissoluble that we know of, and may afford us many other considerable hints, that have been partly intimated already: and if, on the other side, this powder, whether it be true elementary earth or not, be found

to be really produced out of the water it self, it may prove a *magnale* in nature, and of greater consequence than will be presently foreseen, and may make the alchymists hopes of turning other metals into gold appear less wild; since that by experimentally evincing, that two such difficult qualities to be introduced into a body, as considerable degrees of fixity and weight, (whose requisiteness to the making of gold are two of the principal things, that have kept me from easily expecting to find the attempts of alchymists successful) may, without the mixture of the homogeneous matter, be generated in it, by varying the texture of its parts.

I WILL not now adventure to add any thing of what I have been attempting about the transmuting (without additaments) of pure alkali-zate salts into earth, because I do not yet know, whether the trials will answer my hopes, (for I do not yet call them my expectations.) But upon this subject of transmutations, I could, if it did not properly belong to another treatise, tell you something about the changes, that may be wrought upon highly rectified spirit of wine, which would perchance make you think of other things of the like kind less infeasible. For whereas it is a known thing, that that spirituous liquor being kindled, (and that, if you please, by other spirit of wine actually fired) will, for aught appears, burn all away, that is, be totally turned into flame; if I durst rely in so important a case on a couple of trials, whilst I hope for an opportunity of making farther ones, I would tell you, that by a way unthought on (that I know of) by any body, I have without any addition obtained from such spirit of wine, as being kindled in a spoon would flame all away, without leaving the least drop behind it, a considerable quantity of downright incombustible phlegm. And by another way (mentioned indeed by *Helmont*, but not taught to almost any of his readers) some ingenious persons, that you know and esteem, working by my directions, (but without knowing what each other was doing) did both of them reduce considerable quantities of high rectified spirit of wine (that would before have burnt all away) into a liquor, that was for the most part phlegm, as I was informed as well by my own taste, as by the trials I ordered to be made: (being forced my self to be most commonly absent.) From which change of the greatest part of that first liquid spirit into phlegm, it seems deducible, that the same portion of matter, which by being kindled may be turned all into fire, may be, by another way of handling, turned into phlegm or water, and this without the addition of any thing, and without being wrought upon by any visible body, but one so extremely dry as dually prepared salt of tartar; and that it self is not so indispensably necessary to the obtaining of phlegm out of totally inflammable spirit of wine, but that, as I was saying, I did by another way obtain that dull liquor, without employing the salt or any other visible body whatsoever. But I make a scruple to entertain you any longer with extravagancies of this

this nature, and yet if I were sure you would contain your smiles, I would add for conclusion, that if I had had time and opportunity to furnish my self with any quantity of that water, I had it in my thoughts to try, whether that would have afforded me such a terrestrial substance as rain-water had done, and thereby have undergone a new and further metamorphosis.

Experiment X.

THERE is one experiment more, two of the chief phænomena of which belong to another discourse, (where I particularly mention them;) and yet I shall conclude this little treatise with the recitation of the experiment it self, not only because divers of the phænomena do eminently belong to our present subject, but because I have scarce met with any experiments more suitable to the design I have of shewing, before I conclude this discourse, what great and sudden productions and destructions of qualities may be effected by the composition of the smallest number of ingredients, even among liquors themselves; and such too, as are believed to be both of them simple and homogeneous, and incapable of putrefaction; that so it may appear what notable alterations of qualities even seemingly slight and easy mixtures can perform among bodies both of them fluid, as well as among those, that were either both of them stable, or one of them stable, and the other consistent.

TAKE then of good oil of vitriol and of spirit of wine, that will burn all away, equal parts, not in quantity, but in weight; put them together by little and little, and having placed the mixture in a bolt-head or glass-egg with a long neck, and carefully stopped it with a cork and hard wax, set the vessel in a moderate heat, to digest for a competent while, (two or three weeks may do well) then pour out the mixture into a tall glass cucurbite, to which lute on a head and a receiver with extraordinary care, to prevent the avolation of the spirits, which will be very subtile: then with a very gentle fire abstract the spirit of wine, that will first ascend; and when the drops begin to come over fourish, shift the receiver, and continue the distillation with great care, that the matter boil not over: and when you judge, that about half the acid liquor is come over, it will not be amiss, though it be not necessary, to change the receiver once more: but whether you do this or no, your distillation must be continued, increasing the fire towards the latter end, till you have brought over all you can, and what remains in the cucurbite must be put into a glass well stopped to keep it from the air.

N. B. 1. That to the production of most, if not of all the phænomena of this experiment, it is not absolutely necessary, that so long a digestion (not to say, not any) be premised; though if the time above prescribed be allowed, the experiment will succeed the better.

2. THAT, I remember, I have sometimes made use of oil of sulphur *per campanam* (as they call it) instead of oil of vitriol, to produce the recited phænomena; and though the

attempt succeeded not ill as to divers particulars, yet I afterwards chose rather to employ oil of vitriol; both because it did in some points better answer my expectation than the other liquor, and because I would not give occasion to suspect, that the odours, hereafter to be mentioned as phænomena of our experiment, were due to the common sulphur; whence the unctuous liquor made *per campanam* was obtained, as such, and did no way proceed from the acid vitriolate salt, which that oil (as it is improperly called) doth abound with.

3. THAT I had likewise the curiosity to digest oil of vitriol with Spanish wine instead of spirit of wine, by which means I obtained an odd spirit and residence, and some other phænomena, which I content my self to have in this place given hint of, in regard that wine being a liquor of a much less simple nature than its spirit, the phænomena, afforded me by this, are much fitter for my present purpose.

4. THAT great care must be had in regulating the fire, when once a good part of the acid spirit mentioned in the process is come over. For if the fire be not increased, the rest will scarce ascend; and if it be increased but a little too much, the matter will be more apt, than one would suspect, to swell exceedingly in the cucurbite, and perhaps run over into the receiver, and spoil what it finds there, as it hath more than once happened to me, when I was fain to commit the management of the fire to others.

Now the oil of vitriol and the spirit of wine being both of them distilled liquors, and the latter of them several times redistilled, and one of them being drawn from so simple and familiar a substance as wine, and the other from a concrete not more compounded than what nature her self (which, as I elsewhere shew, can without the help of art produce vitriol) doth divers times present us with; these liquors, I say, being both of them distilled, and consequently volatile, one would expect, that by distilling them they should be brought over united, as I have tried, that the spirit of wine and of nitre, or also of common salt may be; and as the spirits of differing vegetables are wont to be; or that at least the distillation should not much alter them from what it found them, after they had been well mingled together. But this notwithstanding, these two liquors being of very odd textures in reference to each other, their conjunction and distillation will make them exhibit divers considerable and perhaps surprizing phænomena.

FOR first, whereas spirit of wine has no great scent, nor no good one, and moderately dephlegmed oil of vitriol is wont to be inodorous; the spirit, that first comes over from our mixture, hath a scent not only very differing from spirit of wine, but from all things else, that I remember I ever smelt. And as this new odour doth to almost all those, whose opinions I have asked about it, seem very fragrant and pleasant, so I have sometimes had it so exceeding subtile, that in spite of the care, that was taken to lute the glasses exactly together, it would perfume the neighbouring parts of the

the laboratory, and would not afterwards be kept in by a close cork, covered with two or three several bladders, but smell strongly at some distance from the phial wherein it was put. I did not think it unlikely, that so noble and piercing a liquor might be of no mean efficacy in physick; and though I missed of receiving an account of its effects from some ingenious physicians, into whose hands I put it to have trials made of it, yet I cannot despair of finding it a considerable medicine, when I remember, partly what hath been done by some acquaintances of mine with bare phlegm of vitriol, upon the account (as is supposed) of that little sulphur of vitriol, that, though but sparingly, doth enrich that liquor; and partly, what the masters of chymical arcana tell us of the wonderful virtues of the volatile sulphur of vitriol, and what I have observed myself, that may invite me to have a good opinion of remedies of that nature.

2. BUT to shew, how much the odours of bodies depend upon their texture, I shall now add, that after this volatile and odoriferous spirit is come over, and has been followed by an acid spirit, it will usually towards the latter end of the distillation be succeeded by a liquor, that is not only not fragrant, but stinks so strongly of brimstone, that I have sometimes known it almost take away the breath (as they speak) of those, who, when I had the receiver newly taken off in my hand, did (either because to make sport I gave them no warning, or because they would not take it, as thinking what I told them was impossible) too boldly adventure their noses in the trial.

3. THERE is in this operation produced a liquor, that will not mingle either with the fragrant, or with the fetid spirit hitherto described, but is very differing from both of them, and is so very pleasant, subtile, and aromatical, that it is no less differing as well from spirit of wine as oil of vitriol. But of this liquor I give a further account in a more convenient place.

4. WHEN the distillation is carried on far enough, you will find at the bottom, that the two above-mentioned diaphanous spirits (for oil of vitriol is indeed rather a saline spirit than an oil) have produced a pretty quantity of a substance, not only very opacous, but black almost like pitch or jet.

5. AND this substance, though produced by two bodies, that were not only fluid but distilled, will not alone be consistent, but (if the distillation have been urged far enough) brittle.

6. AND though spirit of wine be reputed the most inflammable, and oil of vitriol the most corrosive liquor that is known, yet I could not find, that this black substance would easily, if at all, be brought, I say not to flame, but to burn, nor that it had any discernible taste; though both the liquors, from whose mixture it was obtained, have an exceeding strong and pungent taste.

7. AND whereas both oil of vitriol and spirit of wine will each of them more readily, than most liquors, that are yet known, mingle with common water, and diffuse it self therein, I observed, that this pitchy mass, if the distillation had been continued till it was perfectly dry, would not, that I could perceive, dissolve in common water for very many hours, and, if I much misremember not, for some days.

8. AND lastly, whereas the oil of vitriol and the spirit of wine were both of them distilled liquors, and one of them exceeding volatile and fugitive; yet the black mass produced by them was so far fixed, that I could not make it rise by a considerably strong and lasting fire, that would have raised a much more sluggish body than the heaviest of those, that concurred to produce it.

THE remaining particulars, that I have observed in this experiment, belong to another treatise, and therefore I shall forbear to mention them in this; nor shall I at present add any new phenomena to those I have already recited; those freshly mentioned experiments, and those that preceded them being, even without the assistance of the four observations I have delivered before them, sufficient to manifest the truth I have been endeavouring to make out. For in the experiments we are speaking of, it cannot well be pretended, or at least not well proved, that any substantial forms are the causes of the effects I have recited. For in most of the (above-mentioned) cases, besides that in the bodies we employed, the seminal virtues, if they had any before, may be supposed to have been destroyed by the fire, they were such, as those I argue with would account to be factitious bodies, artificially produced by chymical operations. And it is not more manifest, that in the production of these effects there intervenes a local motion and change of texture by these operations, than it is evident and precarious, that they are the effects of such things, as the schools fancy substantial forms to be: since it is in these new experiments, by the addition of some new particles of matter, or the recess or expulsion of some præ-existent ones, or, which is the most frequent way, by the transposition of minute parts, yet without quite excluding the other two, that no more skilful a chymist than I have been able to produce by art a not inconsiderable number of such changes of qualities, that more notable ones are not ordinarily presented us by nature, where she is presumed to work by the help of substantial forms: I see not, why it may, not be thought probable, that the same catholic and fertile principles, motion, bulk, shape, and texture of the minute parts of matter, may, under the guidance of nature, (whose laws the modern Peripateticks acknowledge to be established by the all-wise God) suffice likewise to produce those other qualities of natural bodies, of which we have not given particular instances.

FREE CONSIDERATIONS ABOUT SUBORDINATE FORMS,

As they are wont to be maintained by divers Learned Moderns.

An Advertisement.

THE following discourse about subordinate forms had come forth the last year, annexed to the foregoing examen of substantial forms, as a part of, or an appendix to it, being then written, and promised in the preface to the reader, if by reason of the bookfel-

ler's haste, who was desirous the book might be printed and published at the beginning of the term, it had not been left out, and is here added in this second edition, wherein no other addition is made.

THE generality of vulgar philosophers have for many ages so handled the doctrine of forms, as if they suspected not, that more than one form could belong to a natural body : but some later writers, especially the learned *Sennertus*, and, if you will believe him, the famous Peripatetick *Zabarel* himself, have endeavoured to introduce an hypothesis, which teaches, that in animals and plants, besides the specifick form, as *Sennertus* calls it, which alone is wont to be taken notice of, there may reside in those bodies, and especially in some determinate parts of them, certain other forms proper to those parts, but nevertheless so subjected to the predominant mistress form, if I may so call it, that they deserve the title but of subordinate forms, and during the reign of the specifick form, are subservient to it, but in the capacity (as it were) of matter ; yet so that when the specifick form comes to be abolished or deposed, these subordinate forms may come to set up for themselves, and in reference to those parts of matter they belong to, exercise the functions of specifick forms : as in a dog or a horse, besides the sensitive soul, which is the specifick form of the whole beast, the flesh and blood and bones have their distinct forms, which appertain to them as they are such bodies, though they are ruled and employed by the soul, but as the matter which she animates and informs ; and when by death the sensitive soul or specifick form is deposed or abolished, the body is not presently resolved into the four elements, much less reduced into the first matter, but those subordinate forms do still keep the flesh, flesh ; and the bone, bone ; the one for a little, and the other for a much longer time.

To make out this doctrine, he ingeniously urges the specifick virtues observable in gathered plants, and particularly the purgative faculty of rhubarb, senna, and other cathartick vegetables. And though, as to this noble sort of examples afforded him by the specifick properties they are endowed with, when they are deprived of the life they enjoyed as plants, it may not be pretended by the obstinate, that, for aught has been yet tried, rhubarb, senna,

&c. are not purgative, while they are living plants, and so, when they are dead, do not so much retain as require that specifick virtue ; as wine obtains divers medicable virtues (as that of cooling, dissolving coral, pearl, &c.) when (by some alteration imperceptible to sight) losing its predominant form it turns to vinegar, which it had not before ; yet it were not difficult to propose experiments, that would determine this scruple, if it were thought important enough. And I shall add, that it is evident, that damask-roses, for instance, which are purgative, retain for a considerable time the same colour, and fragrant odour, &c. when they are gathered, and consequently acknowledged to be deprived of life, as when they grew upon the tree.

THIS doctrine of subordinate forms has been so well entertained, and supposed to be of such importance, and (which nearly concerns the past discourse) to afford such countenance to substantial forms, that the nature of our present discourse forbids me to leave it altogether untouched ; and the rather, because I have not found it so much as taken notice of by the corpuscularian philosophers. But as (on the one hand) this consideration invites me to offer something about this matter, so (on the other side) joining with the difficulty and abstruseness of the subject, it would deter a bolder writer than I, to pretend to give a full and satisfactory account of so perplexed and abstruse a matter. And therefore I shall think my attempt may be excusable (if not acceptable) if I can at present show, that subordinate forms may be intelligibly explicated in a general way, according to the corpuscularian principles, or are at least very reconcilable thereunto. And in regard, that, as I just now intimated, the patrons of these subjugated forms assert substantial ones, and proceed upon other notions that we do not admit, I must venture to explicate this matter in a way very differing from theirs. And it will not be amiss to begin my discourse with laying down some observations, which may serve partly to add some things unmentioned to those, that are mentioned by *Sennertus*, or *Zabarel*, towards clearing up the notion

tion and nature of subordinate forms (a subject not obvious, nor easy to be made plain) and partly to make way for the carrying on the subsequent part of the discourse, without those excursions, that would else too much interrupt it.

FIRST then, we may consider, that according to what I have formerly discoursed, the name form is a technical word or term of art, whose signification, as I there also noted, is not so well defined as is presumed, and were to be wished. But without much injury to the more obvious and usual notion of it, we may observe, that it is commonly some one considerable thing (or at most, some few things) such, for the most part, as some conspicuous phenomenon, that is exhibited, or some peculiar operation, that is performed by it, or some particular use, to which it is applicable, upon whose account this or that form is attributed to this or that natural body; and only upon the recess or abolition of which, it is said to lose its form, or, if you please, denomination.

SECONDLY, I consider, that the bodies, whose being or not being endowed with subordinate forms is contended for, are generally either vegetables, or animals, or bodies belonging to them; and consequently, these bodies being of a very compounded nature, consist of parts whether organical or not, that are not all of them of the same nature, which I take to be true, not only of those parts, that are unanimously to be organical, but of many of those, that are reputed similar, because as to sense they are so. This is evident in bones, which, though believed to have as good a right as any to the title of similar parts, do yet by distillation afford salt, oil, phlegm, spirit, and ashes. And vitriol, though similar as to sense, may be (as we formerly noted,) artificially produced by uniting the metalline particles of iron or copper with the saline corpuscles of distilled salt or nitre. Which instance I the less scruple to make use of, because, that though the patrons of subordinate forms seem to have asserted them, to give some account of what happens in vegetables and animals, when the ultimate form is abolished or expelled; yet for my own part I see not, why we may not also attribute subordinate forms to divers inanimate bodies. To illustrate this matter, I will borrow an example from rhubarb, (for this drug, as it is sold in the shops, is an inanimate body) wherein the purgative faculty is affirmed to proceed from a substantial form; which virtue, whilst the rhubarb grew in the ground, did, as they teach us, proceed from the specific form. For if from the same rhubarb we do, by a convenient menstruum, extract together with the finer parts of the body all the purgative virtue, (which, as *Sennertus* himself teaches, may very well be done) I see not why, according to his grounds, the remaining rhubarb, which will retain divers of its former qualities, if not disclose some new ones, ought not to have a peculiar form distinct from that which he and the schools call *Forma missionis* assigned to it; to which those qualities may be attributed, and which consequently may be looked upon as a subordinate

form in reference to that, which the intire, though inanimate rhubarb, had before. But whatever become of this instance, there are other bodies, wherein I see not why, according to his grounds, a subordinate form may not be allowed. For in an olive or an almond (for example) though when it is gathered it ceases to be animated by the vegetative soul of the tree, yet it retains the same shape, colour, &c. that it had before it was gathered, (which it retains upon the account of the subordinate form, that belonged to it as such a fruit) by virtue of which form it may be preserved sound during a whole year, or perhaps much longer; so when by barely crushing the pulp of the olive between your fingers you may immediately squeeze out oil, which confessedly was pre-existent there (the pressure only associating so many parts as to make them visible) and which is a peculiar liquor endowed with noble qualities, and capable of preserving itself divers years: I see not, (I say) why the form of this oil, from whence its qualities must be said to flow, may not be looked upon as having been, whilst the liquor made a part of the olive, a subordinate form to that of the intire fruit; whose remaining part having also its own peculiar qualities, and that such, whereby, for instance, an olive that has lost its oil much differs from an almond that has lost its also, may, for aught I see, deserve to have a distinct subordinate form ascribed unto it. But to make this out the better, I shall here add a couple of examples, that perhaps will seem clear enough; the one is sulphur vive, wherein (to speak according to the chymical notions) nature has united under one form two bodies of very differing kinds, the one readily inflammable, and the other a great resister of fire; and yet these two are easily separable, as may appear by the known chymical practice of kindling sulphur under a glass bell. For the oleaginous part (as the combustible is supposed) manifestly burns away with a blue flame, and the saline corpuscles meeting with the moist vapours, that are commonly interspersed in the air, are condensed against the sides of the glass into a highly sharp and corrosive menstruum: (which may several ways be brought to exhibit its salt in a dry and brittle form.) The other instance I was to mention, is also of a body, that cannot be pretended to be factitious, (namely, *cinnabaris fossilis*,) for in this concrete under the form of a mineral stone, nature has ranged three (if not more) compleat bodies, that has each of them its own distinct form, and that exceeding different from the others; as may appear when these bodies are skillfully separated. For thence, as we noted above, we have obtained a running mercury, an inflammable sulphur, which itself will be easily allowed to be a compounded body, and a strange concrete, whose properties I had not occasion to look into. To these instances I might add divers others, if it were necessary so to do. And if it be said, that these forms are not subordinate, but rather co-ordinate, it will lie upon the objectors to prove it; who perhaps will find it no easy matter to evince, that the same ingredient, for instance

of sulphur, is not as much subjugated by the form of the intire body, as that of the purgative portion of rhubarb, by the form of that drug. But if it did appear, that these forms were more properly styled co-ordinate than subordinate, it would not much trouble me, who am inclined to think, that divers of the forms which *Sennertus* and his followers call subordinate or subjugated, may be as fitly styled co-ordinate or concurrent; since I shall show anon, that I do not ascribe to the specifick, or supreme form in reference to the rest, such a coercive power and dominion, as those learned men are pleased to do.

THIRDLY, I consider, that all these differing bodies, whereof, as of parts, or as of ingredients, a compounded body is made up, are by virtue of the composition and peculiar fabrick thereof so put together or contrived, that they concur to those actions or operations which are proper to the body as such, and therefore are presumed to flow immediately from the form of it. For an instance of which I shall name gunpowder, where three ingredients upon a very slight mixture (as I shall anon shew theirs to be) do by a concurrent action produce those wonderful effects, that are scarce to be matched by nature herself. And that these stupendous operations really result from the proportion of the ingredients, and the manner of their mixture, will be hereafter manifest.

FOURTHLY, I consider, that notwithstanding these several parts, whereof the compounded body consists, do in the proper, and, if I may so call them, specifick actions of the body so concur, as to perform them jointly, and (as the schools in divers cases express themselves) *per modum unius*: yet these thus conspiring bodies may each of them retain those attributes or that modification, which made it a distinct natural body, before it came to be associated with those others, with which it makes up a more compounded body.

AND if it be proper to propose here an argument *ad hominem*, I shall add, that the more considerate of the modern school-men themselves do, though perhaps unawares, teach such things, as do very well agree with the doctrine of subordinate forms. For when in the generation of man they tell us, that, as *Aristotle* also observes, the embryo lives the life of a plant and of an animal, before he attains to live the life of a man, it is plain, that, according to them, upon the introduction of the rational soul the vegetative and sensitive souls, that before successively informed the embryo, do so no more, the advenient human soul becoming now the true form of the human body. And these pre-existent souls are not abolished, and do not lose their being, but only their office, which at first was to inform the body of the embryo, but now ceases, so that they are not destroyed, but only deposed. And this consideration seems to afford ground enough to admit in divers natural bodies forms, that dispose the matter they modify for the reception of a noble stamp, for which reason I sometimes call them preparatory forms, besides those more noted forms, that the schools usually term specifick,

(and which I sometimes call predominant or supreme) by which I suppose is meant (to speak intelligibly) the last and highest stamp, or modification, that nature gives that parcel of matter; whereas the preparatory form is but (if I may so speak) a harbinger, that disposes the matter to receive a more perfect form, which, if it be not to be succeeded by any other more noble, is intitled the specifick form of that body; as in the embryo the vegetative and the sensitive soul is but preparatory to the rational, which alone is said to be the specifick form of man.

BUT here I would not be thought to adopt for mine all those opinions, upon which I think it allowable for me to argue with those, that own them. For I must not omit to intimate *in transitu*, that I elsewhere consider with what congruity to some other of their tenets they can assert, and in what sense, in regard of the nature of the thing itself, we may admit, that the souls of all living creatures be the true forms of their bodies, notwithstanding the scruples suggested to me, as by other things, so particularly by the great difference I take notice of by some of these animating forms (if I may so call them) and other natural forms in reference to the manner of their informing the respective bodies they belong to: of this to give an instance, it is evident, that the reasonable soul, (which some call *animus*, to distinguish it from the *anima* or sensitive) is not the architect of the human body (which they confess and teach must be organized, before it be fit to have that united to it) as many other forms are said to be of theirs; nor do all the properties, or so much as all the specifick ones, flow from that soul (whose mansion was a living animal of a determinate kind before it was united thereto) as those of other natural compounds are held to flow from their forms. And even in beasts and plants (if we will rather consider the thing than men's opinions) if the soul be all the form, there will remain in the matter after the abolition of the form great store of qualities, that by their so remaining show, that they do not flow from the soul, as gravity is said to flow from the form of the earth, and transparency from that of the air, and these surviving qualities are oftentimes not only many, and several of them noble and specifick, as appears in the beauty, fragrancy, and cordial virtue of oranges, lemons, &c. but oftentimes the same, that were there in the body, for aught our senses can perceive, whilst it was said to be informed by the soul. And I believe it would puzzle a Peripatetick to discriminate an apple or an orange, which, having been plucked off from the tree, were with a slender thread artificially tied on again by the stalk, from the other fruit as yet growing on the same branch. And not only the letters, that were carved on the bark of young trees, and grew with them, remain as fair and legible as ever, when the trees are cut down; but a dead body for some time after death (and it matters not how little a while, provided the soul, and consequently the specifick form be really destroyed or departed) does oftentimes so exactly retain the

shape, feature, and even colour, warmth, and other qualities, which it had whilst the soul (a little before) was there, that it often puzzles the best physicians (especially if the sick person were hysterical or apoplectical) to discern with certainty, whether the patient be dead or alive. And as for that conceit of a *forma cadaveris*, whereby divers of the modern Peripateticks have attempted to decline the inconvenience of allowing, contrary to the doctrine of very many of their party, that the same qualities remain *in corrupto* (as they speak) as were *in genito*; and that in spite of their general and fundamental tenet, the matter may be for some time (how little soever it imports not) without a substantial form: this cadaverous form, I say, that seems much to disparage our senses, (which witness divers of the remaining qualities to be the same they were before) seems to be deduced without any ground from the phenomena of nature, being introduced, (as * *Suarez* himself, though a friend to this expedient, ingeniously confesses) but because it is consonant to the Peripatetick doctrine, that it should be so: (though that itself be not so evident, but that *Scotus*, and I know not how many of the Aristotelians themselves, reject this form, if they do not also deride it.)

NOR need we be very solicitous, how the parts of a dead body can be kept together, if neither the soul, nor some new substantial form that succeeds it, perform that office; since competent agents, whatever they were, having contexted a portion of matter into such a human body as the soul left upon its departure, the fabrick of the body and connection of the parts will suffice to make it retain for a little while (and that is enough for our purpose, since dead bodies are not wont to remain long unaltered) their pristine shape, and divers other manifest qualities, which may continue, till the action of outward agents upon the less solid parts of the body, or the internal and inordinate commotions of the juices, and the softer, though not fluid parts, that are contained in it, do by their degeneration vitiate the texture, and consequently the manifest qualities of it. And if these inordinate agitations of the blood, humours, &c. be hindered, though by an external cause, the body, notwithstanding the loss of the soul, will continue unputrified, not only for some hours, but for many months together; as a learned eye-witness, whom I inquired of, assured me he, as well as many others have observed in very cold countries as *Russia*, *Sweden*, &c. where they often keep those bodies that die in the winter unburied, and yet sweet, till the spring, when the sun's heat makes them begin to putrify. And it is plain, in some aromatick gums and fruits, that bodies, that were once plants, may, after they have lost the vegetative soul, not only continue many years uncorrupted, but by embalming other bodies keep them so too.

