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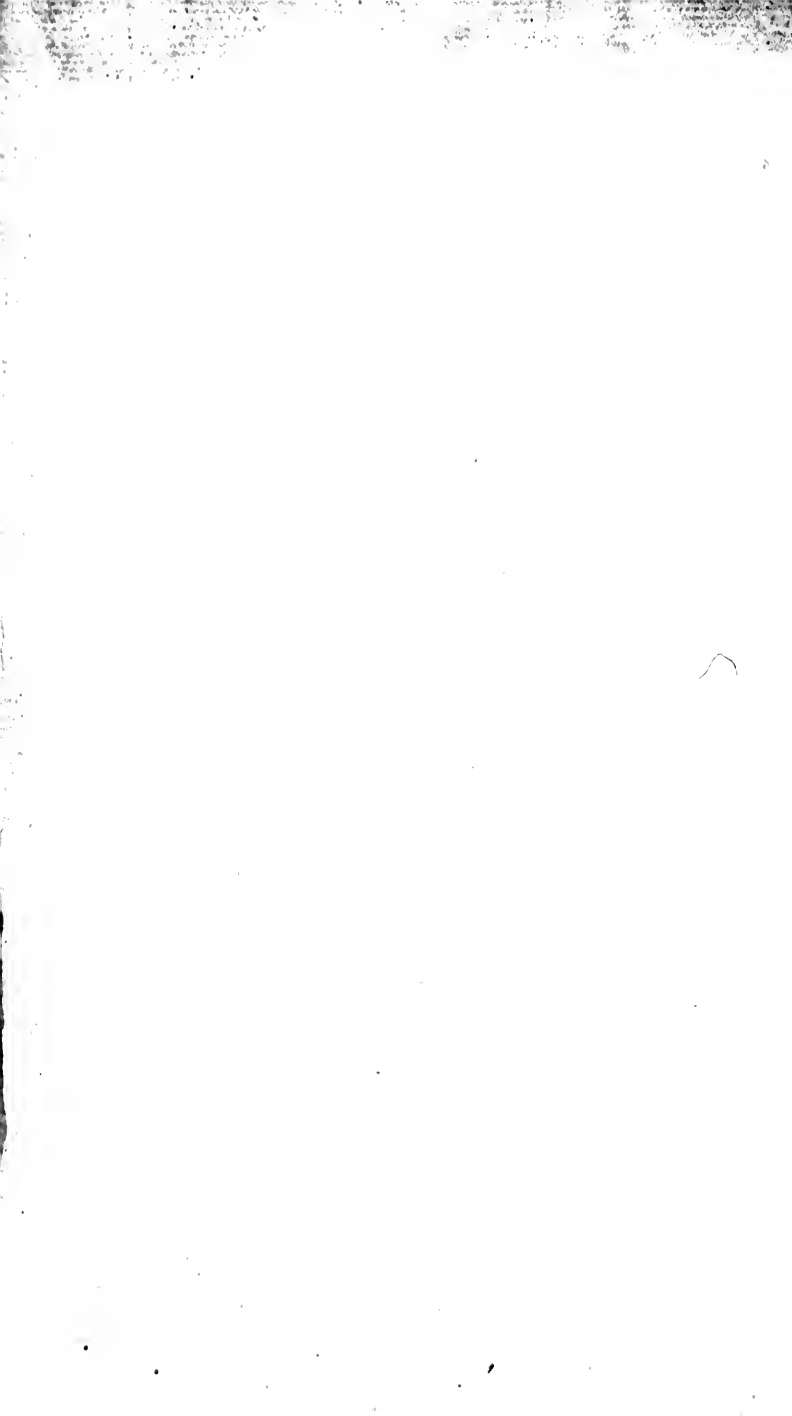
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|   |  | III. In the most amazing Structure of the HEAVENS, with all their Furniture. |

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The THIRD and LAST VOLUME.

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Throughout which, all the late DISCOVERIES in *Anatomy*, *Philosophy* and *Astronomy*, together with the various Experiments made use of to illustrate the same, are most copiously handled by that Learned *Mathematician*, Dr. NIEUWENTYT.

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Translated from the Original,

By JOHN CHAMBERLAYNE, Esq; F. R. S.