BUT as I was saying, the prosecution of this inquiry (whether in living creatures the soul be always the true form, to all the intents and purposes, that the vulgar philosophers would have it)

belongs not to this place, else I might also question the congruity of what is taught as well by *Sennertus*, as the schools, that upon the supervening of the ultimate or specifick form, the forms, that thereupon become subordinate, do but make a part of the matter informed by the new form. I grant indeed, that they may qualify and dispose the several portions of matter they belong to in such a way, as that they make the body, they consist of, a fitter subject or receptacle for the ultimate form, that is to be introduced: and there may be a necessity of such previous dispositions in the subject, because the compounded body is of such a nature, as that no other bodies, but such as are thus and thus qualified, are fit to make it up. But it seems not to me so easy to conceive, how a substance distinct from matter (for such both he and they make their substantial forms to be) can properly be said to have its capacity confounded with that of the matter. And notwithstanding the lately mentioned distinction betwixt specifick and preparatory forms, those (last named) seem to me as true ones, whilst they are either sole or predominant, as the specifick themselves. For bodies are what they are by the matter and modification, that do for the present constitute them, whatever they may prove to be in the future; and it is extra-essential to the form, that is said to be previous, that it is to be succeeded by another, which is said to be more noble. A spring of steel is a true and perfect spring, before it be made a part of the watch, and by becoming so, it is not really bettered in its nature, though it be made indeed more useful to man: and when copper is turned into vitriol, copper was a true and complete metal before, and it is accidental to the copper, that corrosive spirits coagulate themselves with it into a salt-like substance. And antimony is true and perfect antimony before it be turned into glass, whether afterwards it happen to be or be not changed, by the bare operation of the fire, from a black and opacous mineral to a fine red and transparent glass.

AND though I know, *Aristotle* attributes to forms *τιμωτης η ἀτιμία*; yet it is not always so easy duly to apply those civil appellations to physical things, and to determine, whether a succeeding form be more or less noble than the precedent. As when, for instance, pearls are reduced by salts into a chymical magistery, and vitriol is made of iron or copper; where, for divers œconomical and military uses, the metals themselves are fitter than the magisteries, (as in gold-smiths shops and on ladies necks, the intire pearls are much more prized than the prepared ones) and for other purposes, especially in physick, which regards the health of man, the magisteries are better than the crude metals. And these instances put me in mind of taking notice, that as the supervening of a form does not always destroy the old, as in vitriol (such as I formerly mentioned) the copper retains its metalline nature under the disguise of a salt; so upon the abolition of the ultimate form, the previous form may in divers cases be reduced to the exercise of its former functions;

functions; as out of such vitriol as I am speaking of, it is easy, without the addition of any metalline substance, to recover true and malleable copper. But I have dwelt too long upon this fifth consideration, which will invite me to make shorter work with those, that follow.

FIFTHLY, But before I proceed to them, it will not be amiss to intimate, that one may, if one pleases, make some distinction between subordinate forms, there being one sort of them that may deserve a peculiar name. For in men, horses, sheep, and other perfect animals, there are divers parts, especially those, that physicians call similar (in opposition to organical ones) such as bones, ligaments, membranes, which seem evidently to challenge peculiar and distinct forms: for the diversity of their nature, being very manifest and stable, persevering oftentimes a great while (as appears in bones) after the death of the animal, those that allow, that a natural body is what it is upon the account of its form, cannot well deny these so distinct bodies distinct forms; which because the bodies they constitute are the parts of a human body, some modern schoolmen have (not very inconveniently) called partial forms. But this distinction being not of so great weight, that we need insist upon it, the notice already taken of it may at present suffice.

SIXTHLY, I consider, that among the constituent parts of an animal or plant, there may lurk some seminal principles or rudiments, that is, small parcels of matter of such a texture, that though whilst they remain associated with the other parts of the compounded body, they are not by sense (especially when that is employed with no greater attention than is usual) distinguishable from the rest of the compounded body, comes to have its predominant form abolished, these seminal principles or rudiments being set at liberty, and befriended by external heat, and the softness which usually attends corrupting bodies, and perhaps by a lucky concurrence of other circumstances may fall to act according to their own nature, and generate insects, moss, &c. as I have more amply declared in other papers*.

SEVENTHLY, I consider, that besides that when the specific form of a body is destroyed, the change is not oftentimes so great as vulgar philosophers imagine; the corruption of the animal or other body ought not to be looked upon, as if it happened in some of those imaginary and empty spaces, that are conceived to be beyond the universe, but in this world of ours, where the body, which is deprived of its specific form, is subject to be acted upon by the sun, the air, and I know not how many powerful agents, by whose various concurrence with, and operations upon the body, either the pre-existent, though lately eclipsed forms, may be assisted to set up for themselves, or new forms may result from new leagues and contextures of the particles, that composed the body, that lost its principal, or, if I may so call it, sovereign form, (as we have

largely discoursed in the lately mentioned papers. †)

THESE observations being laid down, to avoid the necessity of too much interrupting our future discourse, by being obliged to interpose some of the premised explications and other passages, as obscure and difficult, as we readily confess the subject we are treating of to be, we shall now adventure to try, whether about *Sennertus's* doctrine we can propose any conjectures, that being as agreeable to the phenomena, as his are congruous to the corpuscularian hypothesis, according to which we have hitherto discoursed of forms.

AND (to begin with a concession) I allow the learned *Sennertus* and his followers to be in the right, who, without fearing the invidious title of innovators, asserted, that in an animal or a plant there was something else besides the bare *materia prima*, and the vegetative or sensitive soul, with its essential faculties. And the instances they bring to shew, that in some parts of such bodies there may lurk peculiar forms, which, when the life of the plant or animal determines, come to disclose themselves, are probable enough; and the instances taken by *Sennertus* from the specific virtue, that survives in gathered plants, and particularly the above considered purgative faculty of rhubarb, are ingeniously alledged for their purpose. And it is probable too, what *Sennertus*, according to their grounds, teaches, that this purging property in rhubarb, fenna, &c. as it does not flow from the vital soul of the plant, which is already destroyed, so it does not proceed barely from the form of a mixed body as such; it being no way likely, that so great a variety of specific properties, as roots plucked out of the ground, and fruits torn from the tree, are endowed with, should proceed merely from that general form, that belongs in common to compounded bodies as such. To which argument I forbear to add that other, wherewith it is seconded by *Sennertus*, though he and others of several parties are wont to lay much weight upon it; namely, that these properties flow from the specific form, which even in inanimate bodies is of a sublime nature, and must be the author of such peculiar virtues, which, according to him, being far above the reach of elementary qualities, cannot be produced by any mixture whatever of the elements: this argument, I say, I decline to urge in this place, because I elsewhere purposely examine it, and having declared in what sense only it seems to be safely grantable, I reject the chief supposition, on which it leans.

To proceed then to the next part of our discourse: though (as I was saying) there be some things about the doctrine of subordinate forms, wherein I dissent not from these learned men, yet there are others, wherein I must confess my self unsatisfied; for neither do I acquiesce in some of the notions, whereon they ground the things, wherein we agree, nor do I agree with them in some of the main things they assert: and especially having in the past

discourse

* Essays about spontaneous generation.

† Especially in the latter part or essay.

discourse rejected substantial forms, it is not to be expected, that we should either employ them in our explications, or admit those explications, that necessarily suppose them.

THEY teach us indeed, that the specifick form of a body does command all the subordinate forms, and use them but as instruments to its own purposes, those forms belonging then to the matter, which the specifick informs and rules. But for my part, that do not acknowledge in many bodies, that are or may be said to have subordinate forms; any thing substantial distinct from matter, I confess I do not readily conceive, which way this dominion attributed to the specifick form is exercised, nor do I see any necessity of admitting any such power in that form, nor that the portions of matter, that are endowed with those forms, that are said to be subordinate, can, being under the degrees of souls, and consequently unfurnished with knowledge and will, pay this presumed superintendant form any obedience; I mean any other obedience, than some such kind of one, as the parts of a clock or engine may be said to yield to one another. I should therefore rather conceive the matter thus; when divers bodies of differing natures or schematisms come to be associated, so as to compose a body of one denomination, though each of them be supposed to act according to its own peculiar nature, yet by reason of the coaptation of those parts, and the contrivement of the compounded body, it will many times happen, that the action or effect produced will be of a fixed nature, and differing from that, which several of the parts, considered as distinct bodies or agents, tended to, or would have performed. As when in a balance, by putting in a weight into one of the scales, the opposite scale, though as a heavy body it will naturally tend downwards, yet by virtue of the fabrick of the instrument is made to mount upwards. And when an archer kills a deer with his arrow, the bow being a springy body, naturally endeavours to unbend it self; and the spring being fastened to the bow, must necessarily follow the motion of it, and the shaft, though a heavy body, and, as such, tending directly downwards, is by the forcible impulse it receives from the spring, thrown with such violence (not directly downwards, but in a parabolical or some such crooked line) as far more strongly to hit the mark, than it would (if left to it self) have struck the ground. So that those actions; which *Sennertus* and others attribute to the conspiring of subordinate forms to assist the specifick and presiding form, we take to be but the resultant actions of several bodies, which being associated together, are thereby reduced in many cases to act jointly, and mutually modify each other's actions; and that, which he ascribes to the dominion of the specifick form, I attribute to the structure, and especially to the connexion of the parts of the compounded body: as in a clock, though all the parts it consists of, do contribute to the performance of those things, that belong to a clock, as regularly as if they intended so to do, and did not only

concur, but knowingly conspire in what they do, yet in all this there is no substantial form to superintend their motion; but the lead (or other weight) tends downwards as it is wont to do; and the hand, wheels, and other parts do only perform such motions, as they are forcibly put into by those bodies, which by the descending weight (that does not in the least intend what it effects) are themselves set a moving. And notwithstanding the prodigious operations, that men admire in gun-powder, yet not only, as we formerly intimated, this strange power is but the effect of the mechanical texture, and of the way, wherein the ingredients are mingled, and as it were contexted; but this artificial mixture is far more slight than those made by nature are wont to be. For as the efficacy of the mechanical texture in gun-powder may appear by this, that neither of the ingredients (whether the sulphur, the nitre, or the coal,) is apart able to produce effects any thing near like those of gun-powder; so to convince others, how slightly the ingredients are mingled, I thought the best way was to shew, how easily they may be separated again; to which effect I beat good gun-powder small, and having boiled it a pretty while in a considerable proportion of water, by exhaling a sufficient quantity of the well-filtrated and limpid decoction, I obtained store of crystals, whose figure, taste, and way of flashing upon a quick coal proclaimed them to be good salt-petre; the black stuff left in the filtre remaining, if the solution had been well made, insipid enough, and when dried it will not blow up like the gun-powder, but (in great part) burn along with a blue flame like common brimstone. And for farther proof we may, by boiling this black stuff in a pretty strong lixivium, dissolve the sulphur, as will appear both by the smell, that the lixivium will acquire, and by this, that if you filter it, though the liquor will pass clear enough, and leave the black and coal-like part in the filtre; yet by dropping into it some quantity of an acid liquor (I used spirit of salt) the sulphureous smell will be increased, and the liquor will be made white by the precipitation of the sulphureous corpuscles; whereas if I put spirit of salt into that clear solution, which (I was saying) afforded me the crystals of nitre, the liquor, not troubled by any such precipitation, would continue limpid as before; which argued, that the salt-petre had not intimately incorporated any sensible quantity of the sulphur with it self, but had been only slightly associated with it.

AND to illustrate what I said of resultant actions by an instance purely physical, I shall subjoin what I somewhere mention, with another aim, that by taking a couple of powders fit for my purpose, one blue and the other yellow, and mingling them in a certain proportion, the mixture exhibited a green colour, which did not flow from any new predominant form, which made the blue and yellow corpuscles subservient to its purposes, (for an excellent microscope shewed me the blue and the yellow particles such as they were before) but only hence, that from the mixture of those bodies, the

the distinct actions of the blue and the yellow corpuscles did upon the eye make a compounded impression, like that made by bodies, to whom their specifick forms are supposed to impart, among other qualities, greenness. And when vitriol or sublimate are made by art, there needs nothing besides the manner, wherein the saline and metalline particles are contexed, either to contain the parts together, and keep them united into one body, or (notwithstanding their not only distinct, but very differing forms) to enable the mixture they compose, to effect divers things, which neither of them single would have performed: nay and some of them such things (as to vomit, purge, &c.) as merit to be reckoned among such specifick properties, as many of those are, which when preserved in vegetables, are thought to argue the conspiring of several forms under the direction of a superintendent one.

AND as in a watch the spring is really a spring, and acts as a spring, whilst it is a part of the watch, though by reason of its connexion with the other parts it is reduced to concur with those other parts towards exhibiting the phenomena proper to the whole engine; and though the watch were taken all in pieces, the spring would be a spring still: so in many compounded bodies, besides the specifick form, which the body has as such, and which may be called its total or general form, particular bodies (by whose association and conjunction it is made up) may enjoy their own distinct forms, which may therefore be called partial ones; and these bodies, though whilst the whole subsists they are part of it, and by their connexion with the rest concur to the operations of the body as such, which joint operations are wont to be those, that are attributed to the specifick form; yet they do not always so depend upon it, but that when it is abolished, they may retain their own nature; as a bone will be a bone still, whole ages after the animal it belonged to is dead: whence we need not wonder, that divers forms should survive in bodies deprived of their specifick form. For indeed those, that are called subordinate, may be as true and real forms (nay, and substantial forms, if in any living creature, besides man, there were any such) as that, which bears the title of specifick; and even whilst this is in being, there are many things, which compounded bodies perform by virtue of their particular forms, rather than upon the account of the specifick: as (not to repeat the newly mentioned instance of a spring) in vitriol the friableness, transparency, and aptness to mingle with water, need not be attributed to the compositum as such, but may, for aught we know, be due to the saline corpuscles, which not only retain their own nature, (as may be argued from some vitriols, that I have made, since I have been able to separate and recover them again out of the mixture) but to reduce the metal, they have corroded, into a salt-like body with themselves. And in gunpowder it is manifest, that the blackness proceeds not from the compositum as such, but from the coals, as the nitrous taste does from the salt-petre. And the fragrancy of a rose,

whilst it grows upon the bush, need not be conceived to proceed from the soul or life of the plant, since, when it is gathered, it retains the same grateful smell.

AND this last instance leads me to a farther consideration, wherewith I shall conclude this discourse. We may call to mind what was observed a little after the beginning of it, of the arbitrary, or at least not sufficiently settled use of the word *form*; and that it not seldom happens, that those things, upon whose account we attribute this or that form to a natural body, are but very few of those many attributes that belong to it. Now the form of a body being really no more than a convention of accidents, whereby the matter is stamped and denominated, it is very consonant to reason, that oftentimes hostile agents or causes may deprive the matter of those accidents, which constituted the specifick form, and yet leave the rest, which, according to the law of nature, ought to continue there, till some competent agent put the body out of that state, wherein, upon the form's decease, it was left.

AND to clear up this matter, we may consider, that the same body may have a twofold modification, and be thereby fitted for two, if not more, states and kinds of operations, not necessarily dependent upon one another. For as the spring of a watch by virtue of its texture is an elastical body, and upon the account of another is iron, and therefore though being cast red-hot into cold water it will become stiff and brittle, and consequently cease to be a spring, yet it will continue iron, that is, a hard metalline body easily subject to rust, capable of striking fire with a flint, and of being attracted (as men commonly speak) by a loadstone, and of attracting a magnetical needle; so in a rose, for instance, we may distinguish or consider a twofold modification of the matter, one, whereby it is fitted to receive from the bush it grows on a certain peculiar and spirituous sap, by whose intervention and concurrence it has nourishment and growth, and consequently exercises vital functions as a part of a living plant; and another, which does not so much require the accession of fluid and moveable parts, but consists rather in the texture of the more stable parts: and this texture being commonly more permanent and durable than the other part of the modification, (consisting much in the peculiar motion of a fluid substance) wherein the life participated by the rose consisted, may last, when the flower is deprived of its soul and specifick form by its avulsion from the bush, and retain those qualities, as well occult as manifest, that naturally result from a parcel of matter so contrived.

I MAY somewhat illustrate my meaning on this occasion, by making a comparison betwixt a living creature and a mill. For as a mill is capable of performing divers things only when the water, that passes through certain of its parts, puts them, and by their intervention, others into motion; so there are divers things, that are not performable by a plant, unless when it is irrigated by a vital liquor. And as a mill may nevertheless retain the nature of a structure

structure useful for other purposes, though the drought of summer have perchance made it loose, or the frost have congealed into ice the water, that used to drive it; so although the soul of a plant be destroyed, or cease to act, the body may, upon the account of the more permanent structure of its stabler parts, retain a fitness for divers of the same purposes it served for before. And if it were here pertinent, the comparison might be carried on a little farther, by adding, that as when a mill does upon either of the lately mentioned accounts cease to perform the peculiar operation of a mill, as the wood, iron, and other materials of that mill are not destroyed; so neither does the water vanish into nothing, but either loses its motion, and by being congealed exchanges the name of water for that of ice, or else is dissipated and scattered into exhalations, which contain all the substance, that ever the water had, that, which is lost, being but the usual manner of coëxistence of the water and the mill it was wont to drive: so when a plant is pulled out of the earth, or a rose from the bush, as the dismembred part of the plant may retain the texture of its more stable parts; so the sap or juice, that were wont to enliven the body, does, though invisibly, remain either in the form of steams exhaled into the air, or perhaps in parts condensed and intercepted upon the loss of its wonted agitation in the imperceptible cavities of the fibres, and other parts of the plant, so that nothing, that is substantial, perishes, but only the particular modification, that resulted from the peculiar kind of union of the more permanent parts with those congruously shaped and fitly agitated fluid ones, that permeated them. As to some purposes, the example of a wind-mill, being set on work merely by the impulse of the air, may be more apposite than that of the water-mill; but neither of them affords any more than an imperfect comparison in this regard, among others, that whereas the mill itself by losing, even for a very long time, the motion it was wont to be in, is not thereby considerably impaired, because of the solidity of the materials it is made up of; in vegetables, when that fluid substance, whereof the soul chiefly consists, quite ceases to be influent, one of its chief functions being to repair continually, by assimilated or transmuted aliments, the waste, that was continually made of looser parts in the body it belonged to, the same agents or causes, that destroyed the life of the plant, are wont likewise to produce or occasion such a discomposure in the texture of the remaining part, (especially those, that are more tender or more slightly connected) that they quickly become unfit to be animated again, though a fluid substance, like that, which was wont to irrigate it, whilst the vegetative life lasted, should be again communicated to it; but yet even in this regard the difference betwixt a mill and a plant is not always so vast, as one would imagine. For in classick authors we have relations of a staff or a pike made of a durable wood, that many years after the tree had been cut down, being casually struck into the ground, took root there. And

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as for the rose of *Jericho*, as they call it, a late modern writer, followed, as I remember, by another naturalist of good account, affirms, that divers years after it is gathered, and seems to be quite shriveled up and withered, it may by the help of water be so far recovered, as to be plumped up again, and display its leaves almost as if it had not been long since gathered. And I my self have, not without some wonder, observed, how very long a plant of aloes torn from the ground, and hung in the air near the ceiling of my chamber, would not only continue succulent, but (perhaps after some years) be capable of being made to perform acts, that are wont to be ascribed to vitality and growth, upon the dexterous administration of a convenient liquor: and even some animals themselves are not so very unlike to these plants, and consequently to engines, as one would think. For that, which children are said to do for sport about reviving drowned flies, challenges a more serious consideration than were fit for me to insist on now, and deserves to be both heedfully experimented, and seriously reflected on by a naturalist. I chose to try it chiefly upon wasps and bees, rather than upon flies, because their bigness renders the phenomena more conspicuous; and having drowned them so, that, if let alone, they would not in probability have ever recovered; I found, that the heat of the sun would recover them, as well, as it has been observed, that warm ashes would recover flies; (so that these trials argue celestial heat to be as little more as less vital than elementary:) and the degrees and manner of their recovering again the operations of life suggested observations, not unworthy to be taken notice of elsewhere, though not fit to be delivered here; where I shall not so much as mention what with warm applications we have done, to revive the expired motion of the parts even of perfect and sanguineous animals, when they seemed to have been killed; because I fear, that the excursion I have unawares made already will be looked upon as too much a digression.

WHEREFORE, to take up my discourse where a while since I left it; I shall proceed now to observe, that even in a body, that has lost its specifick form, the noble qualities, that remain, do not always flow from the form of the entire body as such, but from the peculiar form of some particular parts of that body, which being separated from it, though perhaps the more stable parts, that remain, will keep the visible structure from being manifestly altered, yet this remaining body will be quite deprived of the noble properties we were mentioning; as may be gathered, as well from what has been above mentioned out of *Senner-tus* about drawing an extract from rhubarb, in which its whole purgative virtue resides, as in some preparations of cinnamon, and divers other substances endowed with fine parts, which upon the loss of those parts remain but the carcasses of what they were. And even in the gross bark of oak, tanners find, that when the water has extracted the dissoluble parts, or time has wasted some subtil parts, and changed the texture of the rest, though the bark re-

tains its outward form, they cannot make use of it as they might have done before. And (as I formerly intimated*) besides this pre-existent and surviving modification, it is in divers cases very possible, that new qualities and properties (whose principle may be called a form) may be disclosed upon the abolishing of the specifick form, though they were not actually in any part of the matter, but are produced in it by a concurrence of the texture and dispositions left there by the late form, and the operation of external agents. As when out of the flesh of a dead animal there is generated musk; for not only those seminal rudiments, that actually were latent in the corrupted body, gain opportunity to set up for themselves, and become perfect insects, or other creatures of their own kind, but the external agents, to whose action, according to the common course of providence, deceasing plants or animals happen to be exposed, do oftentimes (not without the foreknowledge of the most wise author of nature) so agitate the small parts of the widowed matter, and perhaps by associating themselves with them, do so alter their texture, and thereby introduce a new modification, that by the conjunction of the former dispositions, that were regularly left in the matter with these new agents, promoted by a concurrence of favourable circumstances, there may be produced new and noble forms; (however not vital ones.) As when a limestone, being calcined and left in the open air, will in tract of time, as I have particularly observed, by the assistance of congruous particles it meets with there, and befriended by the more catholick causes of physical mutations, afford true and inflammable saltpetre; and I have seen certain marcasites, that, being burnt and exposed to the air in convenient places, would have such a change produced in their parts, as, after a due time, to afford an efflorescence, which both by the colour, taste, and operation appeared to be vitriol.

BUT of such matters no more at present. I will rather take notice, in prosecution of what I was not long since observing about the twofold modification of living creatures, that I fear we sometimes attribute to the specifick form or soul, things, that may be well enough perform'd without it, by the more stable modification of the body, befriended by an easy concurrence of natural agents. Thus, though the exclusion of excrements be unanimously ascribed to the soul, which for that purpose is said to be endowed with a peculiar faculty, that they call expulsive; yet it has been observed and affirmed by many, that divers times the excrements have been discharged out of the bodies of men a good while after they were unquestionably dead; so much (it seems) of the former structure of the parts remaining, as sufficed to cooperate with the excrements themselves, changed by the death of the animal, to that exclusion. And thus (to add an instance of another kind) though the maturation of fruit be a great, and, as the schools speak, a perfective alteration, which is supposed to be wrought by the vege-

tative soul of the plant; yet it has been vulgarly observed, that apples and grapes gathered before they be ripe, and laid on heaps together, will ripen well enough afterwards; (and the example were more eminent in medlars, if what some call their ripeness, others did not call their rottenness.) And very remarkable is that account, which the inquisitive Oviedo gives the emperor Charles the fifth of the Anana's, if I mistake not the name; which having mentioned as one of the considerablest fruits he met with in the *West-Indies*, he takes notice, that though, notwithstanding their largeness, they grow in clusters, yet they must be gathered whilst all but one are green. For as soon as the first begins to be yellow, the whole cluster must be taken off, leaving the rest to ripen, and attain to the same colour in the chamber, which they will very well do. The learned † *Josephus Acosta* speaks thus of the fruit of the plane-tree, to the same. "This fruit (says he) inclines more to cold than heat."— They are accustomed to gather the boughs or clusters (as I have said) being green, and put them into vessels, wherein they ripen being well covered, especially when there is a certain herb mingled with it, which serves for this effect. But the diligent *Piso*, speaking of those Brasilian plants, which he calls *Pacoeira* and *Bananiera*, punctually relates that, which comes up yet more fully to our present purpose. For not only speaking of the fruit, he says||, *continentur plerumque in uno ramo quatuordecem aut sedecem numero, ut ita una planta proferat septuaginta aut octuaginta, qui subinde virides avulsi, nunc in ædibus, nunc in navibus suspenduntur, donec justam maturitatem & flavedinem consequantur*: but adds this memorable passage concerning the lopped boughs themselves; *Ramus autem ille fructibus onustus, interea dum illi maturefcunt, augetur, floresque semper protrudit ex corpore illo foliaceo, &c.* On this occasion I might here add, that even in our cold climate, onions and some other bulbous plants will in the spring-time shoot out of their own accord. And I have taken pleasure to keep potatoes in the air, to observe, how at that season, when they usually begin to sprout in the ground, they would put forth leaves at so many of the little holes or dimples, as to give themselves a verdant livery: but that not being willing now to examine, whether or how far an animated seed may have an interest in these last mentioned productions, I will rather take notice, that even in animals some things, that are confidently presumed to be the proper effects of the animal's soul, may be really performed by the texture of the body, and the ordinary and regular concurrence of external causes. For (not here to repeat what I lately noted of the exclusion of excrements in dead bodies) though the nails of a man are nourished, and do grow as well as other parts; and though the hair in most animals be sometimes, even in determinate parts of the body, peculiar to the species of animals, to which it belongs; and though in man hairs do not only grow, but in the disease called the *plica Polonica*,

* Especially in the 5th and 6th considerations.

† *Acosta, lib. 4. p. 269.*

|| *Piso, Natur. Hist. cap. 21. pag. 155.*

ionica, it appears to participate of blood, (since the hairs being cut, weep out that liquor) yet nails themselves are observed to grow in dead men. And that they do not so only (as is supposed) for a little time, whilst the impressions left by the soul upon the carcass are yet vivid and recent, but for a much longer while than has been imagined, I have been with pleasure informed by a memorable observation I met with in the experienced * *Paræus*, who speaking of a body, that he by embalming preserved for more than twenty five years, he affirms it still remained whole and sound, and that, as to the nails, he found, that *having often pared them, he still observed them to grow again to their former bigness.*

I KNOW the patrons of *Sennertus's* opinion look upon it as a clear and cogent argument, to prove the soul's performing almost all things done in the body, that in the corpse of a man or other animal newly dead, though the organization remain the same, yet all the animal and vital functions perfectly cease. But besides that I have already taken notice, that some things wont to be attributed to the sensitive soul may be observed in a body avowedly dead, I confess, that this argument seems to me, though very specious, yet grounded upon what is but precarious. For though it may be true, that the visible fabrick may continue for a while without any manifest alteration, yet who can assure us, that the internal organization is not considerably changed and vitiated? For the body of an animal is an engine, that consists not only of solid and stable parts, as bones, muscles, skin, &c. but of divers soft ones, as the brain, nerves, &c. and of some that are fluid, as the blood, and other liquors; and, which is in our case exceedingly considerable, requires a convenient coaptation, or composition of all these: whence it follows, that the external frame of the body remaining unaltered, yet upon death there may be great and sad alterations in the texture of the blood and humours, and in the contexture or structure of other internal parts. And these changes may quite spoil the organization of the body, and make it unfit to perform the wonted functions of such an engine. Thus we see, that in dead bodies, even whilst they are warm, the blood oftentimes coagulates in the vessels, whereby the circulation, that grand wheel of life, is stopped. And in sudden palsies, though there be usually no visible change in the affected limb, yet it loses sense, or motion, or both: and not only in synopes or great swoonings, and in apoplexies, a great part of the animal functions are for the time suspended or unperformed; but even in so natural a state as sleep, the body appears not to move, nor do sounds and odours affect the senses, as when one is awaked, though the soul be present in the body, and the ears and nostrils be open. And how great changes in the nature of liquors, and consequently of the blood, may be produced without any visible alteration, may be guessed at by what often happens in wine upon thunder: for that liquor, which was pleasant, spirituous, inflammable

before, speedily degenerates into a sour and un-inflammable vinegar. Which instance will not, I suppose, appear inconsiderable to those many modern philosophers and physicians, that would have life maintained by a *biolychnum*, or vital flame continually burning in the heart, and fed by the spirituous parts of the circulating blood.

It were not perhaps time mispent to prosecute such inquiries, as we have lately touched. But though I did not want leisure, I should be discouraged by considering, that even some of the things I have already delivered; may be questioned by those who take not the word *life*, and some other terms by me employed, in the same sense that I do. And indeed it is very difficult, that men should avoid falling either into mistakes; or into unprofitable disputes, if they discourse largely of such themes, where the names, that are of a very common and necessary use, have (yet) their significations very little stated or agreed on. For *life*, for instance, is a word, whose meaning is not yet defined, and is applied to subjects, that are exceeding different. For it is ascribed not only to all sorts of animals and plants; but by many chymists and mineralists to stones and metals growing in the bowels of the earth. Nor is it attributed only to things corporeal, but to those, that differ *toto genere*, as they speak; from them; namely, to separate souls, angels good and bad, and to God himself. Nay, what that is even among animals, wherein it consists, is not yet sufficiently agreed on; as may appear by the dispute among the modern naturalists, whether prolific, but as yet unhatched, eggs have life or no? and whether flies be really dead in winter, which some affirm them to be, not only because those insects seem to be devoid of sense and motion, but because they place the notion of life in a constant circulation of the blood, or some analogous juice, and a distribution of the aliment thereby performed to repair the wastes of the body; whilst others, on the contrary, think them to be rather benumbed than dead, because regularly recovering the manifest actions of life in the spring, (or oftentimes before, if a due application of heat be made unto them) it cannot be supposed, that they were during the winter really destitute of life: death being a privation, which, by physical means, admits not of a return to the former state. Nor are the boundaries and differences betwixt the life of a plant and that of an animal so settled and defined, but that divers not impertinent questions may be made about them; and particularly it may be doubted, whether some parts, as nails, hair, horns, &c. that belong to the body of an animal, may not for all that (even whilst he is alive) have the nature of a plant; to which the part where it grows, serves as the stock does to a graft for a soil, and is but an appropriated one. But to do more than point at such matters, would add too much to the digressions, of which I fear the passed discourse may be thought to be guilty already. I shall not therefore add any thing at present further about

about the subordinate forms of plants and animals: but in regard I ventured, about the beginning of this little tract, to ascribe subordinate forms to divers bodies, that never had life, which I doubt will seem a paradox to many, I think it will not be amiss to apply the chief points of our doctrine about subordinate forms to inanimate bodies, because this course, as it will invite me to make some new, though short additions, to illustrate and enlarge some points; so it will help to recal to your memory most of the heads of that doctrine, which the several excursions whereto divers subjects tempted me, may have kept you from taking a distinct view of. And for order's sake I shall cast the main things, I would have considered, into distinct propositions, with short comments annexed to them; having only intimated in general once for all, that you will not, I hope, wonder, that I should often use for examples, such bodies as are looked upon as factitious, if you recal to mind what I have formerly said to shew, that the difference betwixt them and those that are confessedly natural, is not always near so great as men are wont to imagine. To which I shall now add, that in the following discourse they are often employed, not so much to prove, as to illustrate the notions, on whose occasion they are alleged; which sure they may very properly do. And among the bodies themselves, in whose production man's power or skill has a share, I reckon, that there is a great difference between those, wherein man gives an outward shape, such as himself designs, by tools of his own making, that are always external to the produced body, and those (such as are most chymical productions, besides others) wherein his chief work is to apply physical agents to patients, by which means it oftentimes comes to pass, that (as in productions, that all allow to be natural) the instruments he works by are parts of the matter it self he works upon, or at least intrinsical to it. But of this more perchance elsewhere; I come to the propositions themselves.

I. THE word *form* is of a sufficiently indeterminate signification.

THIS I have already had occasion to shew, and it can scarce be denied by them, that shall consider, though it be a technical word or term of art, yet men have not intelligibly defined and agreed, on how many, or what things, they are sufficient to intitle a portion of matter to a determinate and distinct form. For besides that there are I know not how many bodies, such as treacle, beer, gun-powder, coal, ink, &c. about which men seem not so much as to have considered, whether they ought to have particular forms ascribed to them, (or to be looked upon only as factitious things) there are other bodies, that have been taken notice of, about which even the Peripateticks dispute, whether they ought to have particular forms allowed, or no. For not only ice is by some made to be a distinct kind of natural body, whereas others will have it to be only water altered, and thereby deprived of its fluidity, not its form; but even

touching the elements themselves, the schoolmen fiercely dispute, a whole party denying them to have any other forms, than the first qualities, by which they are wont to be distinguished. If I affected paradoxes, I might here add, that perchance there may be bodies, which as they may be diversly considered, seem to have a title to more than one form, and upon that score may puzzle the schools about the assignation of their forms. When, for instance, I have (though not without some difficulty) reduced lead *per se* into a body like that, which chymists call *vitrum Saturni*, and which they make by the addition of flints sand; and it is not easy to determine, whether this shall be one of those kind of bodies, that are called metals, and in our instance is only disguised, or belongs to that other kind of bodies we call glass; for it seems to have the properties of both. For, like lead, it is very ponderous, and dissoluble in aqua fortis and spirit of vinegar, which dissolve not common glass; it affords a very sweet solution, as lead is wont to do; and, which is more, it may without addition by bare heat be quickly reduced in great part into true and malleable lead. On the other side, it is a body fusible, transparent, and brittle, which are the three grand properties of glass; besides which, I have observed in it some others, that will be more properly taken notice of elsewhere. So likewise when mistletoe grows (as I have sometimes seen it) to a very great bigness on a hazle, which (you know) is but a very small tree; or when an apricock or peach is inoculated, and prospers upon the bough of a plumb-tree, the rest of whose branches bear plumbs as they did before, (to which I might add some instances of trees, that I have seen to bear more kinds of fruit;) and when red or blue amel is made, which consists of calcined tin, which they call putty, and of the salt and sand (or fusible stones) whereof the glassmen make what they call their fritta, and of some burnt copper, or some other metalline pigment, most, if not all, of which so differing ingredients may perchance be re-obtained out of the amel, which has divers properties of the respective bodies it consists of, and yet wants others of them; if, I say, such examples as these, to which I could add several others, were proposed, it would perhaps somewhat perplex the schoolmen, to accommodate them fairly to the vulgar doctrine of forms, at whose framing probably such instances were not dreamed of.

II. IT is not easy to decide the nobleness of forms.

THIS point also has been partly handled already, which will make it the less needful to insist long upon it; and indeed, besides that nobleness is rather a civil or political than a physical qualification, it is oftentimes difficult enough to determine even in this sense of nobleness, which of the two forms is the most noble. Of this difficulty we have already elsewhere given some examples, to which we may add, besides the lately mentioned instance of the glass of lead, that of antimony made *per se*; crude antimony being fitter for several purposes

poses both mechanical and medical, than the vitrified calx; and this again being better for divers other uses, than that, which has not been freed from its more fugitive parts.

It seems it was disputable among the ancients, whether or no their electrum (which learned men tell us was a composition of gold and silver) was a nobler thing than either of those metals. And it may be questioned, whether, when chymists have made a precipitate of gold and mercury, the produced powder be a nobler thing than the gold alone. For chymists think it worth while to put themselves to much trouble and some charge to bring gold, by the addition of mercury, to this new state; and therefore if a spagyric physician were judge, he would think, that in such a medicine the gold is improved by the change: but if a goldsmith were to be judge, he would conclude, that gold being the noblest of metals, an alloy must needs imbase it; and he would take the pains, by melting it with borax or some other additament, to free the gold from the quicksilver, and restore it to its pristine form.

It may also be disputed, whether, though in living creatures the ultimate form be wont to be more noble than its previous harbinger, it may not be sometimes otherwise in bodies inanimate, as well as in the productions of art. I will not urge for an example to this purpose, that when corn is ground in a horse-mill, though the whole aggregate consisting of the horse, the wheels, grindstones, and other parts of the mill, be looked upon but as one engine in reference to the use of the whole, which is comminution of grain; yet the horse, though contained in the mill, and looked on as a part of it, is of a much nobler nature than the engine, to whose effects it co-operates. This example, I say, and others of the like kind, (as that of a turnspit-dog, included in a wheel, to make it go round) I shall not press, but rather give this for an instance, that when an artificer, who makes silver solder, adds to the silver a certain proportion (which I have elsewhere specified) of brass or copper, and melts them together, though he thereby obtains a mixture, of good and frequent use for joining together the pieces of brass and silver instruments, and stopping holes and cracks in them; yet it may be much questioned, whether this brittle substance be not less noble than the silver alone was. And when a plant, that grows by some petrifying spring, by imbibing that water is at length turned into a stone, though the rarity of such things makes men prize them; yet it may well be questioned, whether the supervenient form be not less noble than that, which the plant had before.

III. In divers bodies the form is attributed upon the account of some one eminent property or use, which, if it be present and continue, though many other things supervene or chance to be wanting, the matter is nevertheless looked upon as retaining its form, and is wont to be allowed its usual denomination.

An example of this we may be furnished with by our lately mentioned instance of *vitrum antimonii*: for the account, upon which we take

a body to be a glass, being chiefly fusibleness and transparency, this antimonial preparation, by virtue of those qualities, passes without scruple for glass, and would in effect be taken for yellow or red glass, (according as it happens to have more or less of tincture) by an indifferent spectator, who were asked what it is. And yet this substance is not only by its solubility, unfixedness, and disposition to afford a regulus, very differing from common glass, but retains so much of an antimonial nature and properties, as to be vomitive and purgative, as well as *crocus metallorum*. It can scarce be unknown to chymists, that there is a vast difference between those liquors, that are expressed out of olives, almonds, and other unctuous vegetables, and those fine essential oils, as they call them, which are drawn by the help of water in limbeckes; and even of these, some are wont to swim upon water, as oil of aniseeds or nutmegs; others to subside, as the oil of cloves and cinnamon, &c. well drawn; and all these essential oils are very differing from the oil of guaiacum or of box, and other empyreumatical oils, that are distilled in retorts by the violence of the fire; and these do as much differ from expressed oils as from essential ones: and yet all these so differing liquors are reckoned among oils, because they agree in this, that they are fluid bodies, unctuous to the touch, and mingle not with water. And so although some sorts of salts be very fugitive, (as the volatile salts of hartshorn, urine, &c.) others very fixed (as that drawn from the calx of tartar, and from the ashes of wormwood; ash, celandine, and other plants;) and though some saline liquors, as vinegar and juice of lemons, are acid, and dissolve pearl, coral, &c. which lixiviate salts, whose taste is fiery, will precipitate what the others have dissolved; yet all these are numbred among salts, because they agree in the accounts upon which we allow bodies that denomination; namely, their being very sapid, and readily dissoluble in water. Examples to the same purpose with the foregoing I could give you in flame, smoke, glass, coal, and divers other sorts of bodies. And indeed by reason of the unsettled notion and almost arbitrary use of the word, *form*, I have observed it to be so uncertainly applied to the constituting of the distinct classes or kinds of bodies, that I have doubted, whether divers of those forms, by which such kinds are constituted, be not a kind of metaphysical conceptions, by virtue of which, bodies very differing in nature are comprized in the same denomination, because they agree in a fitness for some use, or in some other thing, that is common to them all: as whether a bullet be silver, or brass, or lead, or cork, if it swing at the end of a string, it is enough to make it a pendulum; and whether a burned body be chalk, or rag-stone (which is very hard and coarse) or alabafter, which is a soft and fine stone, or an oyster-shell, or a cockle-shell, or a piece of coral; yet if it have been calcined to whiteness, it is lime, rather than such true physical forms, as are said to make the bodies, that have forms of the same denomination, to be of the same specifick nature. However, these forms seem to be very

generical things, and more such than is commonly heeded. And I have also sometimes questioned, whether some of those things, upon whose score men constitute bodies in this or that species or classis, be so properly the true and intrinsic forms of those bodies, as certain states of matter, wherein bodies very differing in nature may agree. As water, wine, and I know not how many other differing liquors, may each of them apart be made, by congelation, to pass into that sort of body we call ice. And not only the tallow and greafe of animals, and the expressed oils and spirits of fermented vegetables, (some whereof differ exceedingly among themselves) but also (as I have tried) divers mineral and even metalline concretes may be made, (some of them without destruction of their nature) to pass into that classis of body we call flame.

IV. BY reason of the conjunction or connexion of the parts, that make up a *totum*, (or at least an aggregate of bodies, that for their connexion are looked upon as such) it will often happen, that several things will be performed by the joint or concurrent action of these united (or coherent) parts.

THESE kinds of operations are of kin to those mentioned by the schoolmen, when they tell us, that some things are done by divers agents *actione communi*: as when a man disputes *vivâ voce* syllogistically, the rational soul, which dictates the words, and the vocal organs, that pronounce them, are *actione communi* the efficient of the pronounced syllogism. But to give an instance nearer to our purpose; when a bullet is let fall upon a level pavement, though it touches the body it falls on but in a very small part of its superficies, (geometricians having demonstrated, that a perfect sphere can touch a perfect plane but in one point;) yet the plane receives the action of the gravity of the whole body; those parts, that do not immediately come to touch it, striking it nevertheless by the intervention of those that do. And so likewise in a boat, the limbs and clothes of a man, that stands upon the deck, and all the parts of a watch, if he carry one in his pocket, gravitate concurrently on the vessel, though only the soles of his feet or shoes do immediately press upon it, and the wheels and other parts of the watch may be moving at the same time very differing ways. Now in organical bodies, and divers others both natural and factitious, those things, that are performed by the parts as in a state of conjunction, and as it were conspiring, or (if you will have it so expressed) *actione communi* (which action may sometimes be successive) are oftentimes ascribed to the form: as in a watch, most of the chief of the phenomena do so depend upon the concurrent action of the several parts, that few of them can be out of order, but that they will hinder those phenomena to be at all, or at least to be well and regularly produced.

V. WE may yet in a sound sense admit, that in some bodies there may be subordinate forms.

WHAT I mean by a *sound sense* in this proposition may be clearly collected from several passages of the past and remaining parts of

this discourse, where we carefully exclude those senses, in which we do not allow the received doctrine of subordinate forms. Wherefore having met with a couple of plausible objections, started since the death of *Sennertus*, against the admitting them at all, we shall here briefly examine them, not only to make them appear not to be cogent, but because some of our answers may serve for reasons, why we admit the forms disputed of.

THE first argument we are to consider is, that a body can have but one form, being but one body.

BUT though to this I might frame an answer from the loose and indeterminate signification of the word form, yet it may be directly replied, that though a body can have but one total and adequate form, yet nothing hinders but that its parts may have their partial forms subordinate to that: as the steel-spring and the brass-wheels of a watch may retain their distinct metalline forms, though the watch they compose be but one. And it is not wholly to be pretermitted on this occasion, that among the schoolmen themselves there has long been a considerable party, who asserted with many of the ancients, that in compounded bodies the elements retained their respective forms, notwithstanding the new form, that belonged to the mixed body as such.

SECONDLY, It is objected against the supervening of a higher form, that a body being already complete in its own kind by its own form, no other form can accrue to it, without making that, which they call *Ens per accidens*.

To this I answer, that the notion of an *Ens per accidens* belongs rather to metaphysics than natural philosophy; and in what its essence consists, is still so hotly disputed among the moderns, that till the business be agreed on, or at least more clearly stated, an argument drawn from thence will not much press us. And indeed when I consider, that the schools themselves are fain to allow the soul and the body, that is, an immaterial substance and a corporeal, to make up a man, who according to them is *unum per se*, and not *per accidens*, and that the same schools scruple not to teach, that the rational soul, which is a substance, and the understanding and will, which are said to be its faculties, and so its accidents, to make *unum per se*; I cannot but think, that, by a parity of reason, that name, predicate, or qualification, may well be taken in as large a sense, as is requisite for our purpose. And indeed if the parts of a body, whether merely natural or factitious, be by their union or conjunction brought to become the principle of a property or operation, which belongs to neither of them single; I see not, why such a body may not pass for *unum per se*, as well as divers bodies, that are wont to be looked upon under that notion. But to proceed to our further answer, not here to urge, that a whole sect of the Peripateticks themselves maintained (as we newly noted) the forms of the elements to remain in the mixed body, which notwithstanding they hold to be very consistent with the unity or oneness of that compounded body, it may be answered

answered further, that though a body by its own form be complete in its own kind, yet it may be such, as to be capable of being advanced to a nobler state by an accession, that shall not ruin its former nature, but enable it to cooperate to nobler actions than its former could reach to. As when a spring is made a part of a watch, it does thereby, without losing the nature of a spring, mainly contribute to the noblest phenomena of so curious an engine; and the ingredients of gun-powder, by the superinduction of the form or new contexture they acquire by being compounded into that concrete, are each of them enabled to cooperate to the performance of things far exceeding the utmost it could do before. Nor will it follow from this superinduction of forms, that there may be a form of a form as well as of matter, but only that to a body, that has already a form, an ulterior form may supervene, wherein we see no absurdity. But of this point more elsewhere; only in this place it will not be amiss to take notice, that in our proposition we thought fit to imploy the words, *some bodies, and, may be*, because that though in living creatures we may often meet with subordinate forms either properly or less improperly so called, yet that in bodies inanimate this happens not so often, you will be induced to think by what you will find said upon the last proposition of this discourse.

VI. THE supervening of the new form is often but accidental to the præexistent form, and (then) does not at all destroy its nature, but modify its operations.

FOR illustration sake, let us consider a needle, that is not yet touched by a loadstone: this needle has its own form as a piece of steel, as well as its figuration as a needle; but when afterwards it comes to be excited by the loadstone, there are then new and wonderful properties superinduced, and this needle is able to point regularly north and south, and attract other needles, and communicate a verticity to them, and is fit for much nobler uses than it was before. And this new modification does so regulate its motions, that whereas before it was indifferent, if it were nicely poised, to rest at east and west, or at any other point of the compass, it is now determined to keep moving till it points north and south, and to rest in that position. And yet by drawing this magnetick needle after a certain manner upon the pole of a vigorous loadstone, you may in a trice deprive it of all its accessional faculties; notwithstanding which, it will remain as true a steel-needle as it was at first.

AND perhaps we shall need to add but a little reflection on the formerly mentioned instance of the spring of a watch, to declare intelligibly what it is, that the structure or modification, whence the *forma totius* according to us results, does to a body endowed already with its own form. For as the spring, though it retain its own nature, and acts according to it, yet by the contrivance of the watch, it is not only so pent in, that it cannot fly out to its full extent as else it would, but by the same contrivance has its incessant endeavour to stretch

it self so moderated and managed by the wheels and balance, that it mainly concurs to set all the other parts a moving, and perform what is done by a watch as such: so in natural bodies, that which is performed by the supervening of a higher and total form is, that by virtue of the connection and structure of the parts introduced with this new form, the action of the particular parts, though they retain their own partial forms, and act as far as they can, according to them, is so mastered or otherwise modified, that they are brought to concur to those things, that are done by the whole body as one agent, and become subservient to the operations, that are proper to the body in its new and ultimate capacity. So when a piece of lead is without addition vitrified by the meer action of the fire, this happens to the body upon its acquiring the form of glass; that whereas before the metalline particles were so inconveniently situated, and perhaps shaped, that they denied passage to the beams of light, and by reason of their contexture composed a body, that was very flexible, they become now to be so ranged and otherwise altered, that they freely admit the light to traverse them, but admit not of being freely bent as before. And when salt-petre, by the addition of a small proportion of brimstone and coal, is made into gun-powder, this accrues to it from its acquired modification, that if a little fire fall on it, it will not, as before, leisurely consume, and leave behind it a considerable portion of the whole body (perhaps a third part or more) in the form of a fixed or alkalizate salt, but will fly away all at once, and leave little or nothing behind it.

VII. BESIDES the specifick actions of a body, that harbours subordinate forms, there may be divers others, wherein some of the parts or ingredients may act according to their particular and pristine nature.

THIS might be well enough gathered from what we lately delivered, when we shewed, that the total and specifick form has not such a dominion over the partial and subordinate ones, as the patrons of these forms have imagined. For though, by virtue of the modification of the whole, the operations of the parts or ingredients are so compounded and guided, and in some cases as it were overruled, as to concur to those operations that belonged to the *totum* as such, and are requisite to be performed *actione communi*; yet in other respects, and as to other purposes, as it is not necessary that such bodies as we speak of should have their parts intirely under the dominion of the ultimate form, (that is, subservient only to the operations and uses of the *totum*, as such;) so those parts may in such cases act according to their distinct and particular qualifications. This answer, I say, may be deduced from what has been above delivered; but I chuse rather to clear the matter by two or three particular instances, which may shew, that the same may happen to several bodies, that is manifest in a watch, where, though the form of the engine do in many things make the spring and other parts concur to perform the operations

tions proper to such an engine, yet the wheels may look bright and yellow, the spring may move a magnetick needle freely placed, and other parts may do other things, not by virtue of the form of the watch, but by virtue of their own qualities. An example to this purpose may be afforded, by what I remember I have not long since mentioned concerning gun-powder. To which I shall now add, that whereas in pills and divers other medicines made up of several ingredients, the *compositum* has, if the physician do his part well, some resulting virtues distinct from those of the ingredients, and belonging to the *compositum* as such; it may oftentimes happen, that notwithstanding the emergent form of the compounded medicine, some particular ingredient may not only retain its former nature, but so retain it, that the *compositum* is endowed with that quality only upon the score of that ingredient. This I have divers times observed in certain pills, wherein good ambergrease, being mingled with some purgative ingredients, retained its own grateful smell, and communicated it to the whole mass, whereof the pills are made: and the most sort of purging pills in our apothecaries shops taste strong of the alces, whatever the other ingredients be. And a further instance (and that a considerable one) we may take from treacle, that hath not been too long kept. For though it be acknowledged, that opium works by a specifick, and, as they call it, occult quality, and though it be in (*Venice*) treacle blended with above threescore other ingredients, most of which enter that famous composition in far greater quantity than does the opium; yet in spite of the *forma compositi*, which so elaborate a mixture produces, and to which such great peculiar virtues are ascribed by Peripatetick as well as other physicians, yet it is noted by many, that before treacle grows old, it manifestly derives an opiate quality from the little opium admitted in it, and upon that account is a potent remedy in fluxes, and divers other distempers, where quieting medicines are proper. A no less evident example to our purpose we have in the precipitate of gold and mercury, made by heat alone. For though by virtue of the union of the ingredients the resulting powder may have divers qualities, as particularly, a red colour, which neither the gold nor the quicksilver had apart; yet the salivating faculty, which this precipitate usually, though not always, exercises, though it be reckoned among occult qualities, as not having by any been deduced from the first or second, yet it belongs to this medicine barely upon the account of the mercurial ingredient: the gold, without that, having no such faculty, and mercury alone without gold being sufficient (by more ways than one of application) to cause a flux of spittle.

VIII. IN divers bodies, that which is called or looked upon as the specifick form, is often not so much as the presiding, but only the eminentest.

To make out this, we may take notice of the following particulars. 1. We observed above, that the word form has not a settled and deter-

minate signification, but is employed arbitrarily enough; so that divers bodies, to whom particular forms are used to be assigned, deserve not that privilege better than many others, in which (perhaps for want of men's having particularly considered them,) they are not wont to consider any peculiar and distinct form. 2dly, We have also elsewhere shown, that the forms of inanimate bodies (which we here speak of) are wont to be but respective things, resulting from the co-existence of such corpuscles or parts after such a determinate manner. 3dly, It may likewise be remembered, what we have already noted, that it is usually from some particular respect, or for a fitness to some particular use, that men ascribe this or that form to this or that body: as we exemplified in oils, salt, &c. as well as in watches, burning-glasses, and the like. 4thly, To these things it will be agreeable, that the nature and fabrick of a body may be such, that it may have a manifold structure (if I may so speak) answerable to more than one of those respects, on whose score bodies are denominated, or may be fit for more than one of those uses; an aptitude for which, when it is found single in another body, is sufficient to make it be referred to this or that distinct kind or classis of things corporeal. I cannot in few words express this notion more clearly, and therefore shall illustrate it by the example of antimonial glass: for one, that would make beads or microscopes with it, would readily find in it fusibleness and transparency; which, when they are found in common glass or *vitrum Saturni*, are enough to refer them to that sort of bodies, that are comprehended under the name of glass. But besides this combination, or (if many convene) this conjugation of qualities, or (to express it in one word) besides this modification, the body we speak of has another, upon whose account it is yet to work upwards and downwards in a human body; upon which score, as the artificer considers it only as glass, so the chymist and physician look upon it as a medicine. 5thly, Nor is it necessary, that these conjugations of qualities, or (these) modifications, should have a strict dependency upon one another; as for instance, the emetick and cathartick properties of the antimonial glass belong not to it as glass, or (if you please) do not flow immediately from the form it hath of glass; for neither has common glass, nor (that we know of) glass of lead any such properties, nor is it necessary, that if this very portion of matter had not the form of glass, it should want or lose these properties. For the calx of antimony, before its vitrification, had them; and you may even without addition obtain from this glass a regulus, that is not, like glass, transparent, but looks like a metalline body, under which form it may yet preserve the virtues of the calcined antimony. 6thly, To these things it will also be congruous, that since, as was said above, the nobleness or ignobleness of forms is not easy to be decided, and is wont to be measured by men, by the greater or lesser use, that the estimated body affords them, one man may in the same body look upon one kind of modification,

dification, and another upon a quite differing one as the highest form of that body. As in the lately mentioned example of the melted calx of antimony, an artificer may think its noblest form to be that of glass, and a chymist or a physician that of antimony. And so if an ordinary watch, that shows only the hours and their quarters, being hung at a string, were made to swing as a pendulum, to an astronomer or some other, that were to make nice observations, it would be most useful in the capacity of a pendulum, because, as that, it may divide a minute into seconds, and a second itself into half or fourth parts: but for other men, who, though they need an instrument to measure time, need not such minute subdivisions of it, the little engine we speak of will be much more useful and considerable in the capacity of a watch than of a pendulum. 7thly, From all which particulars it will be reasonable to collect, that it may often happen in inanimate bodies, whether confessedly natural, or such as are called factitious, that that, which is looked upon as the ultimate, or at least the chief form, is not the presiding, but only the eminentest: by which I mean, not simply the noblest (for that, were hard to determine, and according to men's estimates would not be always true) but that, which in that body is at least for the time the most considered; or, if that expression will please better, we may say, that sometimes the most regarded form is not so much the predominating as the denominating form.