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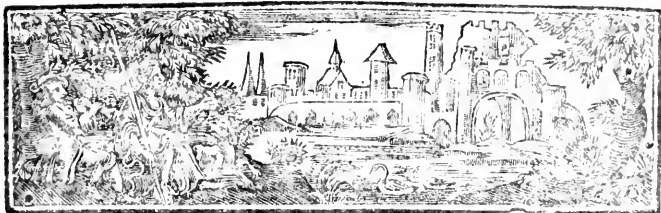
The THIRD EDITION.

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L O N D O N :

Printed by *W. Bowyer* for *J. Senex*, at the *Globe* in *Fleet-street*,  
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Or, the Right USE of the  
*Contemplation of the Works of  
the Creator, &c.*

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V O L. III.

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C O N T E M P L A T I O N XXIV.  
*Of the Visible HEAVENS.*

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S E C T. I. *Transition to the World in General, and  
to the Heavenly Bodies in Particular.*



O ascend now to that wonderful Structure of the glorious HEAVENS, and to shew from thence in a most convincing Manner; to all such as still doubt whether there be a Creator and Ruler of the Universe; there should seem nothing more to be required, than to lift up our Eyes, and only to

Contemplate the Firmament without Prejudice, and therein the incredible Greatness of that unmeasurable Space, and of the Lights that are placed in it; and besides, the wonderful Splendor of them all, the particular Influences which the Sun and Moon, among others, have upon our Globe, their unspeakable swift Motions, hardly to be comprehended by human Imagination; and in the whole, the just and exact Observation of so many Laws and Ways to which such a number of Bodies have been subject for so many Ages, through such vast and unknown Spaces, and with such a terrible swift Motion as far exceeds that of a Cannon Bullet, and without being in the leastwise conscious thereof themselves: And this ought certainly to make an Atheist acknowledge, in case no Adorable and Powerful Direction had place in all these matters, and these Bodies, with respect to their Magnitude and Velocity, were only moved by Chance, that they may likewise fall foul upon, or run against each other by the same Chance; and therefore that it would have been much better for him never to have been born, than to live in a continual Fear, that something like this should happen to the Earth, which is his Dwelling place.

SECT. II. *Convictions from the Sight thereof.*

AND tho' one should not carry one's Thoughts so far; let an Atheist suppose (to make use of the emphatical Proof produced by *Cicero*, in his Book of *the Nature of the Gods*) that from the Beginning of his Life he had been always shut up in the Cavern of a Mountain, in which he had seen no other Lights than little Lamps, nor no other Colours than those of disagreeable Rocks; and that he should at last, through a Crack in this Mountain,

tain, or by any other means, come to look up into the Air, and have a Sight of that Fire Ball, so full of Lustre and Beauty, the glorious Sun moving in the Heavens, and not only enlightening and warming this whole visible Globe of the Earth, but likewise rendering it fruitful; and capable of supporting both Men and Beasts; and besides all this, should see the lovely Green of Trees and Fields, and the charming Colours of such a Number of different Flowers; could he help being exceedingly surprized and amazed, and forbear thinking how unconceivably Great and Glorious the CREATOR of all these Things must be?

SECT. III. *The Sun proved to be bigger than the Earth, by the Eclipses.*

Now how strong and irrefragable a Proof soever may be drawn from the mere Contemplation of the Heavens, that it must have been a Great and Adorable CREATOR by whom these noble Bodies, and particularly the Sun, has been made, and by that means, to many Benefits and Advantages daily communicated to this our Globe; yet there is a great Error, which has hinder'd almost all Men from judging of these Matters according to Truth: It is that childish Prejudice which causes us to look upon the Sun to be a Body of the Dimensions or Breadth of about a Foot, or a Foot and a half at most.

But those who know by the Eclipses of the Moon, that the Shadow ALZ (*Tab. XX. Fig. 2.*) which the Sun DG, by shining upon one Side of the Earth, casts on the other Side, grows continually smaller from AZ to L, and runs out to a Pyramidal or Conical Figure ALZ, the Point or Vertex of which is at L, may, without knowing

much of Opticks (whereby the same is proved) quickly infer, that the Sun DG is much greater than the whole Globe of the Earth; for if the Sun were in its Diameter only as *bb* equal to the Globe of the Earth AZ, it is plain that the Shadow, being then equal at AMNZ, would be every where, or at MN, as big as at AZ, and always remain so.