IX. THE lately mentioned forms seem to be rather concurrent than subordinate.

THIS, as I was saying, follows well enough from, what has been freshly discoursed. For if a body may have divers such conjugations of accidents or modifications, as may intitle it in differing respects to differing forms, and that form, which is considered as the eminentest be not a presiding form, nor so much as always the noblest; what will remain, but that these forms (for I have granted above, that some bodies may have subordinate ones) that happen to coexist in the same body, be more fitly termed concurrent or coincident than subordinate?

AND indeed though I cannot now stay to examine, how far what I shall say may be applied to bodies in general, I confess that, as to inanimate bodies, this dominion and subjection, that is imagined between forms, seems to me, at least in many cases, neither well established, nor easy to be well explicated. And I doubt, that sometimes we mistake names for things; and because when a body by the action of proper agents obtains such a modification, as fits it for such and such actions and uses, we are wont to call it by such a name, and attribute a form to it, we are prone to conclude, that the faculties and qualifications it enjoys, and the things it is able to perform, are due to this form we have assigned it; as if this form were some distinct and operative substance, that were put into the body as a boy into a pageant, and did really begin, and guide, and overrule the motions and actions of the *compositum*. Whereas indeed what we call the form, if it be not sometimes little more than one of those airy things, that

schools call an external denomination, seems oftentimes to be rather a metaphysical conception in our mind than a physical agent, that performs all things in the body it is ascribed to: As when a conveniently shaped piece of steel is, by having a due temper given it, turned into the spring of a watch, not only the motions of the watch, though proceeding from this spring, proceed not from the form of the iron (for a spring made of another elastical body, though it would not be so convenient, might set a watch a moving) but, which is here the main observable, the springiness itself flows not immediately from the form (for steel is not less steel; when it is not springy than when it is) but from the mechanical and adventitious texture, that is superinduced in the metal, and may be given it by several outward agents, as the fire, the hammer, &c. And it is so far from being evident, that in bodies inanimate and compounded the eminentest and most considered form must have a dominion over, and an efficacy in all operations and actions of the *compositum*, that even in bodies not so compounded it is not always necessary, that the specific form should have so much as a concurrent stroke in what is performed: for external agents may introduce such qualities into the body we speak of, as, being once there, will suffice for actions and productions suitable to their own nature, whether the form be active in assisting them or no. We see, that boiling water taken off the fire will raise blisters on one's hands, and dress meat, and perform other things wont to be the effects of the fire, only by virtue of the adventitious heat it has received; though, according to the Peripateticks, the form of water, which is an element naturally cold as well as moist, ought rather to oppose than further the action of the preternatural heat. Another example to the same purpose may be given in the operations of a heated iron taken from the fire, (nay, though that be quite put out) to which divers other instances might be added. I know it may be pretended in favour of the schools, that it is the fire, that was got in, and yet remains in the iron, that was the cause of these effects. But besides that this subterfuge would involve the makers in very perplexing difficulties, I will, to prevent the allegation, put a case, where it cannot be pretended, by supposing the iron to be heated not by the fire, but by forcible strokes between a hammer and an anvil, both of them actually cold. When a piece of silver is by being hammered, or drawn into wire, made to be a springy body, it will be able to act many things by that acquired elasticity, which do not at all flow from the form peculiar to the metal. For not only copper, steel, and many other bodies may be made springy too; but, if you heat it in the fire, the goldsmith will assure you, that it is as true and as good silver as before, and yet it will cease to be a spring. And so when a smith makes a file, by making in it many little impressions across one another, and afterwards hardning the steel, by virtue of this roughness, which is given it by external agents, it

acquires a durable asperity, upon whose account it is qualified to perform many and considerable things, whereto the form of the metal as such does not, that appears, concur. And though the hardness contribute to the making a good file, yet not only the iron was as true and perfect iron, before it became rough, as afterwards, but even that degree of hardness, which qualifies our instrument to be a good file, flows not immediately from the form of the metal, for that was true iron, when it was soft, and its eminent degree of hardness was (as I freshly intimated) given it by the temper it received from the smith. I could easily increase the number of these instances, if it were necessary; and I should here add some examples to shew, that even in occult qualities, which are so generally presumed to flow from the specifick form of a body, it is not always necessary, that this form should have any great interest (or perhaps any at all) in the operations; but that the matter need but be duely excited, and disposed by outward agents, to be enabled to perform them: this, I say, I should here make probable, were it not that such instances do more properly belong to our notes about particular, and especially about occult qualities.

BUT that I may at length conclude this discourse, I shall now in the close, as I have done in some of the passages of it, complain, that the uncertain signification and use of the terms, wont to be employed about the points I have been handling, are apt to occasion much darkness and difficulty in our inquiries into the things themselves; and I am apt to think, that if the meaning of the words, *form, life, soul, animal, vegetative*, and some few other terms were clearly defined and agreed on, a great part of the perplexing controversies, that are agitated about subordinate forms, and points relating unto them, would appear to be disputes about words or terms. And I am not sure, but that some parts of the passed discourse would not be looked upon as of the same kind too, not out of choice, but a necessity imposed upon me, by the nature of my design, that I was drawn to meddle with any controversy, that I think may hereafter look like a verbal one; so if I have not missed my aim, I have both discovered some errors and deficiencies in the received doctrine I took upon me to consider, and contributed something towards the future establishing of a clearer, as well as truer theory about these matters.



A way of preserving BIRDS taken out of the EGG, and other small FOETUS's.

First Printed in the *Philosophical Transactions*, N^o. XII. p. 199.

For Monday May 7. 1666.

THIS was imparted in a letter, as follows, The time of the year invites me to intimate to you, that among the other uses of the experiment, I long since presented the society of preserving whelps taken out of the dam's womb, and other *foetus's*, or parts of them, in spirit of wine; I remember I did, when I was solicitous to observe the process of nature in the formation of a chick, open hen's eggs, some at such a day, and some at other days after the beginning of the incubation; and carefully taking out the embryos, embalmed each of them in a distinct glass (which is to be carefully stoppt) in spirit of wine. Which I did, that so I might have them in readiness to make on them, at any time, the observations I thought them capable of affording; and to let my friends at other seasons of the year see, both the differing appearances of the chick at the third, fourth, seventh, fourteenth, or other days, after the eggs had been fat on, and (especially) some particulars not obvious in chickens, that go about; as the hanging of the guts out of the abdomen, &c. How long the tender embryo of the chick soon after the *punctum saliens* is discoverable, and whilst the body seems but a little organized gelly, and some while after that, will be this way preserved, without being too much shriveled up, I was hindered by some mischances to satisfy my self: but when the foetus's I took out, were so perfectly formed, as they were wont to be about the seventh day, and after, they so well retained their shape and bulk, as to make me not repent of my curiosity; and some of those, which I did very early this spring, I can yet shew you. I know I have mentioned to you an easy application of what I, some years since, made publick

enough; but not finding it to have been yet made by any other, and being persuaded by experience, that it may be extended to other foetus's, which this season (the spring) is time to make provision of, I think the advertisement will not seem unseasonable to some of our friends; though being now in haste, and having in my thoughts divers particulars, relating to this way of preserving birds taken out of the egg, and other small foetus's, I must content myself to have mentioned that, which is essential, leaving divers other things, which a little practice may teach the curious, unmentioned. Notwithstanding which, I must not omit these two circumstances; the one, that when the chick was grown big, before I took it out of the egg, I have (but not constantly) mingled with the spirit of wine, a little spirit of sal armoniac, made (as I have * elsewhere delivered) by the help of quick lime: which spirit I choose, because, though it abounds in a salt not four, but urinous, yet I never observed it (how strong soever I made it) to coagulate spirit of wine. The other circumstance is, that I usually found it convenient, to let the little animals I meant to embalm, lie for a little while in ordinary spirit of wine, to wash off the looser filth, that is wont to adhere to the chick, when taken out of the egg; and then, having put either the same kind of spirit or better upon the same bird, I suffered it to soak some hours (perhaps some days, *pro re nata*) therein, that the liquor, having drawn as it were what tincture it could, the foetus being removed into more pure and well dephlegmed spirit of wine, might not discolour it, but leave almost as limpid, as before it was put in.

An Account of a new kind of BAROSCOPE, which may be called STATICAL; and of some Advantages and Conveniences it hath above the MERCURIAL.

First Printed in the *Philosophical Transactions*, N^o. XIV. p. 256.

For Monday July, 2. 1666.

AS for the new kind of baroscopes, which, not long ago, † I intimated to you, that my haste would not permit me to give you an account of; since your letters acquaint me, that you still design a communicating to the curious as much information, as

may be, in reference to baroscopes; I shall venture to send you some account of what I did but name (in my former letter) to you.

THOUGH by a passage, you may meet with in the 19th and 20th pages of my thermometrical experiments and thoughts, you may find, that

* In the Usefulness of Experimental Philosophy.
 † See Numb. XI. p. 185. Phil. Transactions.

that I did some years ago think upon this new kind of baroscope; yet the changes of the atmosphere's weight not happening to be then such, as I wished, and being unwilling to deprive my self of all other use of the exactest balance*, that I (or perhaps any man) ever had, I confess to you, that successive avocations put this attempt for two or three years out of my thoughts; till afterwards returning to a place, where I chanced to find two or three pair of scales, I had left there, the sight of them brought it into my mind; and though I were then unable to procure exacter, yet my desire to make the experiment some amends for so long a neglect put me upon considering, that if I provided a glass-bubble, more than ordinary large and light, even such balances, as those, might in some measure perform, what I had tried with the strangely nice ones above-mentioned.

I CAUSED then to be blown at the flame of a lamp, some glass-bubbles, as large, thin and light, as I could then procure; and chusing among them one, that seemed the least unfit for my turn, I counterpoised it in a pair of scales, that would lose their æquilibrium with about the 30th part of a grain, and were suspended at a frame. I placed both the balance and the frame by a good baroscope, from whence I might learn the present weight of the atmosphere. Then leaving these instruments together; though the scales, being no nicer than I have expressed, were not able to shew me all the variations of the air's weight, that appeared in the mercurial baroscope, yet they did what I expected, by shewing me variations no greater than altered the height of quick-silver half a quarter of an inch, and perhaps much smaller, than those: nor did I doubt, that, if I had had either tender scales, or the means of supplying the experiment with convenient accommodations, I should have discerned far smaller alterations of the weight of the air, since I had the pleasure to see the bubble sometimes in an æquilibrium with the counterpoise; sometimes, when the atmosphere was high, preponderate so manifestly, that the scales being gently stirred, the cock would play altogether on that side, at which the bubble was hung; and at other times (when the air was heavier) that, which was at the first but the counterpoise, would preponderate, and, upon the motion of the balance, make the cock vibrate altogether on its side. And this would continue sometimes many days together, if the air so long retained the same measure of gravity; and then (upon other changes) the bubble would regain an æquilibrium, or a preponderance: so that I had oftentimes the satisfaction, by looking first upon the statical baroscope (as for distinction's sake it may be called) to foretel, whether in the mercurial baroscope the liquor were high or low. Which observations, though they hold as well in winter, and several times in summer (for I was often absent during that season) as the spring, yet the frequency of their vicissitudes (which perhaps was but accidental) made them

more pleasant in the latter of these seasons.

So that, the matter of fact having been made out by variety of repeated observations, and by sometimes comparing several of those new baroscopes together, I shall add some of these notes about this instrument, which readily occur to my memory, reserving the rest to another opportunity.

AND first, if the ground, on which I went in framing this baroscope, be demanded, the answer in short may be; 1. That though the glass-bubble, and the glass-counterpoise, at the time of their first being weighed, be in the air, wherein they both are weighed, exactly of the same weight; yet they are nothing near of the same bulk; the bubble, by reason of its capacious cavity, (which contains nothing but air, or something that weighs less than air) being perhaps a hundred or two hundred times (for I have not conveniency to measure them) bigger than the metalline counterpoise. 2. That according to a hydrostatical law, (which you know I have lately had occasion to make out) if two bodies of equal gravity, but unequal bulk, come to be weighed in another medium, they will be no longer equiponderant; but if the new medium be heavier, the greater body, as being lighter in specie, will lose more of its weight, than the lesser and more compact; but if the new medium be lighter than the first, then the bigger body will out-weigh the lesser: and this disparity, arising from the change of mediums, will be so much the greater, by how much the greater inequality of bulk there is between the bodies formerly equiponderant. 3. That laying these two together, I considered, that it would be all one, as to the effect to be produced, whether the bodies were weighed in mediums of differing gravity, or in the same medium, in case its (specifick) gravity were considerably altered: and consequently, that since it appeared by the baroscope, that the weight of the air was sometimes heavier and sometimes lighter, the alterations of it, in point of gravity, from the weight, it was of at first counterpoising of the bubble of it, would unequally affect so large and hollow a body, as the bubble, and so small and dense a one, as a metalline weight: and when the air, by an increase of gravity, should become a heavier medium than before, it would buoy up the glass more than the counterpoise; and if it grew lighter than it was at first, would suffer the former to preponderate. (The illustrations and proof can scarce be added in few words; but if it be desired, I may, God permitting, send you them at my next leisure.) And though our English air be about a thousand times lighter than water, the difference in weight of so little air, as is but equal in bulk to a bubble, seemed to give small hopes, that it would be sensible upon a balance; yet, by making the bubble very large and light, I supposed and found the event, I have already related.

SECONDLY, The hermetically sealed glass-bubble I employed, was of the bigness of a somewhat large orange, and weighed about 1 drachm and 10 grains. But I thought it very possible,

* The scales here meant were before competent eye-witnesses made to turn manifestly with the thousandth part of a grain.

possible, if I had been better furnished with conveniences (wherein I afterwards found, I was not mistaken) to make among many, that might be expected to miscarry, some, that might be preferable to this, either for capacity or lightness, or both; especially if care be taken, that they be not sealed up, whilst they are too hot. For, though one would think, that it were advantageous to rarify and drive out the air as much as is possible, because in such sealed bubbles the air itself (as I have elsewhere shewn) has a weight; yet this advantage countervails not the inconvenience of being obliged to increase the weight of the glass, which, when it includes highly rarified air, if it be not somewhat strong, will be broken by the pressure of the external air, as I have sufficiently tried.

THIRDLY, I would have tried, whether the dryness and moisture of the air would in any measure have altered the weight of the bubble, as well as the variation of gravity produced in the atmosphere by other causes; but the extraordinarily constant absence of fogs kept me from making observations of this kind; save that one morning early, being told of a mist, I went to see (being myself in bed) whether it made the air so heavy as to buoy up the bubble; but did not learn, that that mist had any sensible operation on it.

FOURTHLY, By reason of the difficulties and casualties, that may happen about the procuring and preserving such large and light bubbles, as I have been lately mentioning; it may in some cases prove a convenience to be informed, that I have sometimes, instead of one sufficiently large bubble, made use of two, that were smaller. And though a single bubble of competent bigness be much preferable, by reason that a far less quantity and weight of glass is requisite to comprise an equal capacity, when the glass is blown into a single bubble, than when it is divided into two; yet I found, that the employing of two instead of one, did not so ill answer my expectations, but that they may for a need serve the turn instead of the other; than which they are more easily to be procured. And if the balance be strong enough to bear so much glass, without being injured, by employing two or a greater number of larger bubbles, the effect may be more conspicuous, than if only a single bubble (though a very good one) were employed.

THIS instrument may be improved by divers accommodations. As

FIRST, There may be fitted to the anse (or cheeks of the balance) an arch (of a circle) divided into 15 or 20 degrees, (more or less, according to the goodness of the balance) that the cock resting over against these divisions, may readily and without calculation shew the quantity of the angle, by which, when the scales propend either way, the cock declines from the perpendicular, and the beam from its horizontal parallelism.

SECONDLY, Those, that will be so curious, may, instead of the ordinary counterpoise, (of brass) employ one of gold, or at least of lead,

whereof the latter being of equal weight with brass, is much less in bulk, and the former amounts not to half its bigness.

THIRDLY, These parts of the balance, that may be made of copper or brass, without any prejudice to the exactness, will, by being made of one of those metals, be less subject than steel, (which yet, if well hardened and polished, may last good a great while) to rust with long standing.

FOURTHLY, Instead of the scales, the bubble may be hung at one end of the beam, and only a counterpoise to it at the other, that the beam may not be burthened with unnecessary weight.

FIFTHLY, The whole instrument, if placed in a small frame, like a square lanthorn with glass-windows, and a hole at the top for the commerce of the internal and external air, will be more free from dust, and irregular agitations; to the latter of which, it will otherwise be sometimes incident.

SIXTHLY, This instrument being accommodated with a light wheel and an index (such as have been applied by the excellent Dr. *Christopher Wren* to open weather-glasses, and by the ingenious Mr. *Hook* to baroscopes) may be made to shew much more minute variations, than otherwise.

SEVENTHLY, And the length of the beam, and exquisiteness of the balance, may easily, without any of the foregoing helps (and much more with them) make the instrument far exacter, than any of those, I was reduced to employ. And to these accommodations divers others may be suggested, by a farther consideration of the nature of the thing, and a longer practice.

THOUGH in some respects this statical baroscope be inferiour to the mercurial; yet in others it has its own advantages and conveniences above it.

AND, 1. It confirms *ad oculum* our former doctrine, that the falling or rising of the mercury depends upon the varying weight of the atmosphere; since in this baroscope it cannot be pretended, that a *fuga vacui*, or *funiculus*, is the cause of the changes, we observe. 2. It shews, not only that the air has weight, but a more considerable one, than some learned men, who will allow me to have proved, it has some weight, will admit; since even the variation of weight in so small a quantity of air, as is but equal in bulk to an orange, is manifestly discoverable upon such balances, as are none of the nicest. 3. This statical baroscope will oftentimes be more parable than the other: for many will find it more easy to procure a good pair of gold scales, and a bubble or two, than a long cane sealed, a quantity of quick-silver, and all the other requisites of the mercurial baroscope; especially if we comprise the trouble and skill, that is requisite to free the deserted part of the tube from air. 4. And whereas the difficulty of removing the mercurial instrument has kept men from so much as attempting to do it, even to neighbouring places; the essential parts of the scale-baroscope (for the

frame is none of them) may very easily in a little room be carried, whither one will, without the hazard of being spoiled or injured. 5. There is not in statical baroscopes, as in other, a danger of uncertainty, as to the goodness of the instruments, by reason, that in those the air is, in some more, and in some less perfectly excluded; whereas in those, that consideration has no place. (And by the way, I have sometimes, upon this account, been able to discover by our new baroscope, that an esteemed mercurial one, to which I compared it, was not well freed from air.) 6. It being, as I formerly intimated, very possible to discover hydrostatically, both the bigness of the bubble, and the contents of the cavity, and the weight and dimensions of the glassy substance (which together with the included air make up the bubble,) much may be discovered by this instrument, as to the weight of the air absolute or respective. For, when the quicksilver in the mercurial baroscope is either very high, or very low, or at a middle station between its greatest and least height, bringing the scale-barometer to an exact æquilibrium, (with very minute divisions of a grain;) you may, by watchfully observing, when the mercury is risen or fallen just an inch, or a fourth, or half an inch, &c. and putting in the like minute divisions of a grain to the lighter scale, till you have again brought the balance to an exquisite æquilibrium; you may, I say, determine, what known weight in a statical baroscope answers such determinate altitudes of the ascending and descending quicksilver in the mercurial. And if the balance be accommodated with a divided arch, or a wheel and index, these observations will assist you for the future to determine readily, by seeing the inclination of the cock or the degree marked by the index, what pollency the bubble hath, by the change of the atmosphere's weight, acquired or lost. Some observations of this nature I watchfully made, sometimes putting in a 64th, sometimes a 32^d, sometimes a 16th, and sometimes heavier parts of a grain, to the lighter scale. But one, that knew not, for what uses those little papers were, coming to a window, where my baroscopes stood, so unluckily shook them out of the scales, and confounded them, that he robbed me of the opportunity of making the nice observations I intended, though I had the satisfaction of seeing, that they were to be made. 7. By this statical instrument we may be assisted to compare the mercurial baroscopes of several places (though never so distant) and to make some estimates of the gravities of the air therein. As if, for instance, I have found by observation, that the bubble, I employ, (and one may have divers bubbles of several sizes, that the one may repair any mischance, that may happen to another) weigh-

ed just a drachm, when the mercurial cylinder was at the height of $29\frac{1}{2}$ inches, (which in some places I have found a moderate altitude;) and that the addition of the 16th part of a grain is requisite to keep the bubble in an æquilibrium, when the mercury is risen an 8th, or any determinate part of an inch, above the former station: when I come to another place, where there is a mercurial barometer, as well freed from air as mine (for that must be supposed) if taking out of my scale instrument, it appear to weigh precisely a drachm, and, the mercury in the baroscope there stand at just $29\frac{1}{2}$ inches, we may conclude the gravity of the atmosphere not to be sensibly unequal in both those two places, though very distant. And though there be no baroscope there, yet if there be an additional weight, as for instance, the 16th part of a grain requisite to be added to the bubble, to bring the scales to an æquilibrium, it will appear, that the air at this second place is, at that time, so much heavier, than the air of the former place was, when the mercury stood at $29\frac{1}{2}$ inches.

BUT in making such comparisons, we must not forget to consider the situation of the several places, if we mean to make estimates not only of the weight of the atmosphere, but of the weight and density of the air. For, though the scales will shew (as has been said) whether there be a difference of weight in the atmosphere at the two places; yet, if one of them be in a vale or bottom, and the other on the top or some elevated part of a hill, it is not to be expected, that the atmosphere in this latter place should gravitate as much, as the atmosphere in the former, on which a longer pillar of air does lean or weigh.

AND the mention, I have made of the differing situation of places, puts me in mind of something, that may prove another use of our statical baroscope, and which I had thoughts of making trial of, but was accidentally hindered from the opportunity of doing it; namely, that by exactly poising the bubble at the foot of a high steeple or hill, and carrying it in its close frame to the top, one may, by the weight requisite to be added to counterpoise there, to bring the beam to its horizontal position, observe the difference of the weight of the air at the bottom, and at the top; and, in case the hill be high enough, at some intermediate stations. But how far this may assist men, to estimate the absolute or comparative height of mountains, and other elevated places; and what other uses the instrument may be put to, when it is duly improved; and the cautions, that may be requisite in the several cases, that shall be proposed, I must leave to more leisure, and farther consideration.

A New FRIGORIFICK EXPERIMENT,

S H E W I N G

How a considerable degree of COLD may be suddenly produced without the help of SNOW, ICE, HAIL, WIND, or NITRE, and that at any time of the year.

First Printed in the *Philosophical Transactions*, N^o. xv. p. 255.

For *Wednesday* July 18, 1666.

AS for the experiment, you saw the other day at my lodgings, though it belongs to some papers about cold, that (you know) could not be published, when the rest of the history came forth, and therefore was reserved for the next edition of that book; yet the weather having been of late very hot, and threatening to continue so, I presume, that to give you here, in compliance with your curiosity, an account of the main and practical part of the experiment, may enable you to gratify not only the curious among your friends, but those of the delicate, that are content to purchase a coolness of drinks at a somewhat chargeable rate.

You may remember, that the spring before the last, I shewed you a particular account of a way, wherein by a certain substance obtained from sal armoniac, I could presently produce a considerable degree of cold, and that with odd circumstances, without the help of snow, ice, nitre, &c. But that experiment being difficult and costly enough, and designed to afford men information, not accommodations, I afterwards tried, what some more cheap and facile mixtures of likely bodies with sal armoniac would do towards the production of cold, and afterwards I began to consider, whether to that purpose alone (for my first experiment was designed to exhibit other phenomena too) those mixtures might not without inconvenience be omitted. And I was much confirmed in my conjecture by an accident, which was casually related to me by a very ingenious physician of my acquaintance, but not to be repeated to you in a few words, though he complained, he knew not what to make of it.

AMONG the several ways, by which I have made in frigidating mixtures with sal armoniac, the most simple and facile is this: take one pound of powdered sal armoniac and about three pints (or pounds) of water; put the salt into the liquor, either all together, if your design be to produce an intense, though but a short coldness; or at two, three, or four several times, if you desire, that the produced coldness should rather last somewhat longer than be so great. Stir the powder in the liquor with a stick or whalebone, (or some other thing, that will not be injured by the fretting brine, that will be made) to hasten

the dissolution of the salt; upon the quickness of which, depends very much the intensity of the cold, that will ensue upon this experiment. For the clearing up whereof, I shall annex the following particulars.

I. THAT a considerable degree of cold is really produced by this operation, is very evident: First, to the touch; Secondly, by this, that if you make the experiment (as for this reason I sometimes chuse to do) in a glass-body or a tankard, you may observe, that, whilst the solution of the salt is making, the outside of the metalline vessel will, as high as the mixture reaches within, be bedewed (if I may so speak) with a multitude of little drops of water, as I have *elsewhere shown, that it happens, when mixtures of snow and salt, being put into glasses or other vessels, the aqueous vapours, that swim to and fro in the air, and chance to glide along the sides of the vessels, are by the coldness thereof condensed into water. And in our armoniac solution you may observe, that if you wipe off the dew from any particular part of the outside of the vessel, whilst the solution does yet vigorously go on, it will quickly collect fresh dew, which may be sometimes copious enough to run down the sides of the vessel. But thirdly, the best and surest way of finding out the coldness of our mixture is that, which I shewed you, by plunging into it a good sealed weather-glass furnished with tinted spirit of wine. For, the ball of this being put into our frigorifick mixture, the crimson liquor will nimbly enough descend much lower, than when it was kept in the open air, in common water, of the same temper with that, wherein the sal armoniac was put to dissolve. And if you remove the glass out of the mixture into common water, the tinted spirit will, (as you may remember it did) hastily enough re-ascend for a pretty while, according to the greater or lesser time, that it continued in the armoniac solution. And this has succeeded with me, when instead of removing the mixture into common water, I removed it into water newly impregnated with salt-petre.

THE duration of the cold, produced by this experiment, upon several circumstances; as, first, upon the season of the year, and present temperature of the air; for in summer

* In the *History of Cold*.

mer and hot weather the cold will sooner decay and expire. Secondly, upon the quantity of the salt and water: for, if both these be great, the effect will be as well more lasting, as more considerable. Thirdly, for aught I yet know, we may here add the goodness and fitness of the particular parcel of salt, that is employed: for though it be hard to discern beforehand, which will be the more, and which the less proper; yet some trials have tempted me to suspect, that there may be a considerable disparity, as to their fitness to produce cold, betwixt parcels of salt, that are without scruple looked upon as sal armoniac; of which difference it were not perhaps very difficult to assign probable reasons from the nature of the ingredients of this compound concrete, and the ways of preparing it. But the duration of the cold may be conceived to depend also, fourthly, upon the way of putting the salt into the water; for, if you cast it in all at once, the water will sooner acquire an intense degree of coldness, but it will also the sooner return to its former temper; whereas, if you desire but an inferior degree of quality, but that may last longer, (which will usually be the most convenient for the cooling of drinks,) then you may put in the salt by little and little. For, keeping a long weather-glass for a good while in our impregnated mixture, I often purposely tried, that, when the tinted liquor subsided but slowly, or was at a stand, by putting in, from time to time, 2 or 3 spoonfuls of fresh salt, and stirring the water to quicken the dissolution, the spirit of wine would begin again to descend, if it were at a stand, or rising, or subside much more swiftly than it did before. And if you would lengthen the experiment, it may not be amiss, that part of the sal armoniac be but grossly beaten, that it may be the longer in dissolving, and consequently in cooling the water. Whilst there are dewy drops produced on the outside of the vessel, it is a sign, that the cold within continues pretty strong; for, when it ceases, these drops especially in warm weather, will by degrees vanish. But a surer way of measuring the duration of the cold, is, by removing from time to time the sealed weather-glass out of the saline mixture into the same common water, with part of which it was made. And though it be not easy to determine any thing particularly about this matter, yet it may somewhat assist you in your estimates, to be informed, that I have in the spring by a good weather-glass found a sensible adventitious cold, made by a pound of sal armoniac at the utmost, to last about two or three hours.

3. To cool drinks with this mixture, you may put them in thin glasses, the thinner the better; which (their orifices being stopped, and still kept above the mixture) may be moved to and fro in it, and then be immediately poured out to be drunk: though when the glass, I employed, was conveniently shaped, as like a sugar-loaf, or with a long neck, I found it not amiss to drink it out of that, without pouring it into any other; which can

scarce be done without lessening the coldness. The refrigeration, if the glass-phial be convenient, is quickly performed: and if one have a mind to cool his hands, he may readily do it, by applying them to the outside of the vessel, that contains the refrigerating mixture; by whose help, pieces of crystal, or bullets for the cooling of the mouths or hands of those patients, to whom it may be allowed, may be potently cooled, and other such refreshments may be easily procured.

4. How far sal armoniac, mingled with sand or earth, and not dissolved, but only moistned with a little water sprinkled on it, will keep bottles of wine or other liquors more cool, than the earth or that sand alone will do, I have not yet had opportunity by sufficient trials fully to satisfy myself, and therefore resign that inquiry to the curious.

5. For the cooling of air, and liquors, to adjust weather-glasses, to be able to do which, at all times of the year, was one of the chief aims, that made me bethink myself of this experiment; or to give a small quantity of beer, &c. a moderate degree of coolness, it will not be requisite, to employ near so much as a whole pound of sal armoniac at a time. For you may easily observe by a sealed weather-glass, that a very few ounces, well powdered and nimbly dissolved in about four times the weight of water, will serve well enough for many purposes.

6. AND that you may the less scruple at this, I shall tell you, that even before and after midsummer, I have found the cold producible by our experiment to be considerable, and useful for refrigerating of drinks, &c. but if the sal armoniac be of the fittest sort, (for I intimated above, that I suspected, it is not equally good) and if the season of the year do make no disadvantageous difference, the degree of cold, that may be produced by no more than one pound (if not by less) sal armoniac, may within its own sphere of activity, be much more vehement, than, I presume, you yet imagine, and may afford us excellent standards to adjust sealed weather-glasses by; and for several other purposes. For I remember, that in the spring, about the end of *March*, or beginning of *April*, I was able with one pound of sal armoniac, and a requisite portion of water, to produce a degree of cold much greater, than was necessary the preceding winter, to make it frosty weather abroad; nay, I was able to produce ice in a space of time, almost incredibly short. To confirm which particulars, because they will probably seem strange to you, I will here annex the transcript of an entry, that I find in a note-book of phenomena and success of one of those experiments, as I then tried it; though I should be ashamed to expose to your perusal a thing so rudely penned, if I did not hope, you would consider, that it was hastily written only for my own remembrance. And that you may not stop at any thing in the immediately annexed note, or the two that follow, it will be requisite to premise this ac-

count of the sealed thermoscope, (which was a good one) wherewith these observations were made; that the length of the cylindrical pipe was 16 inches; the ball, about the bigness of a somewhat large walnut, and the cavity of the pipe by guess about an eighth or ninth part of an inch diameter.

THE first experiment is thus registered. *March* the 27th, in the sealed weather-glass; when first put into water, the tinted spirit rested at $8\frac{5}{8}$ inches: being suffered to stay there a good while, and now and then stirred to and fro in the water, it descended at length a little beneath $7\frac{5}{8}$ inches: then the sal armoniac being put in, within about a quarter of an hour, or a little more, it descended to $2\frac{1}{2}$ inches, but before that time, in half a quarter of an hour it began manifestly to freeze the vapours and drops of water on the outside of the glass. And when the frigorifick power was arrived at the height, I several times found, that water, thinly placed on the outside, whilst the mixture within was nimbly stirred up and down, would freeze in a quarter of a minute, (by a minute watch.) At about $\frac{3}{4}$ of an hour after the infrigidating body was put in, the thermoscope, that had been taken out a while before, and yet was risen but to the lowest freezing mark, being again put in the liquor, fell an inch beneath the mark. At about $2\frac{1}{2}$ hours from the first solution of the salt I found the tinted liquor to be in the midst between the freezing marks, whereof the one was at $5\frac{1}{2}$ inches (at which height when the tincture rested, it would usually be some, though but a small frost abroad;) and the other at $4\frac{3}{4}$ inches; which was the height, to which strong and durable frosts had reduced the liquor in the winter. At three hours after the beginning of the operation, I found not the crimson-liquor higher than the upper freezing mark newly mentioned; after which, it continued to rise very slowly for about an hour longer; beyond which time I had not occasion to observe it.

THUS far the note-book; wherein there is mention made of a circumstance of some former experiments of the like kind, which I remember was very conspicuous in this newly recited. For, the frigorifick mixture having been made in a glass-body (as they call it) with a large and flattish bottom, a quantity of water, which I (purposely) spilt upon the table, was, by the operation of the mixture within the glass, made to freeze, and that strongly enough, the bottom of the cucurbit to the table; that stagnant liquor being turned into solid ice, that continued a considerable while unthawed away, and was in some places about the thickness of a half-crown piece.

ANOTHER observation, made the same spring, but less solemn, as meant chiefly to shew the duration of cold in a high degree, is recorded in these terms: The first time, the sealed weather-glass was put in, before it touched the common water, it stood at $8\frac{1}{8}$, having been left there a considerable while, and once or twice agitated the water, the tinted liquor sunk but to $7\frac{7}{8}$, or at furthest, $7\frac{6}{8}$; then the frigorifick liquor being put into the water

with circumstances disadvantageous enough, in (about) half a quarter of an hour the tinted liquor fell beneath $3\frac{3}{4}$; and the thermoscope being taken out, and then put in again, an hour after the water had been first infrigidated, subsided beneath 5 inches, and consequently within $\frac{1}{4}$ of an inch of the mark of the strongly freezing weather.

7. WHEREAS the grand thing, that is like to keep this experiment from being as generally useful, as perhaps it will prove luciferous, is the dearthness of sal armoniac, two things may be offered to lessen this inconvenience. For first, sal armoniac might be made much cheaper, if instead of fetching it beyond sea our country-men made it at home; which it may easily be, and I am ready to give you the receipt, which is no great secret. But next I considered, that probably the infrigidating virtue of our mixture might depend upon the peculiar texture of the sal armoniac, whereby, whilst the water is dissolving it, either some frigorific particles are extricated and excited, or rather some particles, which did before more agitate the minute parts of the water, are expelled (or invited out by the ambient bodies) or come to be clogged in their motion: whence it seemed reasonable to expect, that upon the re-union of the saline particles into such a body, as they had constituted before, the redintegrated sal armoniac, having near upon, the same texture, would, upon its being redissolved produce the same, or a not much inferiour degree of coldness: And hereupon, though I well enough foresaw, that an armoniac solution, being boiled up in earthen vessels (for glass ones are too chargeable) would, by piercing them, both lose some of the more subtil parts, and thereby somewhat impair the texture of the rest; yet I was not deceived in expecting, that the dry salt, remaining in the pipkins, being redissolved in a due proportion of water, would very considerably infrigidate it; as may further appear by the notes, which for your greater satisfaction you will find here subjoined, as soon as I have told you, that, though for want of other vessels I was first reduced to make use of earthen ones, and the rather, because some metalline vessels will be injured by the dissolved sal armoniac, if it be boiled in them; yet I afterwards found some conveniences in vessels of other metal, as of iron; whereof you may command a farther account.

March the 29th, the thermoscope in the air was at $8\frac{7}{8}$ inches; being put into a somewhat large evaporating glass, filled with water, it fell (after it staid a pretty while, and had been agitated in the liquor) to 8 inches: then about half the salt, or less, that had been used twice before, and felt much less cold than the water, being put in and stirred about, the tinted spirit subsided with a visible progress, till it was fallen manifestly beneath 4 inches; and then, having caused some water to be freshly pumped and brought in, though the newly mentioned solution were mixt with it, yet it presently made the spirit of wine manifestly to ascend in the instrument, much faster than one would have expected, &c.

Method of transfusing the BLOOD

AND thus much may suffice for this time concerning our frigorifick experiment; which I scarce doubt but the *Cartesians* will lay hold on as very favourable to some of their tenets; which you will easily believe, it is not to the opinion, I have elsewhere opposed, of those modern philosophers, that would have salt-petre to be the *primum frigidum*: (though I found by trial, that whilst it is actually dissolving, it gives a much considerabler degree of cold,

than otherwise.) But about the reflections, that may be made on this experiment, and the variations, and improvements, and uses of it, though I have divers things lying by me; yet, since you have seen several of them already, and may command a sight of the rest, I shall forbear the mention of them here, not thinking it proper, to swell the bulk of this letter with them.

The Method observed in Transfusing the Blood out of one Animal into another.

First Printed in the *Philosophical Transactions* N^o. XX. p. 353.

For Monday, December 17, 1666.

THIS method was promised in the last of these papers. It was first practised by Dr. *Lower* in *Oxford*, and by him communicated to the author, who imparted it to the Royal Society, as follows;

FIRST, Take up the carotidal artery of the dog or other animal, whose blood is to be transfused into another of the same or a differing kind, and separate it from the nerve of the eighth pair, and lay it bare above an inch. Then make a strong ligature on the upper part of the artery, not to be united again: but an inch below, *viz.* towards the heart, make another ligature of a running knot, which may be loosened or fastened as there shall be occasion. Having made these two knots, draw two threads under the artery between the two ligatures; and then open the artery, and put in a quill, and tie the artery upon the quill very fast by those two threads, and stop the quill with a stick. After this, make bare the jugular vein in the other dog about an inch and a half long; and at each end make a ligature with a running knot, and in the space betwixt the two running knots draw under the vein two threads, as in the other. Then make an incision in the vein, and put into it two quills, one into the descendant part of the vein, to receive the blood from the other dog and carry it to the heart; and the other quill put into the other part of the jugular vein, which comes from the head, (out of which, the second dog's own blood must run into dishes.) These two quills being put in and tied fast, stop them with a stick, till there be occasion to open them.

ALL things being thus prepared, place the dogs on their sides towards one another so conveniently, that the quill may go into each other; (for the dog's necks cannot be brought so near, but that you must put two or three several quills more into the first two, to convey the blood from one to another.) After that, unstop the quill, that goes down into the first dog's jugular vein, and the other quill coming out of the other dog's artery; and by the help of two or three other quills, put into each other, according as there shall be occasion, insert them

into one another. Then slip the running knots, and immediately the blood runs through the quills, as through an artery, very impetuously. And immediately, as the blood runs into the dog, unstop the other quill, coming out of the upper part of his jugular vein, (a ligature being first made about his neck, or else his other jugular vein being compressed by one's finger;) and let his own blood run out at the same time into dishes, (yet not constantly, but according as you perceive him able to bear it) till the other dog begin to cry, and faint, and fall into convulsions, and at last die by his side.

THEN take out both the quills out of the dog's jugular vein, and tie the running knot fast, and cut the vein asunder, (which you may do without harm to the dog, one jugular vein being sufficient to convey all the blood from the head and upper parts, by reason of a large anastomosis, whereby both the jugular veins meet about the larynx.) This done, sew up the skin and dismiss him, and the dog will leap from the table, and shake himself, and run away, as if nothing ailed him.

AND this I have tried several times, before several in the universities, but never yet upon more than one dog at a time, for want of leisure, and convenient supplies of several dogs, at once. But when I return, I doubt not but to give you a fuller account, not only by bleeding several dogs into one, but several other creatures into one another, as you did propose to me, before you left *Oxford*; which will be very easy to perform, and will afford many pleasant, and perhaps not unuseful experiments.

BUT because there are many circumstances necessary to be observed in the performing of this experiment, and that you may better direct any one to do it, without any danger of killing the other dog, that is to receive the other's blood, I will mention two or three.

FIRST, that you fasten the dogs at such a convenient distance, that the vein nor artery be not stretched; for then, being contracted, they will not admit or convey so much blood.

SECONDLY, that you constantly observe the pulse beyond the quill in the dog's jugular vein, (which it acquires from the im pulse of the arterious blood;) for if that fails, then it is a sign the quill is stopt by some congealed blood, so that you must draw out the arterial quill from the other, and with a probe open the passage again in both of them, that the blood may have its free course again. For this must be expected, when the dog, that bleeds into the other, hath lost much blood, his heart will beat very faintly, and then the impulse of blood being weaker, it will be apt to congeal the sooner, so that at the latter end of the work you must draw out the quill oftener, and clear the passage; if the dog be faint-hearted, as many are, though some stout fierce dogs will bleed freely and uninterruptedly, till they are convulsed and die. But to prevent this trouble, and make the experiment certain, you must bleed a great dog into a little one, or a mastive into a curr, as I once tried; and the little dog bled out at least double the quantity of his own blood, and left the mastive dead upon the table; and after he was untied, he ran away, and shaked himself, as if he had been only thrown into water. Or else you may get three or four several dogs prepared in the same manner; and when one begins to fail and leave off bleeding, administer another; and I am confident one dog will receive all their blood, (and perhaps more) as long as it runs freely, till they are left almost dead by turns: provided you let out the blood proportionably, as you let it go into the dog, that is to live.

THIRDLY, I suppose the dog, that is to bleed out into dishes, will endure it better, if the dogs, that are to be administered to supply his blood, be of near an equal age, and fed alike the day before, that both their bloods may be of a near strength and temper.

THERE are many things I have observed upon bleeding dogs to death, which I have seen since your departure from *Oxford*, whereof I shall give you a relation hereafter. In the mean time since you were pleased to mention it to the Royal Society, with a promise to give them an account of this experiment, I could not but take the first opportunity to clear you from that obligation, &c.

So far this letter; the prescriptions whereof having been carefully observed by those, who were employed to make the experiment, have hitherto been attended with good success; and that not only upon animals of the same species, (as two dogs first, and then two sheep;) but also upon some of very differing species, (as a sheep and a dog; the former emitting, the other receiving.)

NOTE only, that instead of a quill, a small crooked thin pipe of silver or brass, so slender,

that the one end may enter into the quill, and having at the other end, that is to enter into the vein and artery, a small knob, for the better fastening them to it with a thread, will be much fitter than a strait pipe or quill, for this operation; for so they are much more easy to be managed.

It is intended, that these trials shall be prosecuted to the utmost variety the subject will bear: as by exchanging the blood of old and young, sick and healthy, hot and cold, fierce and fearful, tame and wild animals, &c. and, that not only of the same, but also of differing kinds. For which end, and to improve this noble experiment, either for knowledge, or use, or both, some ingenious men have already proposed considerable trials and inquiries; of which perhaps an account will be given hereafter. For the present, we shall only subjoin some

Considerations about this kind of Experiments.

1. It may be considered in them, that the blood of the emittent animal may, after a few minutes of time, by its circulation, mix and run out with that of the recipient. Wherefore to be assured in these trials, that all the blood of the recipient is run out, and none left in him but the adventitious blood of the emittent, two or three or more animals (which was also hinted in the method above) may be prepared and administered, to bleed them all out into one.

2. It seems not irrational to guess beforehand, that the exchange of blood will not alter the nature or disposition of the animals, upon which it shall be practised; though it may be thought worth while, for satisfaction and certainty, to determine that point by experiments. The case of exchanging the blood of animals seems not like that of grafting, where the cyon turns the sap of the stock, grafted upon, into its nature; the fibres of the cyon so straining the juice, which passes from the stem to it, as thereby to change it into that of the cyon: whereas in this transfusion there seems to be no such percolation of the blood of animals, whereby that of the one should be changed into the nature of the other.

3. THE most probable use of this experiment may be conjectured to be, that one animal may live with the blood of another; and consequently, that those animals, that want blood, or have corrupt blood, may be supplied from others with a sufficient quantity, and of such as is good, provided the transfusion be often repeated, by reason of the quick expence, that is made of the blood.

Trials proposed to Dr. LOWER,
To be made by him, for the improvement of transfusing
Blood out of one live Animal into another.

(Promised Numb. XX. p. 357.)

First Printed in the *Philosophical Transactions*, N^o XXII. p. 385.
For Monday, February 11. 1666.

THE following queries and trials were written long since, and read about a month ago in the Royal Society, and do now come forth against the author's intention, at the earnest desire of some learned persons, and particularly of the worthy doctor, to whom they were addressed; who thinks, they may excite and assist others in a matter, which to be well prosecuted, will require many hands. At the reading of them, the author declared, that of divers of them he thought he could foresee the events, but yet judged it fit, not to omit them, because the importance of the theories, they may give light to, may make the trials recompence the pains, whether the success favour the affirmative or the negative of the question, by enabling us to determine the one or the other upon surer grounds, than we could otherwise do. And this advertisement he desires may be applied to those other papers of his, that consist of queries or proposed trials.

The Queries themselves follow.

1. WHETHER by this way of transfusing blood, the disposition of individual animals of the same kind, may not be much altered? (as whether a fierce dog, by being often quite new stocked with the blood of a cowardly dog, may not become more tame;) & *vice versa*, &c.

2. WHETHER immediately upon the unbinding the dog, replenished with adventitious blood, he will know and fawn upon his master; and do the like customary things as before? and whether he will do such things better or worse at some time after the operation?

3. WHETHER those dogs, that have peculiarities, will have them either abolished, or at least much impaired by transfusion of blood? (as whether the blood of a mastiff, frequently transfused into a blood-hound, or a spaniel, will not prejudice them in point of scent?)

4. WHETHER acquired habits will be destroyed or impaired by this experiment? (as whether a dog, taught to fetch and carry, or to dive after ducks, or to sett, will after frequent and full recruits of the blood of dogs unfit for those exercises, be as good at them, as before?)

5. WHETHER any considerable change is to be observed in the pulse, urine, and other excrements of the recipient animal, by this operation, or the quantity of his insensible transpiration?

6. WHETHER the emittent dog, being full fed at such a distance of time before the operation, that the mass of blood may be supposed to abound with chyle, the recipient dog, being before hungry, will lose his appetite, more than if the emittent dog's blood had not been so chylous? and how long, upon a vein opened of a dog, the admitted blood will be found to retain chyle?

7. WHETHER a dog may be kept alive without eating by the frequent injection of the chyle of another, taken freshly from the receptacle, into the veins of the recipient dog?

8. WHETHER a dog, that is sick of some disease chiefly imputable to the mass of blood, may be cured by exchanging it for that of a sound dog? and whether a sound dog may receive such diseases from the blood of a sick one, as are not otherwise of an infectious nature?

9. WHAT will be the operation of frequently stocking, (which is feasible enough) an old and feeble dog with the blood of young ones, as to liveliness, dulness, drowsiness, squeamishness, &c. & *vice versa*.

10. WHETHER a small young dog, by being often fresh stocked with the blood of a young dog of a larger kind, will grow bigger than the ordinary size of his own kind?

11. WHETHER any medicated liquors may be injected together with the blood, into the recipient dog? and, in case they may, whether there will be any considerable difference found between the separations made on this occasion, and those, which would be made, in case such medicated liquors had been injected with some other vehicle, or alone, or taken in at the mouth?

12. WHETHER a purgative medicine, being given to the emittent dog a while before the operation, the recipient dog will be thereby purged, and how? (which experiment may be hugely varied.)

13. WHETHER the operation may be successfully practised, in case the injected blood be that of an animal of another species, as of a calf into a dog, &c. and of a cold animal, as of a fish, or frog, or tortoise, into the vessels of a hot animal? & *vice versa*?

14. WHETHER the colour of the hair or feathers of the recipient animal, by the frequent repeating of this operation, will be changed into that of the emittent?

15. WHETHER by frequently transfusing into the same dog, the blood of some animal of another species, something further, and more

tending to some degrees of a change of species, may be effected, at least in animals near of kin; (as spaniels and setting dogs, Irish grey-hounds and ordinary grey-hounds, &c?)

16. WHETHER the transfusion may be practised upon pregnant bitches, at least at certain times of their gravitation? and what effect it will have upon the whelps?

THERE were some other queries proposed by the same author; as, the weighing of the emittent animal before the operation, that (making an abatement for the effluvia, and for the excrements, if it voids any) it may appear, how much blood it really loses. To which were annexed divers others, not so fit to be perused but by physicians, and therefore here omitted.

PROPOSALS

To try the Effects of the PNEUMATICK ENGINE exhausted, in Plants, Seeds, Eggs of Silk-worms.

First Printed in the *Philosophical Transactions*, N^o. XXIII. p. 424.
For Monday March 11. 1666.

THE ingenious Dr. Beale did formerly suggest, as follows,

IT would be, I think (saith he) very well worth the trial, to see what effects would be produced on plants, put into the pneumatick (or rarifying) engine of Mr. Boyle, with the earth about their roots, and flourishing; whether they would not suddenly wither, if the air were totally taken from them. And particularly to try in the season cherry-blossoms, when partly opened, partly not opened, upon a branch; to wit, whether the air may be so attenuated as to blast. But it may be noted, that the blossoms do not forthwith discover the blast; an old experienced countryman having once given me notice of a blasty noon, (it being then sultry weather, and somewhat gloomy with the thickness of exhalations, almost like a very thick mist) and within a day or two shewing the proof upon the cherry-blossoms then flagging, but not much altering their colour till two days more were past.

THE noble Mr. Boyle suggests, as proper for the approaching season; that it may be tried,

1. WHETHER seeds (especially such as are of a hasty growth, viz. orpin, lettuce, garden-cress-seeds, &c.) will germinate and thrive in the exhausted receiver of the said engine?

2. WHETHER the exclusion of air from the sensitive plant would be harmful to it?

3. WHETHER the grafting of pears upon spina cervina (the almost only purgative vegetable known in England) will produce the

effect of communicating to the fruit that purging quality, or not?

4. WHETHER silkworms eggs will be hatched in such an exhausted receiver, in the season proper for hatching?

To which may be added the trials of putting in a phial, full of water, some of those herbs, that will shoot and grow in water alone, including them in such a receiver, and pumping out what air you can, to see, whether they will then shoot or not?

AND though some of these proposals have been formerly begun to be experimented, yet ought they to be diligently prosecuted, to see how far the air is necessary to vegetation; and whether plants do indeed live as much upon the air, as the earth; and the branches of them are rooted (as it were) in, and quickened by the air, as their roots are planted and nourished in and by the earth?

THE experiment heretofore made of this kind was, that some lettuce-seed being sown upon some earth in the open air, and some of the same seed at the same time upon other earth in a glass-receiver of the above mentioned engine, afterwards exhausted of air; the seed exposed to the air was grown up an inch and a half high, within eight days; but that in the exhausted receiver, not at all. And air being again admitted into the said emptied receiver, to see whether any of the seed would then come up, it was found, that in the space of one week it was grown up to the height of two or three inches.

A CONFIRMATION of the Experiments mentioned in Numb. XXVII. to have been made by Signor FRACASSATI in *Italy*, by injecting Acid Liquors into BLOOD.

First Printed in the *Philosophical Transactions*, N^o. XXIX. p. 551.

For Monday, November 11. 1667.

THE author, having seen the particulars inserted in Numb. XXVII. concerning some experiments made by Signor *Fracassati*, and recollecting, what himself had experimented of that nature, several years ago, was pleased to give to the publisher the following information about it, by the favour of a letter, written to him from *Oxford*, October 19. 1667.

SIR,

I Hinted to you in my last something about the original of the experiments, made in *Italy*, by injecting acid liquors into blood: to explain which, I shall now tell you, that about this time three years *, I mentioned at *Gresham* college to the Royal Society an odd experiment, I had formerly made (not by chance, but design) upon blood yet warm, as it came from the animal, *viz.* That by putting into it a little aqua fortis, or oil of vitriol, or spirit of salt, (these being the most usual acid menstruums,) the blood not only would presently lose its pure colour, and become of a dirty one, but in a trice be also coagulated; whereas if some fine urinous spirit, abounding in volatile salt, such as the spirit of sal armoniac, were mingled with the warm blood, it would not only not curdle it, or imbase its colour, but make it rather more florid than before, and both keep it fluid, and preserve it from putrefaction for a long time.

THIS experiment I devised, among other things, to shew the amicableness of volatile spirits to the blood. And I remember it was so much taken notice of, that some very in-

quisitive members of the Society came presently to me, and desired me to acquaint them more particularly with it; which I readily did, though afterwards I made some further observations about the same experiment, that I had no occasion to relate.

THIS having been so publickly done, though I shall not say, that Signor *Fracassati* may not have hit, as well as I, upon the experiments published in his name, yet there is so little difference between the warm blood of an animal out of his veins and in them, that it is not very improbable, that he may have had some imperfect rumour of our experiment without knowing whence it came; and so may, without any disingenuity, have thence taken a hint to make and publish, what now is englished in the *Transactions*. If it be thought fit, that any mention be made of what I related so long since, I think I can send you some other circumstances belonging to it. For I remember, I tried it with other liquors, (as spirit of wine, oil of tartar, oil of turpentine,) and I think also, I can send you some remarks upon the colour of the upper part of the blood. And I shall on this occasion add, in reference to anatomical matters in general, that after I saw, how favourably *the Usefulness of experimental Philosophy* was received, I was invited to enlarge it in another edition; and for that, I provided divers anatomical, as well as other experiments, and designed many more; so that, I have by me divers things, that would not perhaps be unwelcome to anatomists, &c.