And in case the Sun's Diameter were as *aa*, less than that of the Earth AZ, it is plain enough that the Shadow of the Earth would become continually larger towards PO, and farther.

So that since it appears, by undeniable Observations in the Eclipses of the Moon, that the Diameter of the Shadow at the Distance of the Moon, is not equal to that of the Earth, nor becomes bigger when farther from it, but that growing continually lesser, it makes the Pyramid ALZ, it will entirely satisfy those that understand this, that the Sun DG, is bigger than the Earth AZ.

The Knowledge of this may perhaps in some manner deliver People from the aforesaid childish Prejudice, and raising their Astonishment, at the Power of their Creator, make them consider the Sun in its true Magnitude. But this will be done much more effectually, when they know that, according to undoubted Astronomical Observations, we may safely suppose the Sun to be above a *hundred thousand times* bigger than the Earth. I know very well that this will appear altogether incredible to those that are unexperienced in Astronomy; 1<sup>st</sup>, Because the Ancients have not allowed the Sun to be more than 166 times bigger than the Earth, and some not so much. 2<sup>dly</sup>, Because the Disagreement among the Astronomers themselves, concerning the Sun's Magnitude, is the Cause that their Conclusions have little or no Weight with ignorant Persons.

To remove this stumbling Block, we shall endeavour, as far as the Brevity of this Discourse will permit, to shew the Certainty of what has been advanced, and tho' we can't easily know the exact Magnitude of the Sun, yet it will appear plain enough, that a Hundred Thousand Globes of the Earth being put together, will not be larger than the Body of the Sun. But they who know this by the Principles of Astronomy, may pass by the following Demonstration, and proceed to *Set. IV.*

SECT. IV. *The Magnitude of the SUN, proved from ASTRONOMY.*

*A Brief DEMONSTRATION of the Foundation of the Astronomical Conclusions about the MAGNITUDE of the SUN.*

THAT the *Astronomers* in their Calculations of the Bigness of the *Sun*, do proceed upon the same Principles and Foundations, as the *Geometricians* in measuring the Height of a Tower, a Hill, or the like, is obvious to all that understand any thing of Mathematicks. For which cause we may be equally certain of the Conclusions of the former, as of the latter, provided that the *Astronomers* can make their Observations as justly and accurately as the *Geometricians*.

To prove this Assertion a little more clearly :

I. They take the Semi-Diameter of the Earth **AB** (*Tab. XX. Fig. 1.*) for an *Unit*, in order to determine the Sun's Magnitude **BG**, with respect to the same.

II. They observe, after different Manners, (which we shall not here describe) the Angle  $ACB$ , which is made at the Centre of the Sun  $C$ , and takes in the half Diameter of the Earth  $AB$ . This they call the Angle of the *Parallax*, because, if we look along the Lines  $AC$  and  $BC$ , which make this Angle (and consequently from the Superficies of the Earth  $A$ , and from its Center  $B$ ) to the Center of the Sun  $C$ , the said Center  $C$ , seems to cover the Point  $I$ , to those that look at it from  $A$ , and the Point  $F$  in the Heavens  $KL$ , to such as look at the same from  $B$ . This *Difference of Sight* they call the *Parallax*; and forasmuch as the Angle  $ABC$  is thereby determin'd, they are us'd, for Brevity sake, to call this Angle the *Parallax*: And when they have found this Angle  $ACB$  at any Height of the Sun above the Horizon, they compute how much it amounts to when the Center of the Sun  $C$  is in the Horizon  $AI$ ; and this they call the *Horizontal Parallax*.

III. This Angle was first observed from the Antients down to *Tycho Brabé*, to be about \_\_\_\_\_ } 03 Min. 00 Sec.

But by *Longomontanus*, a Disciple of *Tycho Brabé*, reduced to } 02 Min. 40 Sec.

And lastly, By *Kepler*, after various Observations, farther reduced to \_\_\_\_\_ } 01 Min. 00 Sec.

IV. Afterwards another Method of Observation being found out, which was not liable to so great Mistakes as the former, to wit, by the Moon's Distance; *Ricciolus* has found, that the aforesaid Angle does not exceed 30 Sec. or half a Minute.

And this is also counted a great Concession, since, according to Mr. *Whiston*, it does not exceed



ceed 25 Seconds, 10 Thirds. And *Wendelinus* brings it yet down to 15 Seconds.

V. There is another Method brought into Practice by *Monfieur Caffini*, and *Monfieur De la Hire* in France, by *Mr. Flamstead* in England, and other great Men elsewhere; to wit, by Telescopes arm'd with *Micrometers*, whereby, without any Danger of falling into so many Mistakes, the said Angle *ACB* may be observ'd with the utmost Exactness, in case it can bear, by reason of its Smallness, any Determination by us that dwell upon the Earth.

From whence the said Angle is computed by *Flamstead*, (vid. *Whiston. Præleſ. Phyf. Mathem.* p. 276.) by *Cassini*, (vid. *La Hire's Tab. Astron.* p. 8.) by *Sir Isaac Newton*, (vid. *Gregory Astron.* p. 336.) to amount to but 10 Seconds.

VI. From all which 'tis plain, that in Proportion, as the Means have become more certain, and the Instruments of measuring more exact, it has been observ'd, that the Angle *ACB* of the Parallax of the Sun, has constantly grown less and less.

And therefore that these abovemention'd Differences, that have occur'd among the Astronomers, have only proceeded from the Moderns using better Methods, and more exact Instruments than the Antients; but they are by no means to be accounted Disagreements, as some unskilful Persons have called them, since the Antients have only shown thereby how far they had attain'd, and the Moderns, how much farther: And this is the more remarkable, because the said Differences have only been found between the Antients and the Moderns; but so far as they occur between Antients and Antients, and Moderns and Moderns, that have made use of the same Methods and Instruments, they are hardly worth the naming.

VII. Now to proceed. Since Astronomers have found in the Triangle ABC the Side AB or the Semidiameter of the Earth, with the Angle of the Horizontal Parallax of the Sun ACB; and knowing that the Angle BAC is a right, when the Center of the Sun C is in the visible Horizon AI, they have found in this Triangle, two Angles and one Side; wherefore by Trigonometry, they may find out the Line BC, or the Distance of the Sun from the Earth.

VIII. Now this Distance BC of the Sun from the Earth being known, which is likewise one Side of the Triangle BDC, they still seek for two Angles in the same, they being here necessary to compute the Semidiameter of the Sun DC.

IX. To find this, they observe with their Instruments (which, by the way, exceed very much in Exactness those of the Antients) the Angle DBG, containing the whole visible Breadth of the Sun, and this they term the *Apparent Diameter* of the Sun.

The half whereof is the Angle DBC, or the *Apparent Semidiameter* of the Sun, so called, because it contains the half of its Diameter.

X. There has not occur'd, in the Course of Ages, so great a Difference in this Observation as in that of the *Parallax*; as will appear from the Computation of the following Observers: when the Sun is in its middle Distance, that is, between the farthest from, and nearest to the Earth the apparent Diameter of the Sun, or the Angle DBG is computed by

<i>Ptolemy</i> , to be	—	—	31 Min. 20 Sec.
<i>Copernicus</i> , at about	—	—	32 Min. 45 Sec.
<i>Tycho</i> and <i>Longomontanus</i>			31 Min. ———
			<i>Ricciolus</i>

<i>Ricciolus</i>	—————	-----	31 Min. 56 Sec.
<i>Huygens</i>	—————	—————	30 Min. 30 Sec.
<i>Newton</i> , who much approves the Observation of <i>Cassini</i> and <i>Flaustead</i>	—————	-----	} 32 Min. 15 Sec.
<i>La Hire</i> , about	—————	-----	

XI. So that the highest Computation of the apparent Diameter amounts to 32 *Min.* 45 *Sec.* and the lowest being but 30 *Min.* and 30 *Sec.* the Difference is no more than 2 *Min.* 15 *Sec.* the half of which being taken for the Angle *DBC*, produces only a Difference of 1  $\frac{1}{8}$  *Min.* that is, about  $\frac{1}{15}$  Part of the whole.