* The Journals of the Royal Society being looked into by the publisher, (who, by the honour of his relation to that illustrious body, hath the advantage of perusing them, as he by his office hath the care of seeing them faithfully managed) do fully agree with the affirmation of this noble person, as well in the circumstance of the time, as the substance of the matter in question; it being in the month of *December* of An. 1664. when, what is now alledged in this letter, was publickly related by its author.

NEW EXPERIMENTS

Concerning the Relation between LIGHT and AIR, in shining Wood and Fish; made by the Author, and by him addressed from *Oxford* to the Publisher, and so communicated to the ROYAL SOCIETY.

First Printed in the *Philosophical Transactions*, N^o. XXXI. p. 581.

For Monday January 6. 1667.

SIR,

TO perform now the promise I made you the other day, I must acquaint you with what will perhaps somewhat surprize you, by giving you an account of what I tried on *Tuesday* night last (*October* 29. 1667.) and the two or three following nights, about the relation between air and light, as this is to be found in some bodies.

THE occasion of these trials was this: Having, as you know, long since made some notes, chiefly historical, upon particular qualities, and finding light to be (how justly, I now dispute not) reckoned by the generality of philosophers among qualities, I huddled together what observations I had either made my self, or received from some ingenious travellers (to whom I recommended my inquiries) about shining bodies; and had also prepared several trials about them, to be made when I should have opportunity and requisite instruments to put them in practice; which, as to some of those designed experiments, have been long denied me. But having at length got hither one of my little engines, and having also procured, after much inquiry, a few small pieces of shining wood, I began on the day above-mentioned to try with them an experiment, I found in my list. And though the main experiment be but one; I intend to set down what occurred to me about it but as several phenomena of it: yet finding it requisite to acquaint you with some trials, that are not so properly parts of it, I shall, for distinction sake, propose them as several experiments; the narratives whereof are taken, for the most part, *verbatim* out of the notes I set down for my own use, when the things to be registered were freshly done. Which advertisement I give you, both to excuse the carelessness of the style, and to induce you not to distrust a narrative, that was made only to serve my memory, not an hypothesis.

EXPERIMENT I.

TO try, whether or no a piece of shining wood, being put into a receiver of our pneumatick engine, would, upon the withdrawing and re-admitting of the air, suffer such changes, as I have often observed a live coal, placed there, to do. Having at length procured a piece of such wood, about the bigness of a groat or less, that gave a vivid light (for rotten wood) we put it into a middle-

sized receiver, so as it was kept from touching the cement; and the pump being set a work, we observed not, during the five or six first exsuctions of the air, that the splendor of the included wood was manifestly lessened, (though it never was at all increased;) but about the seventh suck, it seemed to grow a little more dim, and afterwards answered our expectation, by losing of its light more and more, as the air was still farther pumped out; till at length about the tenth exsuction, (though by the removal of the candles out of the room, and by black clothes and hats we made the place as dark as we could, yet) we could not perceive any light at all to proceed from the wood.

EXPERIMENT II.

WHEREFORE we let in the outward air by degrees, and had the pleasure to see the seemingly extinguished light revive, so fast and perfectly, that it looked to us all, almost like a little flash of lightning, and the splendour of the wood seemed rather greater, than at all less, than before it was put into the receiver. But partly for greater certainty, and partly to enjoy so delightful a spectacle, we repeated the experiment with the like success as at first. Wherefore being desirous to see how soon these changes might be produced, we included the wood in a very small receiver of clear glass, and found, that in this the light would begin to grow faint at the second, or at least at the third exsuction of the air, and at the sixth or seventh would quite disappear. And we found by a minute-watch, that the sending the candles out of the room, the pumping out the air till the wood would shine no more, the re-admitting of the air, (upon which in a trice it would recover its light) and the sending in for the candles to consult the watch, did in all take up but six minutes.

EXPERIMENT III.

THE fore-mentioned experiment, without taking notice how long it lasted, being reiterated twice in this new receiver, we had a desire to see, whether this luminous wood would more resemble a coal, or the life of a perfect animal, in being totally and finally extinguished, in case the air were kept from it a few minutes; or else the life of insects, which in our exhausted receiver I had observed

to lose all appearance of its continuing, and that for a much longer time than a few minutes, and yet afterwards, upon the restitution of air, to recover presently, and shew manifest signs of life? Wherefore having exhausted the receiver, till the wood quite disappeared, we stayed somewhat above a quarter of an hour in the dark, without perceiving, that the wood had regained any thing of light, though about the end of this time we made the place about it as dark as we could; and then it being too late at night to protract the experiment, we let in the air, upon whose admission the wood presently recovered light enough to be conspicuous at a distance; though it seemed to me somewhat less vivid than before: which yet may be either a weakness in my sight, or an effect of the steams of the cement, unfriendly perhaps to the luminousness of the wood.

Thus far we proceeded yester-night, to which we this night added these observations.

WE put in a piece of wood bigger than the former, (this being above an inch long) and that shone very vigorously. And having by a few sucks quite deprived it of light, we left it in the exhausted receiver for full half an hour, and then coming into the dark room again, we found all had not continued so stanch, but that some small portion of air had insinuated it self into the receiver. This we concluded to be but a small portion of air, because the wood was but visible to an attentive eye. And yet, that it was really some air, which was got in, that caused the little glimmering light which we perceived, may appear by this, that it did presently (as we expected) vanish at the first or second suck; and then the air being let into the dark receiver, the included wood presently shone again as before: though I suspected, I discerned some little diminution of its brightness; which yet, till further trials of the like kind, and for a longer time, have been made, I dare not affirm. Before the receiver was sufficiently emptied at the beginning of the experiment made with this great piece of wood, a small leak accidentally sprung, which, letting in a little air, did, sooner than we intended, recall the almost disappearing light.

EXPERIMENT IV.

THERE is an experiment of affinity with the former, which we thought it not altogether impertinent to try. For having observed on another occasion, that sometimes the operation, which the withdrawing the air hath upon a body included in the receiver, proves more considerable some minutes after we have ceased pumping, than immediately after the exercise is left off; I imagined, that even in such cases, where the light is not made wholly to disappear (though it be made almost quite to do so) by the emptying of the pneumatical glass, the suffering the body to remain a while there, though without any pumping (unless now and then a very little to remove the air, that might have stolen in, in the mean time) the remaining light of the body might be further impaired, if not reduced quite to vanish.

To examine this conjecture we put in a body, that was not wood, which had some parts far more luminous than the rest; and having drawn out the air, all the others disappeared, and even the formerly brighter ones shone but faintly, when the pneumatical glass seemed to be exhausted. But keeping the included body a while in that unfriendly place, we perceived the parts, that had retained light, to grow more and more dim, some of them disappearing, and that, which was formerly the most conspicuous, being now but just visible to an attentive eye, and that scarce without dispute. For, if we had not known beforehand, that a shining matter had been included in the receiver, perhaps we should not have found it out. And he, that had the youngest eyes in the company, could not at all discern it: (the air being let in, the body began to shine again.) But this being a single trial, which the lateness of the night hindered us from reiterating, is to be further prosecuted, and in differing substances, before much be built upon it.

EXPERIMENT V.

THE rarefaction or expansion of the air having so notable an operation upon our shining wood, I thought it would not be amiss to try, what the compression of the air would do to it. For which purpose we included a piece of it in such a little instrument to compress, which you may remember to have been devised and proposed by Mr. Hook. But though we impelled the air forcibly enough into the glass, yet, by reason of the thickness requisite in such glasses, and the opacity thence arising, we were not able then, to determine whether or no any change was made in the luminousness of the wood.

WHICH I thought the less strange, because by some experiments purposely devised, (at one of which I remember you were present) I had long since observed, that even a great pressure from a fluid body, which presseth more uniformly against all the parts it toucheth of the consistent body, does work a far less manifest change, even on soft or tender substances, than one would expect from the force wherewith it compresseth.

AND were it not, that one contrary oftentimes minds us of another, I might have forgot, that I had divers thoughts about finding some good ways of trying, whether any such change of texture might be discovered to be made in the shining wood by the absence and return of the ambient air, as might with any probability have the loss or recovery of the wood's splendour attributed to it. For I had formerly (if I were not mistaken) found by several circumstances, which I shall not now stay to name, that a slight (so it be an appropriated) variation of the texture of this wood, and which may seem mainly to respect the pores, (which perhaps ought to be of a determinate shape and size, and filled with a determinate matter) will have a great operation upon its splendour. And I formerly found by other trials, that even consistent bodies, if soft

soft ones, may have their pores enlarged and vitiated, and their bulk, and consequently their texture (at least as to their pores) manifestly enough altered by having the air withdrawn from about them, (whereby the aerial particles within them were able to expand themselves) and let in again; whereby, as to sense, they seemed pretty well restored to their former state. But the success of my endeavours either with microscopes (through which a vivid piece of wood will shine by its own light) or otherwise, was not considerable enough to deserve a particular account; especially in this paper, where I am not to venture at matter of theory.

EXPERIMENT VI.

THINKING fit to try, whether a small quantity of air, without being ventilated or renewed, might not suffice to maintain this cold fire, though it will not that of a live coal, or a piece of match, we caused a piece of shining wood to be hermetically sealed up in a pipe of clear and thin glass: but though, carrying it into the dark, we found it had quite lost its light, yet imagining, that that might proceed from its having been over-heated, (being sealed up in a pipe not long enough to afford it a due distance from the flame of the lamp we employed to seal it,) we caused two or three pieces of fresh wood, amounting all of them to the length of about two inches, to be sealed up in a slender pipe between four or five inches in length; which being warily done, the wood retained its light very well, when the operation was over: And afterwards laying it by my bedside, when the candles were carried away out of the room, I considered it a while before I fell asleep, and found it to shine vividly.

THE next morning when I awaked, though the sun was risen, yet forbearing to draw open the curtains of my bed, till I had looked upon the sealed glass, which I had fenced with a piece of cloath, held between it and the window, my eyes having not yet been exposed to the day-light, since the darkness they had been accustomed to during the night, made me think the wood shined brighter than ever. And this night, after ten of the clock, looking on it in a dark place, it appeared luminous all its length, though not so much so as in the morning.

THE morning after, and the night after that, the same wood did likewise manifestly, though not vigorously shine; especially one piece, whose light was much more vivid than the rest. And, for aught I know, I might have observed them to shine longer, if one of the sealed ends of the glass had not been accidentally broken.

EXPERIMENT VII.

WHILST the former trials were making, I was wishing for a good *Bolonian* stone, to try what effect the withdrawing of the air would have upon it. For though I knew it might be objected, that the experiments of light performable in our engine must be made in the night, whereas the *Bolonian* stone gains its light by being exposed to the sun-beams;

yet that objection did not hinder my wish, since the better sort of *Bolonian* stones may be induced with a luminousness by the flame of fire, or of large candles.

I ALSO wished for such a shining diamond, as is now in the hands, that best deserve such a rarity, our Royal Founder's. For you may remember, that in the observations I made of that stone, and annexed to the conclusion of the book of colours, I shew how it may, several ways, be brought to shine; so that by one or other of those ways, especially that of external heat, I thought it very likely, I should be able to make the light continue four or five minutes; which would be long enough to try in a very small receiver, exhaustible at a suck or two, whether the withdrawing and restoring the air would have any visible operation on it?

I ALSO wished for some of the glow-worms, with which I formerly made other trials. For though I forgot not, what operation the withdrawing of the air, by our engine, is wont to have upon living creatures, yet that made me not forbear my wish; not only because of the different effect I have found the engine to have on insects in respect of other animals, but because I am not of the opinion of those modern writers, who will have the light of the glow-worms depend altogether upon their life, and end with it. But being not likely by my wishes to procure any new subject to make trials on, I thought fit at least to do what was in my power; and accordingly (to gratify them, who, I presumed, would, if present, propose such a trial) caused a piece of iron to be forged, whose top was of the bigness of a nutmeg; the rest being a stem, of an inch, or an inch and half long; for which we provided a little candle-stick of tobacco-pipe-clay, which would not yield any smoke to fill and darken the receiver. Then having heated the iron red-hot, and placed it in this clay, so that the round part was clearly protuberant, we conveyed it into a receiver of white glass, which was so placed, as to keep the sides at as good a distance, as we could, from the iron, lest the excessive heat should (as we much feared it would) break the glass. Then sending away the candles, and making the room dark, we hastily pumped out the air, but could not perceive the withdrawing of it had any operation on the glowing iron. And though it continued shining long enough to give us opportunity to pump out and let in the air three several times, yet we could not observe, that the air had any manifest operation one way or other. For though, upon the withdrawing of the air, the iron grew dimmer and dimmer, yet that I attributed to the cooling of it: and the rather, because, having (to examine the conjecture) let in two or three times the air, when the receiver had been exhausted, there appeared no manifest increase of light upon the sudden admission of it.

EXPERIMENT VIII.

HAVING formerly in our *Physico-mechanical* experiments about the spring of the

the air observed, that the air is thus far a vehicle of sound, that a body but faintly sounding, being placed in our receiver, gave a yet weaker sound, when the air was withdrawn from about it, than when the receiver was full of air; I presumed, some curious persons would, if they had been present, desire to have a trial made, whether or no a small piece of shining wood being so included in the receiver, as that the pumping out of the air should have no injurious operation upon the body of it, its light would upon the withdrawing of the air be manifestly diminished. And this I was the less backward to try, because (not to mention the relation, which the former experiments shew there may be in some cases between light and air) it did not readily occur to my memory, that by any manifest experiment (for I know, there are probable reasons to prove it) it appeared, that a body more thin than air will or can transmit light, as well as other diaphanous mediums. And those modern Atomists, that think, there is in our exhausted receiver very many times more vacuum than body, would, I presumed, be glad to be supplied with an argument against the Peripateticks, to shew, that the motion of bodies, *viz.* the corpuscles of light, may be freely made *in vacuo*, and proceed without the assistance of a vehicle.

WHEREFORE having hermetically sealed up a small piece of shining wood in a slender pipe, and placed it in a small receiver, that was likewise made of clear glass, we exhausted it of air, and afterwards let in again that, which we had excluded. But by neither of the operations could we perceive any sensible decrement or increase of the light of the wood; though by that very observation it appeared, that the glass had been well sealed, since otherwise the included air would have got out of the pipe into the receiver, and have left the wood without light.

EXPERIMENT IX.

I Had also a mind to try, both what degree of rarefaction of the air would deprive the wood of its splendour in such and such measures, and whether or no the self-same air, which, when rarefied, would not suffer the wood to shine, would, when reduced to its former density, allow it to shine as much as before.

THIS I proposed to do by putting some shining wood into a clear and conveniently shaped glass, that the long stem or pipe being so far filled with quick-silver, as that there might be about half a spoonful of air left at the closed end, where the wood was placed, it might be inverted into a little glass of stagnant quicksilver, and therewith conveyed into a slender receiver, out of which as the air should come to be pumped, that included in the glass, which held the wood, might be rarefied, and afterwards upon the admission of the outward air (which must impel up the quicksilver to its former height) might be restored to its former state. But when we came to make trial of this, we had no receiver con-

veniently shaped, that was so clear and thin, as that we could see the wood shine through both the glasses. And though we would for an expedient have substituted a fine thin bladder, wherein the wood was to be put, and a convenient quantity of air strongly tied up with it, yet for want of a bladder fine enough for our turn, that expedient also proved useless to us. But being desirous to make what trial we could by the least unfit means we had in our power, we got an old, but thin glass, sealed at one end, whose shape was pretty cylindrical, and whose bore was about the bigness of a man's little finger, and whose length was about a foot or more. Into this pipe near the sealed end we put a piece of shining wood, wedged in with a piece of cork, to keep it from falling; and having inverted the nose of it into another slender glass, but not cylindrical, wherein was pretty store of quicksilver, we put them both into a long receiver, shaped almost like a glass churn; and having pumped a while, that the air included in the pipe, expanding it self, might depress the quicksilver, and so make escapes into the receiver, as long as we thought fit; we then let in the outward air, that the stagnant quicksilver might be impelled into the cavity of the pipe now freed from much of the air, to the height requisite for our purpose.

THIS done, we plied the pump again, and observed, that, as the air in the pipe did by its own spring expand it self more and more, and grow thinner and thinner, the shining wood grew dimmer and dimmer, till at length it ceased to shine, the internal air being then got a good way lower than the surface of the external quicksilver: whereupon opening the commerce between the cavity of the receiver, and the atmosphere, the quicksilver was driven up again, and consequently, the air above it was restored to its former density; upon which the rotten wood also recovered its light. What the greatest expansion of this air was, we could not certainly determine, because the expansion raised the external quicksilver so high, as to hinder us to see and measure it. But we guessed, that the air reached to about a foot or more from the top of the pipe to the surface of the quicksilver near the bottom of it. But, when that rarefied air was impelled into its former dimensions, we measured it, and found, that the upper part of the tube, unpossessed by the quicksilver, was about three inches; and the wood being about an inch long, there remained two inches or somewhat better for the air. But this experiment is to be repeated, when exacter instruments can be procured.

EXPERIMENT X.

THINKING it fit to try, aswell whether stinking fish, that shines, be of the same nature as to luminousness with rotten wood, that shines too; as whether the withdrawing of the air will extinguish or eclipse the light of a considerable bulk of luminous matter, as in the experiments, hitherto made, we found it would do to a small one; we took a fish, that we had

had kept, and caused to be watched, till it was almost all over luminous; though much more in the belly and some parts of the head, than elsewhere: and having suspended him in a conveniently shaped receiver, we found him to give so great a light, that we suspected beforehand, that the withdrawing of the air would hardly have its full operation upon a body, whose bulk was considerable, as well as its light very vivid, and which had many luminous parts retired to a pretty distance from the air. Accordingly, having exhausted the receiver as much as we were wont, it appeared indeed, especially towards the latter end of the operation, that the absence of the air did considerably lessen, and in some places eclipse the light of those parts, that shone less strongly. But the belly appeared not much less luminous than before: wherefore supposing, that upon the turning of the stop-cock the air coming in much more hastily than it could be drawn out, we should have the best advantage to discern, what interest it had in the luminousness of the fish, we re-admitted it; and upon its rushing in, perceived the light to be as it were revived, and increased; those parts of the fish, that were scarce visible before, or shone but dimly, receiving presently their former splendour.

AND not to leave un-prosecuted the remaining part of the experiment, which was to try, whether it was the kind of the luminous body, or only the greatness of the bulk, and the vividness of light, and, if I may so speak, the tenacity of the substance it resided in, that made the difference between the fish and the wood; we put part of the fish of another kind, that shone much more faintly than that, hitherto spoken of, and but in some places; and by the withdrawing the air, we made some of the luminous parts disappear, and the others so dim, as scarce to be discerned; and yet both the one and the other regained their former light upon the return of the air.

AND to pursue the experiment a little further, we put in such a piece of the first fish, as though it were bright, was yet but thin, and not considerably great; and upon pumping out the air, we found it, according to our expectation, quite eclipsed, though it recovered its light upon the air's re-entry.

THESE, Sir, are the experiments, I have lately made about the shining bodies in our engine. More I would have tried, notwithstanding the trouble we found in managing the engine in the dark, if rotten wood had not failed us, and I were not in a place, where the glass-men's shops are not near so well furnished as the stationers.

I SCARCE doubt, but these experiments will occasion among the virtuosi several queries and conjectures, according to the differing hypotheses, and inquiries, to which men are inclined. And particularly it is probable, that some will make use of this discourse to countenance their opinion, that notwithstanding the coldness (at least as to sense) of fishes and other animals, there may be in the heart

and blood a vital kind of fire, which needs air, as well as those fires, that are sensibly hot: which may lessen the wonder, that animals should not be able to live, when robbed of air. And if I had now time, I could possibly furnish you with some other trials, that seem much to favour the comparison, though, as to the opinion it self of a vital flame, I shall not now tell you my thoughts about it. And though not only the Cartesians will perhaps draw an argument from the past phenomena in favour of their theory of light, but divers others will discourse upon them, and propose further questions, and perhaps inquiries, suitable to their several hypotheses; yet I shall content my self at present to have faithfully delivered the historical part of these appearances, without making, at least at this time, any reflections on them. And the rather indeed, because I enjoyed so little health, when I was making the experiments, that it was not fit for me to engage in speculations, that would much exercise my thoughts; which, I doubt, have been more gratified, than my health hath been by the bare trials, which are most seasonably made at hours unseasonable for one, that is not well.

POSTSCRIPT, sent by the same noble Author from the same place, December 6. 1667.

My condition in point of health being not much improved, since I writ to you in October last, when I shall have added, that I have not these five or six weeks been able to procure any shining wood, (except one single piece, which though large, was so ill conditioned, that it afforded me but one trial) you will not, I hope, expect, that I should add much to the experiments I formerly sent you about the relation betwixt light and air. But however, since the subject is new and noble, and since your curiosity about other matters has been so welcome and useful to the Virtuosi, I shall not decline even on this occasion to comply with it; and the rather, because I had promised you some additions a good while since, and because too, that though what I shall acquaint you with, may seem to be but a confirmation of two or three of the former experiments, yet, besides that it is of them, which most needed a confirmation, these trials will also afford some circumstances, that will not, I think, be unwelcome.

EXPERIMENT XI.

TO examine then the conjecture, mentioned in the last experiment, that the durability of the light in the shining fish, in spite of the withdrawing the air, might proceed in great part from the vividness of it, and the beauty of the matter it resided in, rather than from the extent of the luminous body in comparison of the small pieces of shining wood, I hitherto had made my trials with; I put in the above-mentioned piece of wood, whose luminous superficies might be perhaps ten or twelve times as great, as that, which the eye saw at once, of the surface of such fragments of shining wood, as I was wont to employ: and though some parts of this large
super-

superficies shined vividly, (for the light was usually enough, for rotten wood, inferiour to that of our fish) yet this great piece, being put into a convenient receiver, was, upon the withdrawing of the air, deprived of light, as the smaller ones had been formerly; the returning air restoring its light to the one, as it had done to the other.

EXPERIMENT XII.

BUT this is not the chief thing I intended to acquaint you with; that being the success of some trials, which we made in prosecution of these two neighbouring experiments.

In the first of these I told you, I had been able to try but for half an hour, or a little more, that a shining piece of wood, deprived in our engine of light, would yet retain a disposition to be as it were rekindled upon the fresh access of the air. Wherefore, though I could have wished to have made a further trial with the same kind of bodies, yet being able to procure none, I substituted in their room small pieces of rotten fish, that shone some of them more faintly, and some of them more vividly, in reference to one another, but none as strongly as some that I could have employed: and having, in a very small and clear receiver, so far drawn off the air, as to make the included body disappear, we so ordered the matter, that we kept out the air for about 24 hours; and then allowing the air to re-enter in a dark place, and late at night, upon its first admittance the fish regained its light.

EXPERIMENT XIII.

THIS, compared with some of my former observations about putrefaction, put me upon a trial, which, though it miscarried, I shall here make mention of, that in case you, who are better furnished with glasses, think it worth while, you may get reiterated by the Society's operator. Considering then, how great an interest putrefaction hath in the shining of fishes, and air in the phenomena of putrefaction, I thought it might be somewhat to the purpose, to take a fish, that was, according to the common course I had observed in animals, not far from the state, at which it would begin to shine: and having cut out a piece of it, I caused the rest to be hung up again in a cellar, and the expected piece to be put into a small and transparent receiver, that we might observe, if a day or two, or more, after the fish in the cellar should begin to shine, that in the exhausted receiver would either also shine, or (because that seemed not likely) would, notwithstanding the check, which the absence of the air might be presumed to give the putrefaction, be found to shine too, either immediately upon the admission of the air, or not long after it.

But this experiment, as I lately intimated, was only designed and attempted, not completed; the receiver being so thin, that upon the exhaustion of the internal air, the weight of the external broke it; and we could ill spare another of that kind from trials, we were more concerned to make: notwithstanding which,

we made one trial more, which succeeded no better than the former, but miscarried upon a quite differing account, *viz.* because neither the included piece of fish, nor the remaining, though it were of the same sort with the fishes I usually employed, would shine at all, though kept a pretty while beyond the usual time, at which such fishes were wont to grow luminous.

If this experiment had succeeded, I had some others to try in prosecution of it, which I shall not now trouble you with the mention of. But that this paragraph may not be useless to you, I'll take this occasion to give you a couple of Advertisements; that may relate not only to this experiment, but also more generally to those, whether precedent or subsequent, where shining fish are employed.

ADVERTISEMENT I.

IN the first place then, I will not undertake, that all the experiments you shall make with rotten fish, shall have just the same success with these I have related. For, as I elsewhere observed, (in a discourse written purposely on that subject) that the event of divers other experiments is not always certain; so I have had occasion to observe the like about shining of fishes. And, besides what I lately took notice of at the close of the tenth Experiment, I remember, that having once designed to make observations about the light of rotten fishes, and having in order thereunto caused a competent number of them to be bought, not one of them all would shine, though they were bought by the same person I was wont to employ, and hung up in the same place, where I used to have them put, and kept not only till they began to putrify, but beyond the time, that others used to continue to shine; although a parcel of the same kind of fishes bought the week before, and another of the same kind bought not many days after, shined according to expectation. What the reason of this disappointment was, I could not determine; only I remember, that at the time it happened, the weather was variable, and not without some days of frost and snow. Nor is this the oddest observation I could relate to you about the uncertain shining of fishes, if I thought it necessary to add it in this place.

ADVERTISEMENT II.

NOTICE must also be taken in making experiments with shining fish, that their luminousness is not wont to continue very many days. Which advertisement may be therefore useful, because without it we may be apt sometimes to make trials, that cannot be soon enough brought to an issue; and so we may mistake the loss of light in the fish, to be a deprivation of it caused by the experiment; which indeed is but a cessation, according to the usual course of nature.

EXPERIMENT XIV.

I KNOW not, whether you will think it worth while to be told of a trial, that we made to save those criticks a labour, that else might perhaps demand, why it was not made.

We

We put therefore a piece of shining fish into a wide-mouthed glass, about half filled with fair water, and having placed this glass in a receiver, we exhausted the air for a good while, to observe, whether, when the pressure of the air was removed, and yet (by reason of the water that did before keep the air from immediately touching the fish) the exhaustion of the receiver did not deprive the fish of that contact of air, which it had lost before; whether, I say, in this case the absence of the air would have the same influence on the shining body, as in the former experiments; and here, as far as the numerous bubbles excited in the water would give us leave to discern it (for they did, though not unexpectedly, somewhat disturb the experiment, which inconvenience we might have prevented, if we had thought it worth while) we could not perceive, that either the absence or return of the air had any great operation upon the light of the immersed body: which yet did not keep me from intending to make a somewhat like trial with shining wood (when I can get any) fastened to the lower part of a clear glass, and covered over, but not very deep, with quicksilver. Of which practice I shall not now stay to give you the reasons, having elsewhere fully enough expressed them.

AND that this Section may acquaint you with something besides the (seemingly) insignificant experiment related in it, I shall here inform you, (since I perceive, I did not in the first papers I sent you,) that though, when I formerly put together some notes about luminous bodies, I confined not my observations to one or two sorts of fishes, yet the experiments, sent you since *October* last, were all of them (except a collateral one or two) made with whittings, which among the fishes, I have had occasion to take notice of, is (except one sort, that I cannot procure) the fittest for such trials, and consequently fit to be named to you, to facilitate their future ones, in case you think it requisite to make any upon such subjects.

EXPERIMENT XV.

THE other of the two neighbouring experiments, I lately mentioned (*viz.* the ninth) I told you, when I sent it you, needed a reiteration to confirm it, since we had but once tried it (and that without all the convenience we desired) that a shining body, which upon the first withdrawing the air loseth much, but not all its light, may be deprived of the rest by continuing in that unfriendly place, though the air be no farther exhausted. To prosecute therefore both the experiments in one trial, we took somewhat late at night a piece of rotten fish, which we judged to shine too strongly, to be quickly deprived of all its light, and having put it into a small and clear receiver, we found (as we had foreseen) that the light was much impaired, but nothing near suppressed by the withdrawing of the air. Wherefore having removed the receiver into a convenient place, I caused it to be brought to me about midnight (after I was a-bed) and having by close drawing the curtains, and other means, made the place pretty dark, I

perceived the included body to continue to shine more vividly, than one would have expected, (and, if I mistake not, I saw it shining in the morning, whilst it was dark;) but the night after, coming to look upon it again, its light appeared no more: notwithstanding which I made a shift to keep out the air about 24 hours longer, and so after 48 hours in all, we opened the receiver in a dark place, and presently upon the ingress of the air were pleasingly saluted with so vivid an apparition of light, that the included body continued to shine, when carried into a room, where there was both fire and candle, if it were but by a hat screened from their beams.

BEING encouraged, as well as pleased with this success, we forthwith exhausted the air once more out of the same receiver, and having kept it about four hours longer, we looked upon it again in a dark place, and finding no appearance of light, let the air in upon it, whereby it was made to shine again, and that vigorously enough, so that I caused the receiver to be exhausted once more; but that it being *Sunday* night, I was unwilling to scandalize any, by putting my servants upon a laborious, and not necessary work.

THE suddenness, with which the included body appeared to be, as it were, re-kindled upon the first contact of the air, revived in me some suspicions I have had about the possible causes of these short-lived apparitions of light (for I speak not now of real lamps, found in tombs, for a reason to be told you another time,) which disclosing themselves upon men's coming in, and consequently letting in fresh air into vaults, that had been very long close, did soon after vanish. These thoughts, as I was saying, occurred to me upon what I had been relating, by reason of the sudden operation of the fresh air upon a body, that but a minute before disclosed no light. For, though the lights reported to have been seen in caves, quickly disappeared, which that of our fish did not; yet that difference might possibly proceed from the tenacity, or some other disposition of the matter wherein the luminousness of the fish resides. For I remembered, that I had more than once observed a certain glimmering and small light to be produced in a sort of bodies upon putting them out of their former rest, and taking them into the air, which sparks would vanish themselves sometimes within one minute, sometimes within a few minutes. But as these thoughts were but transient conjectures, so I shall not entertain you any longer about them, but rather contenting my self with the hint already given, take notice of what may be more certainly deduced from our experiment; which is, that the air may have a much greater interest in divers odd phenomena of nature, than we are hitherto aware of.

AND for confirmation of our experiment I shall add, that, having in another receiver eclipsed a piece of fish, that shone, when it was put in, more languidly than divers others, that we had tried, I kept it about three days and three nights in a receiver, which (receiver) being somewhat like another, at first suggested

to me, when I came to take it, some scruple; but afterwards, upon farther examination, concluded it to be the same: wherefore I opened it in the dark, and upon letting in the air on this body, that shined but faintly at first, it immediately recovered its long suppressed light. And having included another piece, that was yet more faint than this, when it was put into the receiver, I thought fit to try at once the experiment hitherto confirmed, and the converse of it. And therefore having kept this piece also three days and three nights in the exhausted glass, I let in the air upon it, and notwithstanding the darkness of the place, nothing of life was thereupon revived. But this being little other than I expected from a body, that shined so faintly, when it was put into the receiver, and had been kept there so long, I resolved to exercise my patience a while as well as my curiosity, and try, whether the appulse and contact of the air would have that operation after some time, that it had not at first; and accordingly, after having waited a while, I observed the fish to disclose a light, which, though but dim, was manifest enough; but having considered it for some time, I had not leisure to watch, whether it would increase, or how long it would continue.

I KNOW not, Sir, whether you are weary with reading, but I am sure I am quite tired with making so many experiments upon one subject; and therefore I shall here conclude this paper, as soon as I have added this confirma-

tion, as well of what I last related, as of something, that I observed before, that having included in small receivers two pieces of rotten whittings, whereof the one, before it was put in, scarce shone so vividly, as did the other after the receiver was exhausted; and having ordered the matter so, that we were able to keep out the air for some days, at the end of about 48 hours we found, that the more strongly shining body retained yet a deal of light. But afterwards looking upon them both in a dark place, we could not perceive in either any show of light. Wherefore having let in the air into that receiver, whereinto the body that at first shined the fainter had been put, there did not ensue any glimmering of light for a pretty while: nay, upon the rushing in of the air into the other glass, (then also made accessible to the atmosphere) the body, that at first shone so strongly, and that continued to shine so long, shewed no glimmering of light. But being resolved to expect the issue a while longer, our patience was rewarded in less than a quarter of an hour with the sight of a manifest light in the body last named; and a while after the other also became visible, but by a light very dim. The more luminous of these bodies I observed to retain some light twenty-four hours after: and the hitherto recited experiment had this peculiar circumstance in it, that the two receivers were un-interruptedly kept exhausted no less than four days, and as many nights*.

Observations and Trials about the Resemblances and Differences between a BURNING COAL and SHINING WOOD.

First Printed in the *Philosophical Transactions*, N^o XXXII. p. 605.

For Monday February 10. 1667.

THESSE particulars were already in our hands, when we published the experiments made on shining wood and fish, in the last Papers, imparted then by the same noble author, that those were; but wanted then room enough to contain these, which now follow, as they were sent in a letter from Oxford, viz.

AND now, Sir, seeing the want of shining wood hath kept me ever since I sent you the former experiments from making any new ones on that subject, I shall, by way of amends, subjoin some of the observations, that I heretofore intimated to you, I had made of the resemblances and differences between a live coal and a piece of shining wood; in perusing of which you will easily discern, that to those particulars, which my memory and the former observations, I had noted down about lighter and luminous bodies, had suggested to me, I have

added some, that have been afforded me by those late trials, made in my engine, whereof I sent you an account.

RESEMBLANCES.

THE things, wherein I observed a piece of wood and a burning coal to agree or resemble each other, are principally these five.

1. *Both of them are luminaries, that is, give light, as having it (if I may so speak) residing in them; and not like looking-glasses or white bodies, which are conspicuous only by the incident beams of the sun, or some other luminous body, which they reflect.*

THIS is evident, because both shining wood and a burning coal, shine the more vividly, by how much the place, wherein they are put, is made the darker by the careful exclusion of the adventitious light. It is true, that the moon

* What method the noble author of these experiments used in keeping out the air for so long a time, will probably be made known ere long by himself.

moon and Venus appear brightest at or about midnight, and yet have but a borrowed light; but the difference between those planets and the bodies we treat of, in reference to the difficulty we are considering, is obvious enough. For, though the beholder's eye, that looks upon those stars, be advantaged by being in the dark, which enlarges the pupil of the eye, yet the object it self is freely exposed to the beams of the sun; which, if they were intercepted, those planets would quickly be darkened, as experience manifests in eclipses.

2. *Both shining wood and a burning coal need the presence of the air, and are too of such a density, to make them continue shining.*

THIS has been proved as to a coal, by what I long since published in my *Physico-mechanical Experiments*, where I relate, how quickly a coal would be extinguished upon the withdrawing the air from about it: and as to shining wood, the experiments I lately sent you, make it needless for me to add any other proof of the requisiteness, not only of air, but of air of such a thickness, to make its light continue. How far this is applicable to flame, it is not necessary here to determine; though when I have the satisfaction of seeing you again, I may tell you something about that question, which perhaps you do not expect.

3. *Both shining wood and a burning coal, having been deprived for a time of their light, by the with-drawing of the contiguous air, may presently recover it by letting in fresh air upon them.*

THE former part of this particular trials have often shown you to be true, when kindled coals, that seem to be extinguished in our exhausted receivers, were presently revived, when the air was restored to them: and the latter part is abundantly manifest by the experiments, to which this paper is an appendance.

4. *Both a quick coal and shining wood will be easily quenched by water and many other liquors.*

THE truth of this, as to coals, is too obvious to need a proof; and therefore I shall confirm it only as to wood. For which purpose you may be pleased to take the following transcript of some of my notes about light.

I TOOK a piece of shining wood, and having wetted it with a little common water in a clear glass, it presently lost all its light*.

THE like experiment I tried with strong spirit of salt, and also with weak spirit of sal armoniac; but in both the light did, upon the wood's imbibing of the liquor, presently disappear.

AND lest you should think, that in the words, *many other liquors*, I intended not to comprise any, that consist of soft and unctuous parts, or that are highly inflammable, I shall subjoin a couple of notes, that I find next to those just now transcribed.

I MADE the like trial with rectified oil of turpentine, with a not unlike success. The same experiment I tried more than once with high rectified spirit of wine, which did imme-

diately destroy all the light of the wood, that was immerfed in it; and having put a little of that liquor with my finger upon a part of the whole piece of wood, that shone very vigorously, it quickly did, as if were, quench the coal, as far as the liquor reached; nor did it in a pretty while regain its luminousness: (which whether it recovered at all, I know not; for this trial being made upon my bed, I fell asleep, before I had waited long enough to finish the observation.)

5. *As a quick coal is not to be extinguished by the coldness of the air, when that is greater than ordinary, so neither is a piece of shining wood to be deprived of its light by the same quality of air.*

As much of this observation, as concerns the coal, will be readily granted; and for proof of the other part of it, I could relate to you more trials than one, but that I suppose, one may suffice, circumstanced like that, which I shall now relate.

I TOOK a small piece of shining wood, and put it into a slender glass-pipe, sealed at one end, and open at the other, and placed this pipe in a glass vessel, where I caused to be put a strongly frigorifick mixture of ice and salt; and having kept it there full as long, as I thought would be requisite to freeze an aqueous body, I afterwards took it out, and perceived not any sensible diminution of its light. But to be sure, the frigorifick mixture should not deceive me, I had placed by this pipe another, almost filled with water, which I found to be turned into ice; and though I suffered the wood to remain, a pretty while after, exposed to so intense a cold, yet when I took it out, it continued shining, and, if I much mistake not, it ceased not to do so, when I looked on it, twenty-four hours after. But though the light of shining fish be usually (as far as I have observed) more vigorous and durable, than that of shining wood; yet I cannot say, that it will hold out against cold so well, as the other. For, having ordered one of my servants to cut off a good large piece of the luminous whiting, and bury it in ice and salt, when I called for it in less than half an hour after, I found it much stiffened by the cold, and to have no light, that I could discern in a place dark enough. And for fear, that this effect may have proceeded not barely from the operation of the cold, but also from that of the salt, (for which suspicion you would see reason enough, if I could shew you my trials about shining fish) I caused another time a piece of whiting to be put in a pipe of glass sealed at one end, and having seen it shine there, I looked upon it again, after it had stayed but a quarter of an hour, by my estimate, in a frigorifick mixture, which the glass kept from touching the fish; and yet neither I, nor a youth, that I employed to look on it, could perceive in a dark place, that it retained any light; which whether the cold had deprived it of by that great change

* From hence you will easily gather the reason, why, when I lately told you of the trial, I made with a piece of shining fish under water in the un-exhausted receiver, I did not propose to have the like trial made with shining wood and water, but for this liquor substituted mercury.

change of texture, that the congelation of the aqueous juice of the fish (which I have several times observed to be luminous) may be supposed to have made in the body invaded by it; or whether the effect depend more principally on some other cause, I shall not now examine.

DIFFERENCES.

1. *The first difference I observed betwixt a live coal and shining wood, is, that whereas the light of the former is readily extinguishable by compression (as is obvious in the practice of suddenly extinguishing a piece of coal by treading upon it) I could not find, that such a compression, as I could conveniently give, without losing sight of its operation, would put out or much injure the light even of small fragments of shining wood: one of my trials about which I find thus set down among my notes about light.*

I TOOK a piece of shining wood, and having pressed it between two pieces of clear glass (whereof the one was pretty flat, and the other convex) so that I could clearly see the wood through the glass, I could not perceive, that the compression, though it sometimes broke the wood into several fragments, did either destroy or considerably alter the light.

THIS experiment I repeated, with the same success. But what a stronger or more lasting compression may do in this case, I had not opportunity to try.

2. *The next unlikeliness to be taken notice of betwixt rotten wood and a kindled coal, is, that the latter will in very few minutes be totally extinguished by the with-drawing of the air; whereas a piece of shining wood, being eclipsed by the absence of the air, and kept so for a time, will immediately recover its light, if the air be let in upon it again within half an hour after it was first with-drawn.*

THE former part of this observation is easily proved by the experiments, that have been often made upon quick coals in the pneumatical engine; and the truth of the latter part appears by an experiment about shining wood made by us in *October* last. Neither is it unprobable, that if I had had the conveniency to try it, I should have found, that a piece of shining wood deprived of its light by the removal of the ambient air, would retain a disposition to recover it upon the return of the air, not only for half an hour, (which is all that I lately asserted) but for half a day, and perhaps a longer time.

3. *The next difference to be mentioned is, that a live coal being put into a small close glass, will not continue to burn for very many minutes, but a piece of shining wood will continue to shine for some whole days.*

THE first part of the assertion I know you will readily grant; and the rather, because it contains matter of fact, without at all determining, whether the coals not continuing to burn, proceeds from its being, as it were, stifled by its own smoke and exhalations, (which can have no vent in a small close glass) or from the want of fresh air, or from any particular

cause, which I must not here debate; though I have sometimes made experiments somewhat odd, to facilitate that enquiry. The other part of our observation may be easily made out by what I tried upon shining wood, sealed up hermetically in very small glasses, where the wood did for several days (though I remember not precisely how many) retain its light.

4. *A fourth difference may be this; that, whereas a coal, as it burns, sends forth store of smoke or exhalations, luminous wood does not so.*

5. *A fifth, flowing from the former, is, that, whereas a coal in shining wastes it self at a great rate, shining wood does not.*

THESE two unlikelinesses I mention together, not only because of their affinity, but because what concerns the coal in both, will need no proof; and as for what concerns rotten wood, it may be verified by an observation, that, I find by my notes, I made in a piece of it hermetically sealed up in a small clear glass; where, after it had continued luminous some days, I looked on it in the day-time to perceive, if any store of spirits or other steams had, during all that while, exhaled from the wood; but could not find any on the inside of the glass, save that in one place there appeared a kind of a dew, but consisting of such very small drops (if at least their size were not below that name) that a multitude of them would go to the making up of one ordinary drop. But in pieces of shining fish I found the case much otherwise, as was to be expected.

6. *The last difference I shall take notice of betwixt the bodies hitherto compared, is, that a quick coal is actually and vehemently hot; whereas I have not observed shining wood to be so much as sensibly lukewarm.*

WHAT is said of the coal's heat being as manifest as its light, I shall need only to make out, what relates to the shining wood. To assist me wherein, I meet among my notes that, whose transcript I shall subjoin, when I have premised, that (if my memory do not deceive me) the piece of wood to be mentioned was one, that shone so vividly, that waking in the night some hours before I tried it, and perceiving, as it lay near me on the bed, how luminous it was, I was invited to reach out to a place near the bed's-head, where there stood several books, and laying the wood on that, which came to hand, I could discern by the light of it, that the book was an Hebrew bible, and that of the page I lighted on, the wrong end was turned upwards: to which intimation having added, that the little glass instrument, mentioned in the note, is such an one, as you may find described in my preliminaries to the history of cold, save that part of this was a little bending inward at the basis, that it may sometimes stand by it self, and sometimes receive a small body into the dimple at its basis: having, I say, premised this, and, that as shining wood did not feel at all warm to me, so I also found shining fish palpably cold, I shall conclude your trouble with the premised note, which speaks thus:

[I PUT upon a large piece of wood, which was partly shining, and, as near as I could, upon one of the most luminous parts of it, one of those thermoscopes, that I make with a pendulous drop of water. But as I had formerly tried, that by laying the tip of my nose or finger upon it, when it shone vividly enough, to enable me to discern both the one and the other, at the time of contact I could not perceive the least of heat, but rather an actual coldness; so by this trial I could not satisfy my self, that it did visibly raise the pendulous drop, though the instrument were so tender, that by approaching one finger near it, yet without actually touching of it, it would manifestly be impelled up, and upon

the removal of my finger, would presently descend again.]

AND I remember, that having put such an instrument upon a shining fish, that was pretty large, I could not thereby perceive, that it had any degree of heat, but rather the contrary. For having divers times taken off the glass, to apply it with the more advantage to several parts of the luminous fish, I divers times (for I remember not, whether it were always) took notice, that upon the removal of the glass into the air, the pendulous drop would manifestly rise a little, and subside again, when the glass was applied to the fish. But whether this part of the experiment will hold in all temperatures of the air, I had not opportunity to try.

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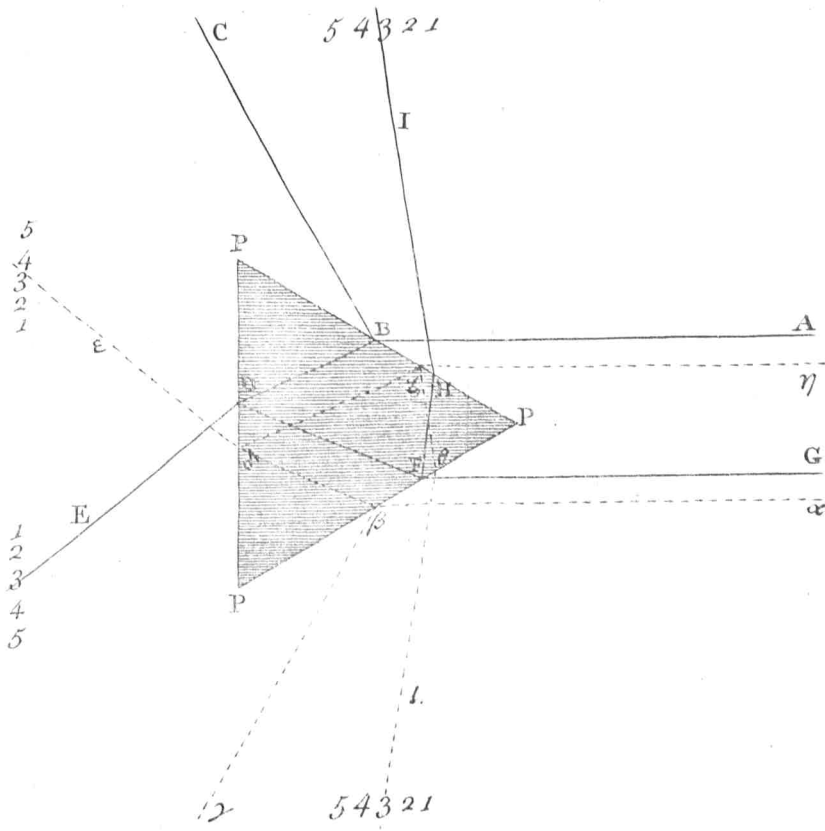
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The Explication of the Scheme

PPP. An Equilateral triangular Crystalline Prism, one of whose edges P. is placed directly towards the Sun
 AB & $\alpha\beta$ Two rays from the Sun falling on the Prism at B β . and thence partly reflected towards C & γ . and partly refracted towards D & δ
 BC & $\beta\gamma$. Those reflected Rays
 BD & $\beta\delta$. Those refracted Rays which are partly refracted towards E & ϵ . and there paint an Iris 12345. denoting the five consecutions of colours Red, Yellow, Green, Blue, and Purple; & are partly reflected towards F & ζ .
 DE & $\delta\zeta$. Those Reflected Rays which are partly refracted towards G & η . colourless, and partly reflected, towards H & θ .
 EH & $\zeta\theta$ Those Reflected Rays which are refracted towards I & ι . and there paint an other fainter Iris, the colours of which are contrary to the former 54321. signifying Purple, Blue, Green, Yellow, Red, so that the Prism in this posture exhibits four Rainbows.

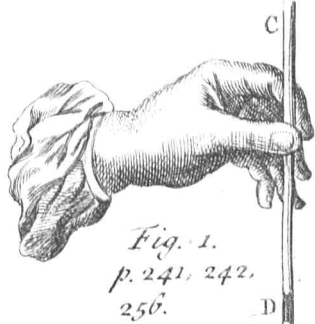


Fig. 1.
p. 241, 242, 256.

Fig. 2.
p. 244, 247.

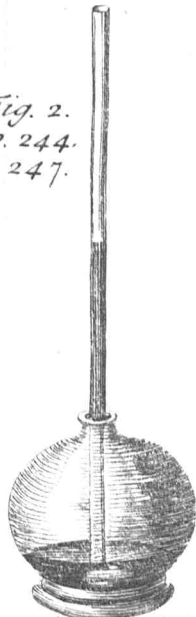


Fig. 5. an Instrument
p. 255.
A. the Vial
BC. the Pipe cemented into the neck of the Vial. open at C. & sealed at B.

Fig. 3.
p. 244, 249.

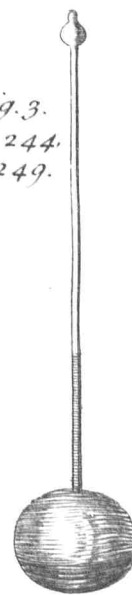


Fig. 6.
p. 256.

Fig. 6. p. 256.
A. the Bolt head
B. the small Stem
BC the Cylinder of Water inclosed

Fig. 4.
p. 244.

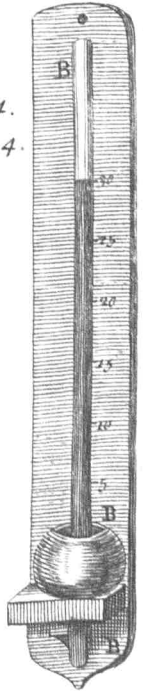
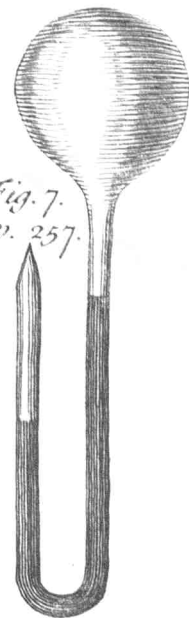


Fig. 7. p. 257.

Fig. 7.
p. 257.



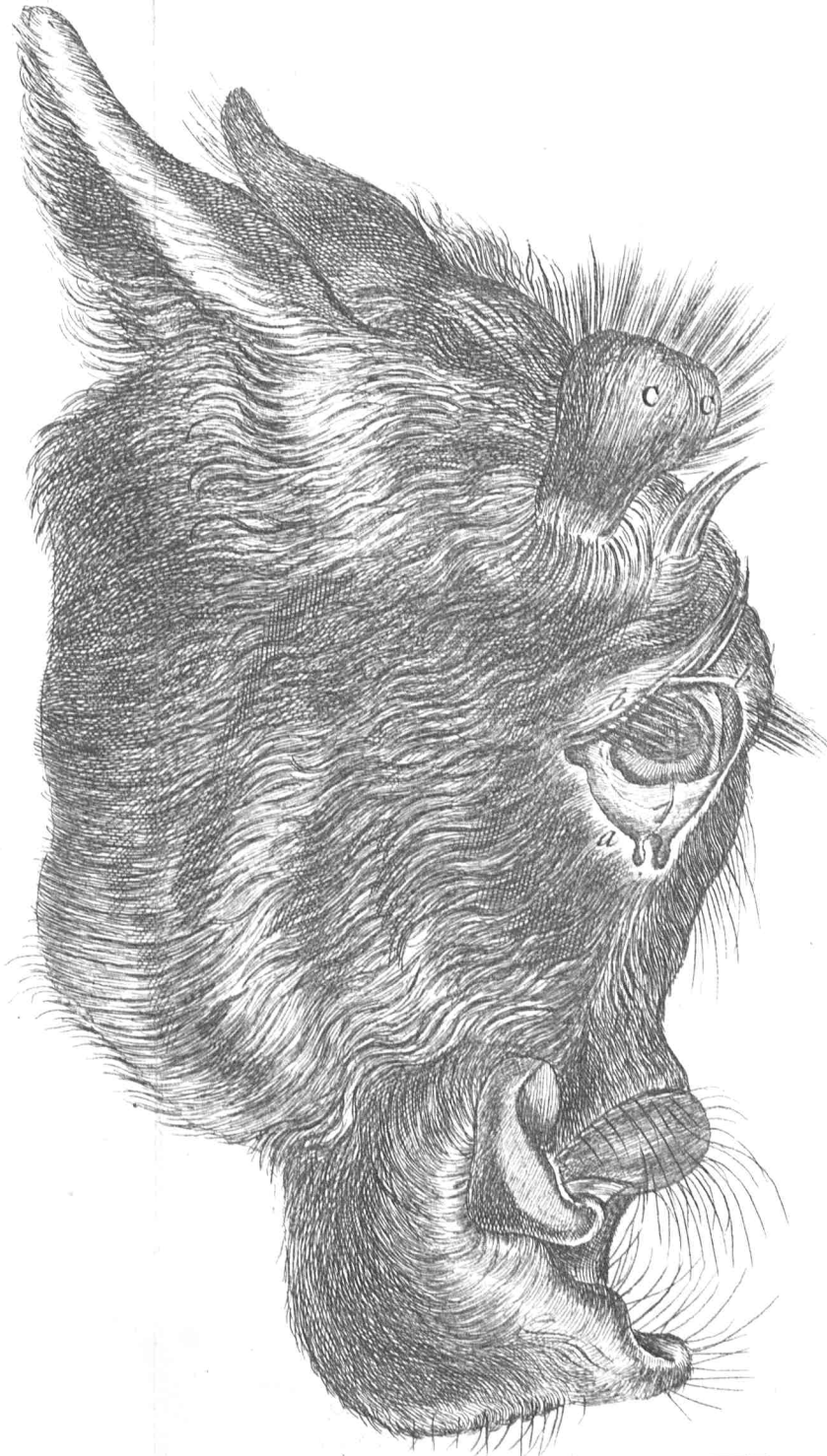
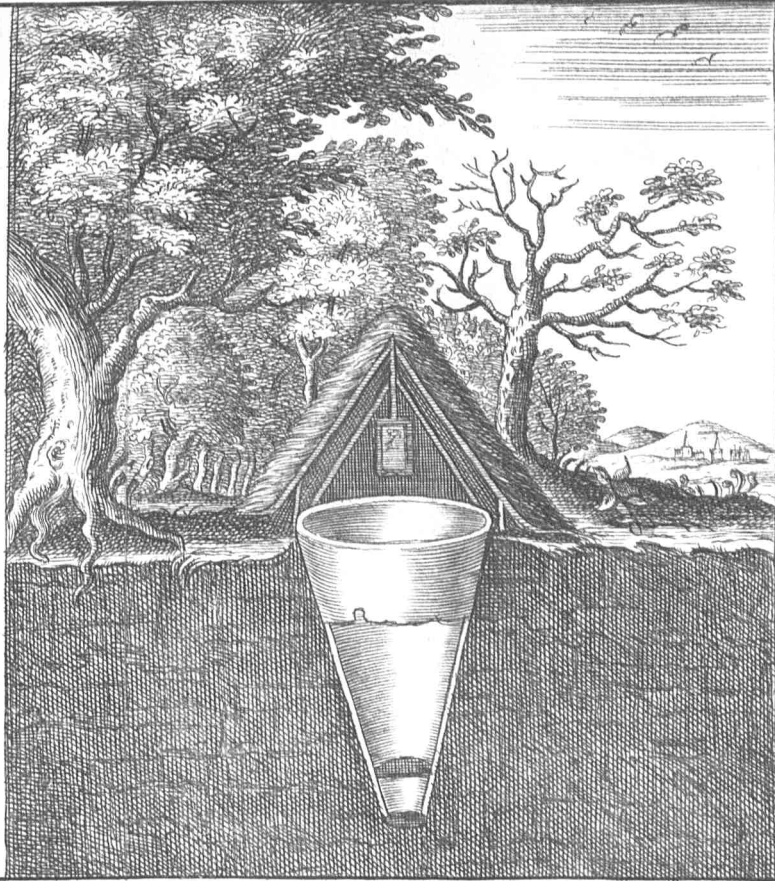


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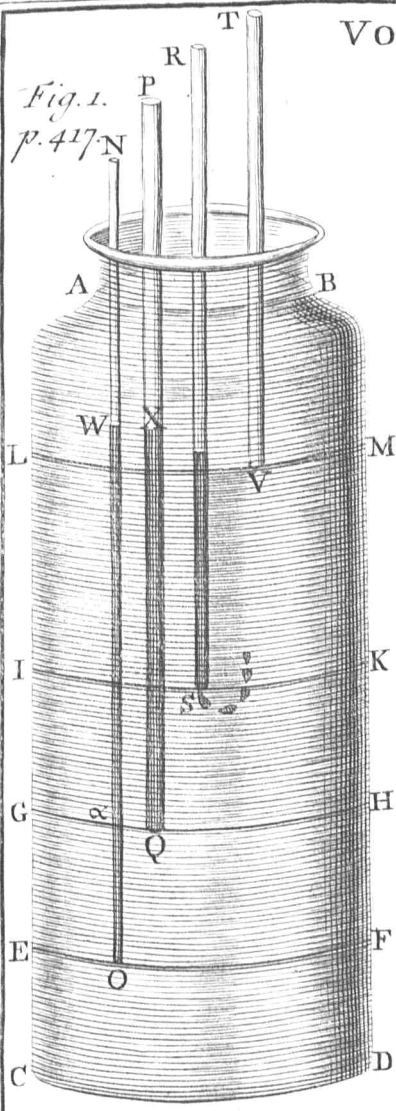


Fig. 2. p. 421.