XII. Whereas the greatest Parallax being of 3 *Min.* and the smallest but of 6 *Sec.* the former is above 30 Times bigger than the latter, as we have shewn above by *Numb.* III, IV, V.

XIII. And from hence it is manifest, that the Variety of the Observations, in the apparent Diameters, may produce some, tho' but a very small Difference; but in the Angle of the Parallax, it will occasion a very great one in the Magnitude of the Sun.

XIV. Finally, forasmuch now that in the Triangle *DBC*, is found the before-given Side *BC*, or the Distance of the Earth, and the half apparent Diameter of the Sun, or the Angle *DBC*; and moreover, the Angle *BDC* being a Right Angle, because the Line *BD* touches the Circle *DOG* at *D*; it follows, that in the said Triangle *DBC*, there are found two Angles on one Side, whereby the third, *DC*, or the sought-for Semi-diameter of the Sun may be found.

XV. We might now, after this manner, from these and the preceding Concessions, compute, first the Distance of the Sun from the Earth *BC*, and afterwards the Bigness of its Diameter *DC*.

But

But since our View here is only to shew the Magnitude of the Sun, and the Difference thereupon between the Old and Modern Astronomers, but not so much to enter into any Discussion of the Distance thereof, we shall make use of a more concise Method, which is nevertheless attended with a Mathematical Certainty, and will be obvious to such as are experienced in Geometry.

And this consists in the following Proportion, or Rule of Three; in which we shall use the Angles ACB and DCB in the stead of their Sines, which indeed will be most agreeable to Geometrical Exactness; but because there results no considerable Difference from it, and yet the Calculation is much more convenient, we shall use it as other Astronomers have done. And thus it proceeds:

*As the Angle ACB, or, the Horizontal Parallax of the Sun, is, to The Angle DCB, or the apparent Semidiameter thereof; so is The Earth's Semidiameter AB, to The Sun's real Semidiameter DC.*

And this Rule does not only obtain with respect to the Sun, but likewise to all other Heavenly Bodies whatsoever.

XVI. So that according to Tycho, taking the Parallax 3 Minutes and the half apparent Diameter $15\frac{1}{2}$ Min. the Semidiameter of the Sun is greater than that of the Earth AB, —————	}	$5\frac{1}{8}$ times.
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And these Numbers being cubed, (forasmuch as Spherical Bodies are to each other as the Cubes of their Semidiameters) the Sun is bigger than the Earth	}	128 times.
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XVII. Ac-

XVII. According to *Ricciolus* the Parallax 30 Seconds, is to the apparent Semidiameter 15 Min. 58 Sec. as 30 to 958 Seconds, or 1 to  $31\frac{1}{3}$ ; and consequently the Semidiameter of the Sun DC is greater than that of the Earth AB.

$31\frac{1}{3}$  times.

This being multiply'd cubically, makes the Globe of the Sun bigger than that of the Earth above

31000 times.

XVIII. According to *Sir Isaac Newton*, the Parallax 10 Sec. is to the apparent Semidiameter  $16\frac{1}{8}$  Min. as 10 Seconds to  $967\frac{1}{2}$  Seconds; and consequently the Sun's Semidiameter is bigger than the Earth's

$96\frac{3}{4}$  times.

And this being multiply'd cubically, the Body of the Sun exceeds that of the Earth about

900,000 times.

XIX. Finally *la Hire's* Proportion requiring 6 Second. Parallax, they are 16 Min.  $5\frac{1}{2}$  Sec. apparent Semidiameter, as 6 Sec. to 965 Sec. or 1 to  $160\frac{1}{3}$ ; accordingly the Semidiameter of the Sun is greater than that of the Earth

160 times.

And by cubing this Number, it appears that the Sun exceeds the Earth's Magnitude, at least

4,000,000 times.

XX. From

XX. From all which compared with one another we may gather,

*First*, That the Semidiameters of the Sun have increas'd from full Five, or hardly Six; first to full 31, afterwards to full 96, and lastly, to 160 Semidiameters of the Earth; which, to those that are not much vers'd in these Matters, since the Numbers are not great, may seem probable enough.