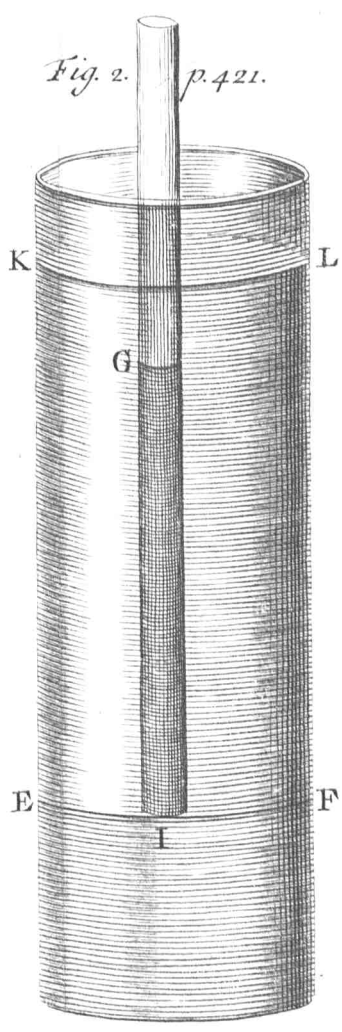


Fig. 3. p. 421.

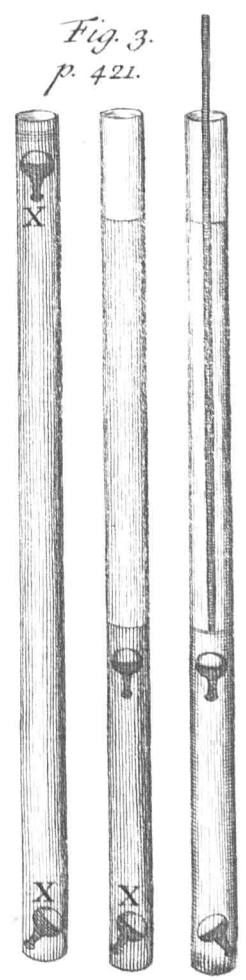


Fig. 4. p. 423.

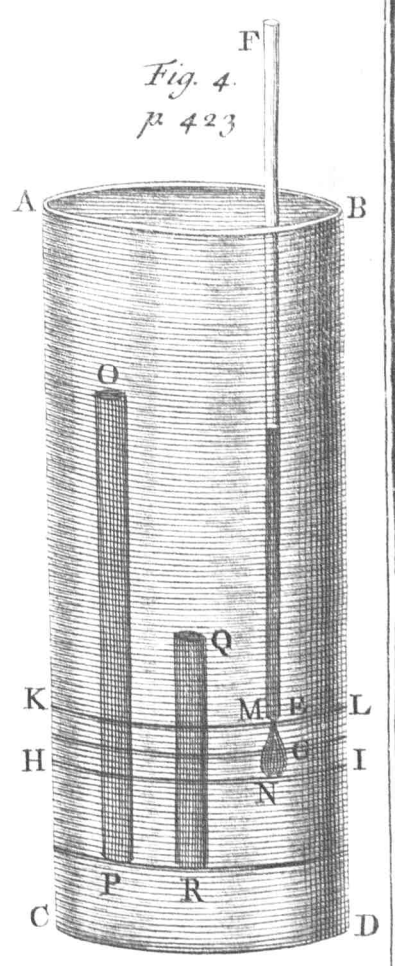


Fig. 5. p. 425.

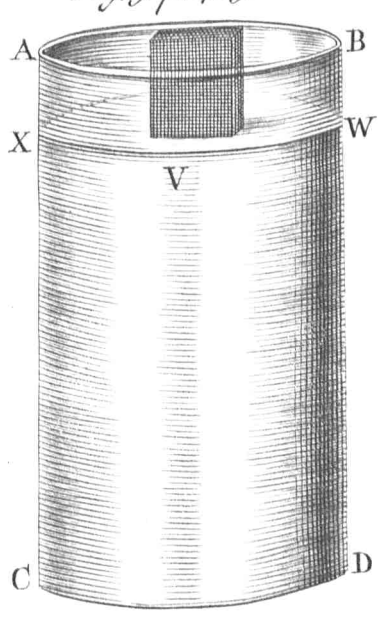


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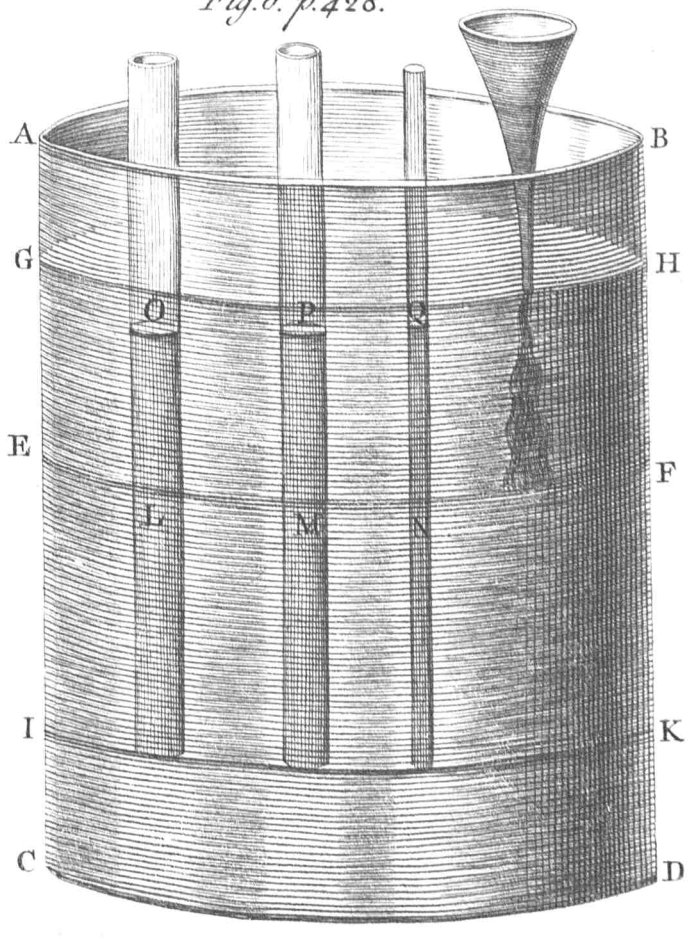


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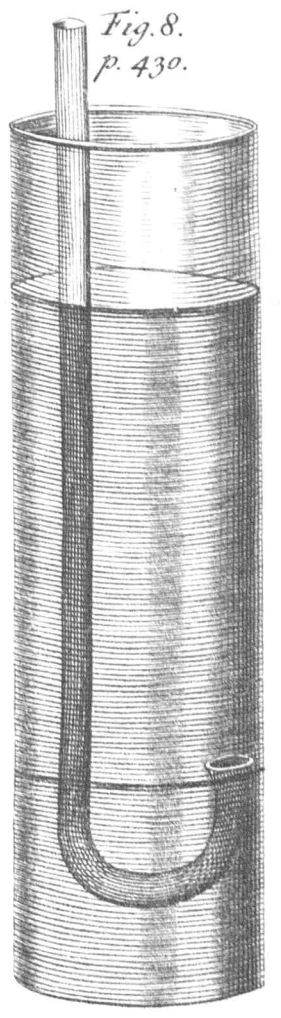


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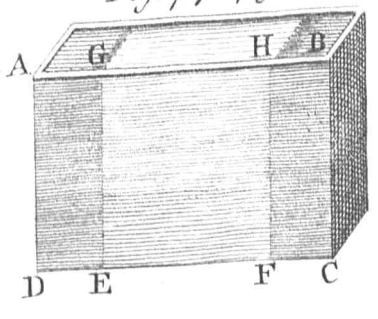


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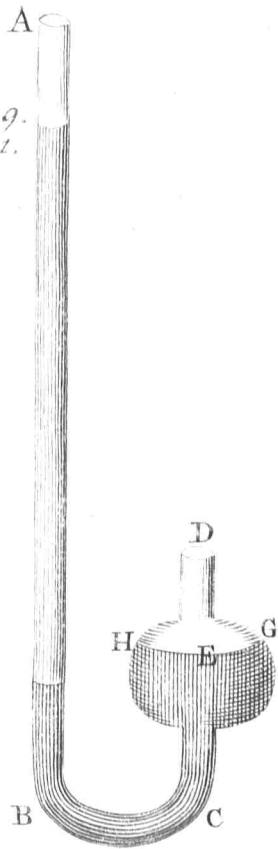


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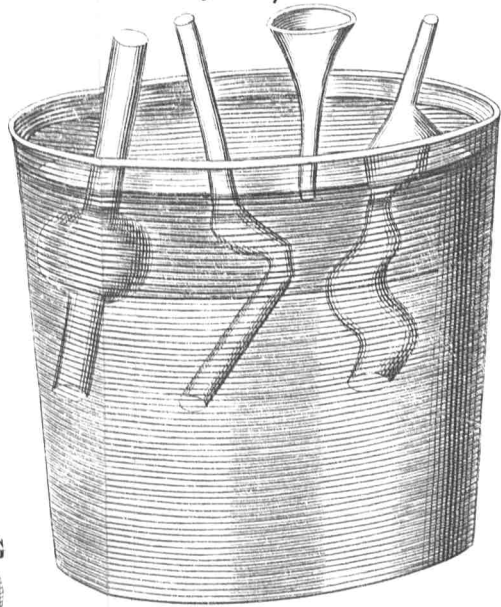


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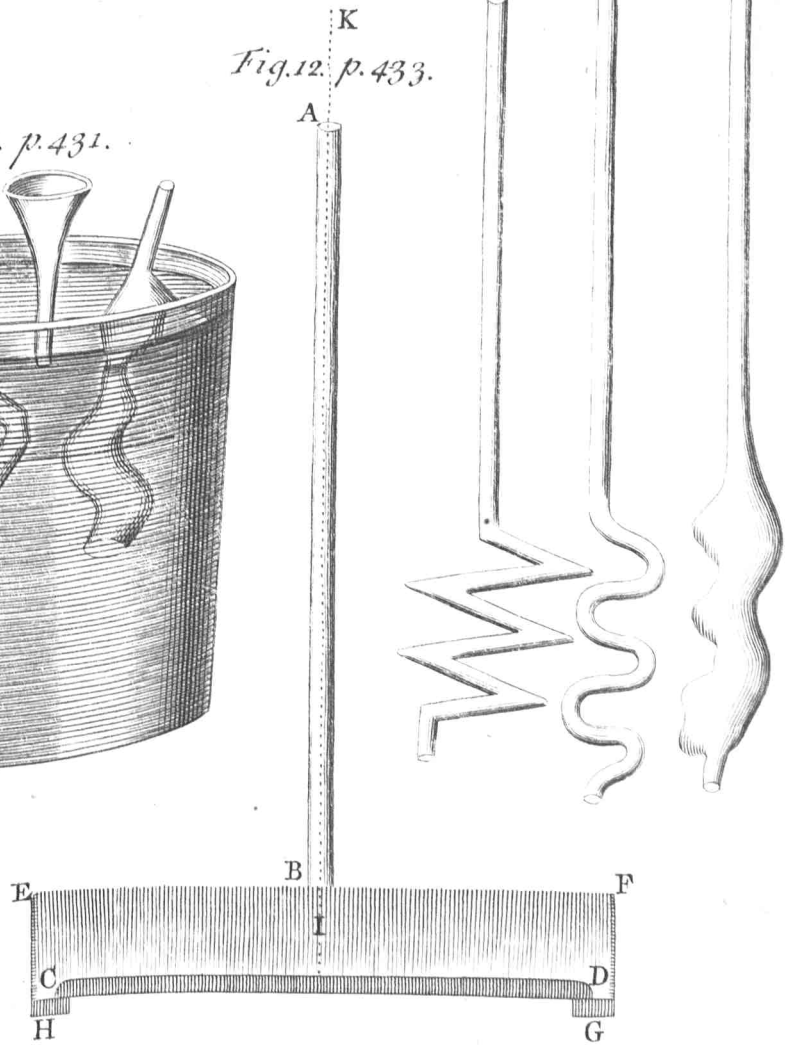


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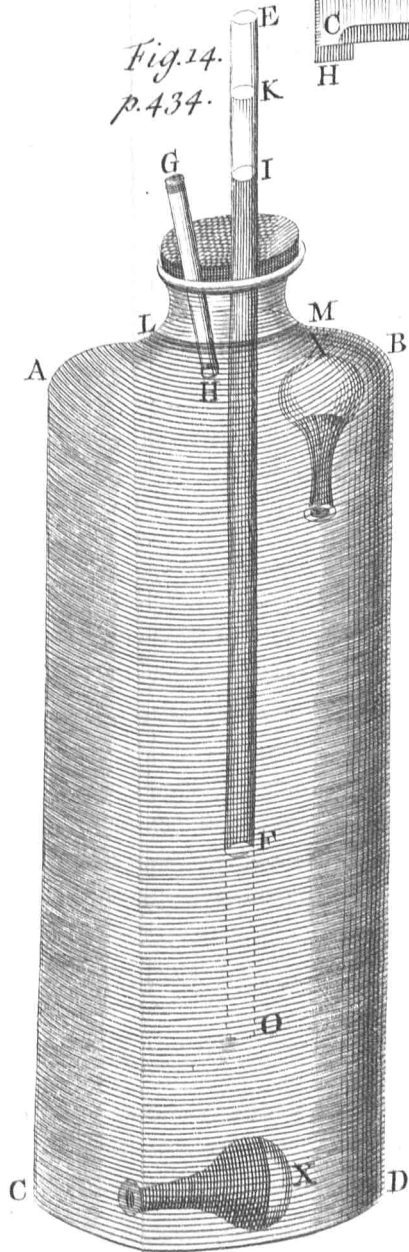


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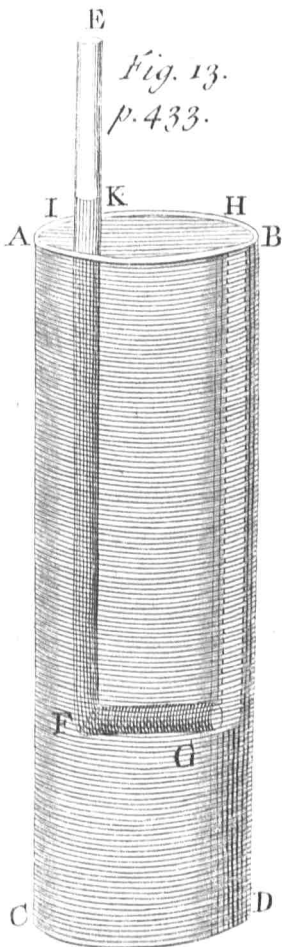


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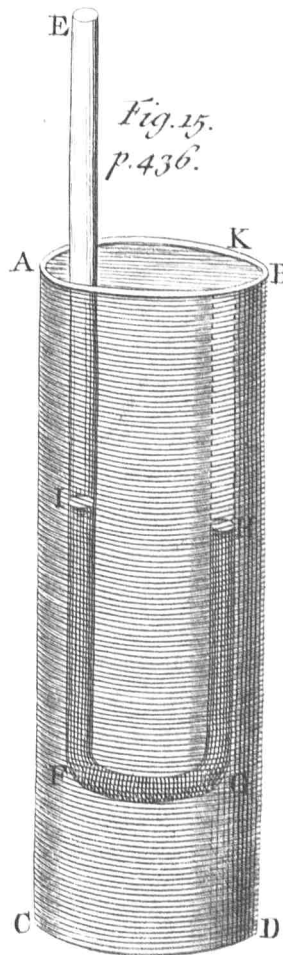


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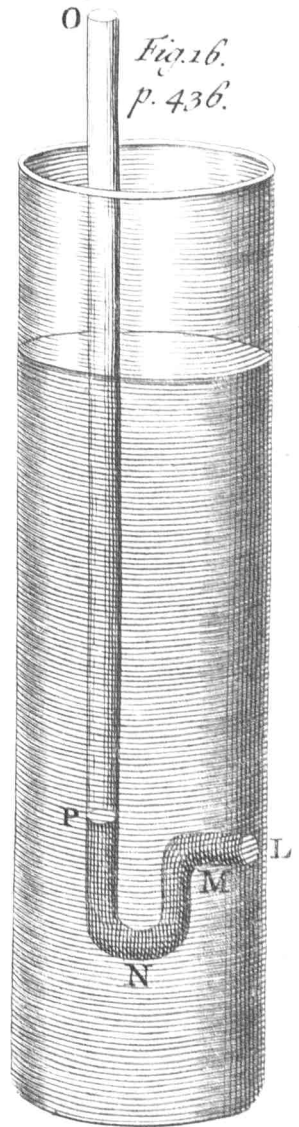


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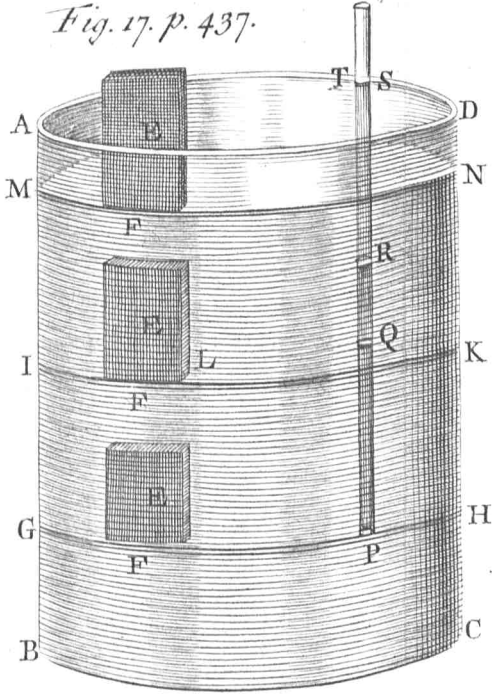


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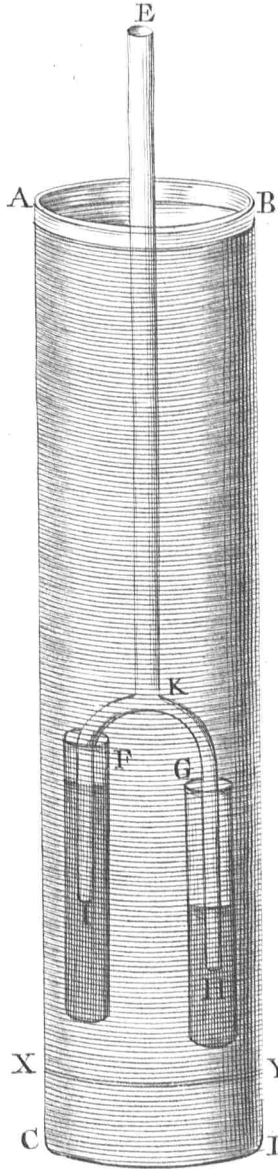


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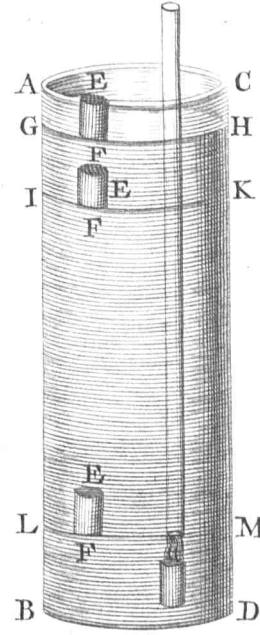


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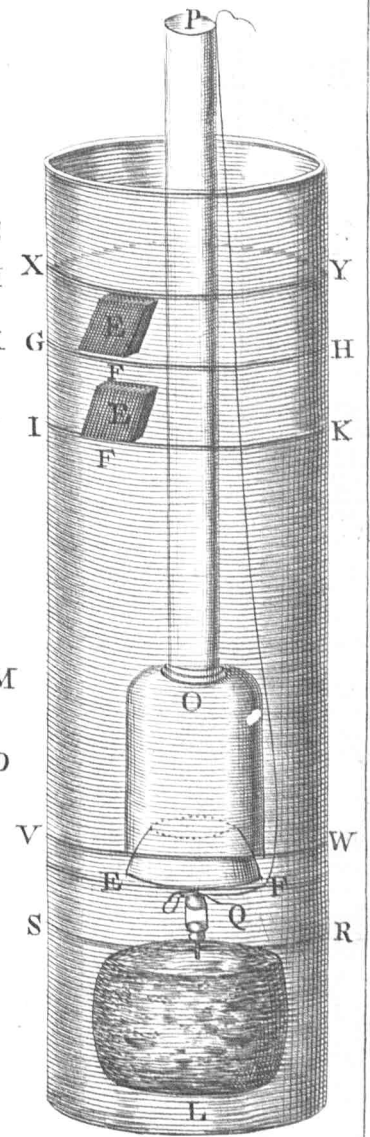


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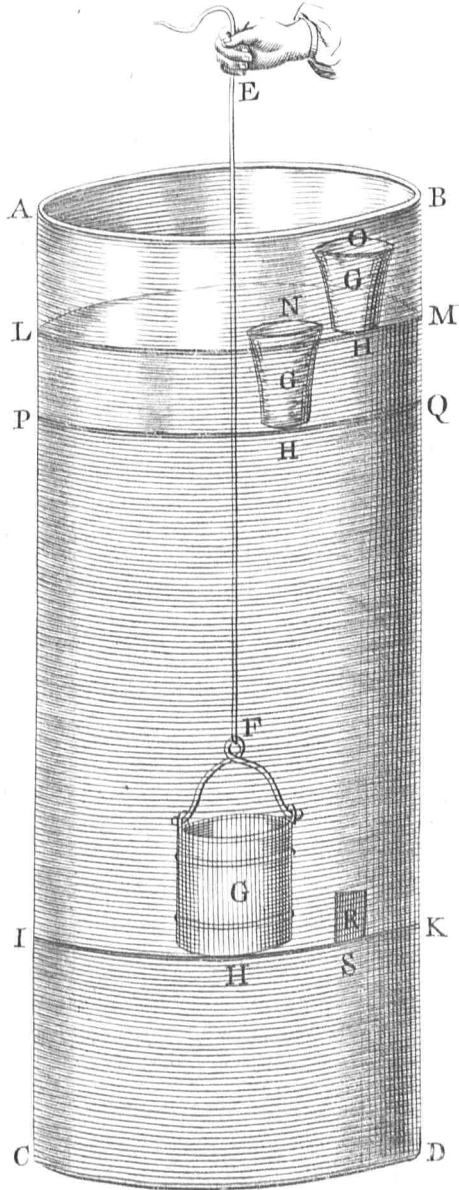


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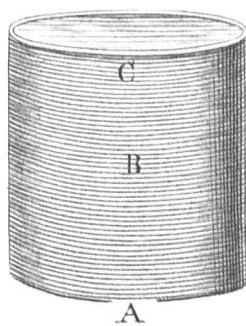


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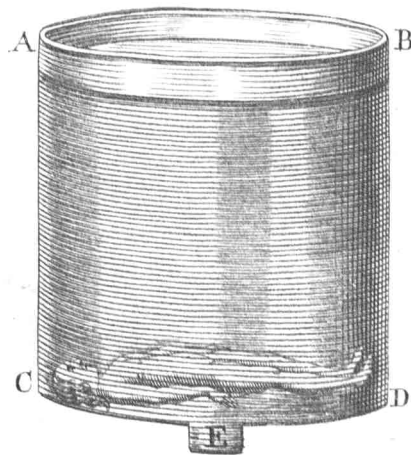


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