*Secondly*, But that the Globe of the Sun itself should grow from hardly 140 Magnitudes of the Earth, first, to 31000, and afterwards on a sudden to 900,000, and lastly, to the Size of four Millions of Times greater than the Globe of the Earth, is such a surprizing thing, that they who are not used to these kinds of Calculations, must needs judge it impossible, and think that altho' all that has been said about the Semidiameters were true, yet this would appear a Mistake in Astronomy: But every one that understands Geometry, knows that one is as sure as the other.

So that we now see finally, that this Increase and Difference of the Sun's Magnitude, manifesting it self in the Sequel of Time, was principally and mostly occasion'd by the continual Diminution of the Angle of the Parallax, since the small Diversity in the apparent Semidiameters might indeed contribute something, but yet very little thereto. But its amazing Magnitude is now particularly to be ascribed to the Cubical Multiplication of the real Semidiameter thereof.

XXI. Since therefore all that has been advanced, carries along with it a Mathematical Certainty in the manner of computing, it remains only to be inquired, whether the latest Astronomers have likewise rightly observed that the Angle of the Parallax is so small, which we shall leave to the Study of those that think themselves concern'd

cern'd therein; forasmuch as the comparing the three Ways that were in Use from the Times of the Antients, to *Tycho Brabé*, and from him in the last Age by *Ricciolus*, *Wendelinus*, and others, and now by Messieurs *Cassini*, *Flamsteed*, and *La Hire*, would prove too great a Digression, and take up too much room here.

This is certainly true, and obvious to all that understand the Science of Astronomy, that the Antients, according to their own Confession, could hardly be certain to a Minute in their Observations of the Heavenly Bodies, even with their largest Instruments; and that the following Methods have had great Advantages above the former, both in proceeding more certainly, and in coming much nearer; because that the Angle, which was necessary to them for computing the Sun's Distance, was so much greater, comprising the whole Space between the Moon and the Earth, which is about sixty Times as large as the Semi-diameter of the Earth, of which the Antients were obliged to make use, which renders the Mistakes of the latter in their Observations so much less than those of the former. But the Moderns, by the help of their Telescopes and Micrometers, seem to have brought this Science of Astronomy to as great a Perfection as it is possible for Men to do, making the Firmament itself serve them for a Quadrant, by the means of the aforementioned Instruments and proper Pendulum-Clocks; and so, with no less Certainty than the former, they are able to make their Observations to a few Seconds.

SECT. V. *It may be shewn, with sufficient Certainty that the Sun is above 100,000 Times bigger than the Earth.*

BUT if the Parallax of the Sun does still remain immensurable to those Observers that can measure every thing with so much Exactness, especially if they endeavour to measure that of the neighbouring Planets, *Mars* and *Venus*, which (if their Distance also do not hinder) have Parallaxes much greater and more capable of Observation, and thence make their Calculation of the Parallax of the Sun and Planets, (the Ratio whereof is better and sufficiently known to them) it may be inferr'd, that it consists of a very few Seconds or less, if they observe and discover it after this Manner. And therefore that we may conclude upon just and true Principles, that altho' these Magnitudes which the present Astronomers do ascribe to the Sun, can't be so nicely determin'd, by reason of the Smallness of the Parallax (as all of 'em, even the chiefest, allow, and whereof I could produce many Proofs) nevertheless the same must be unconceivably great. And in case we should not admit of the 160 Semidiameters of *La Hire*, and consequently of the Magnitude of the Sun above four Hundred Thousand times bigger than the Earth, yet we can't think those of Mr. *Huygens* so much to exceed the Truth, who makes the half Diameter of the Sun equal to 110 of those of the Earth, and its Magnitude consequently 1.331,000 more than that of the Earth; which, as it is easy to compute, does require a Parallax of eight, or near nine Seconds.



Or we may come yet nearer, and take the Calculation which Sir *Isaac Newton* makes use of in his *Theory of the Moon*, which supposes the Sun's Semidiameter to be  $96\frac{3}{4}$ , and its Magnitude to be 900,000 Globes of the Earth. Yea, if we take that of *Flamsteed* and *Horrox*, of about 12 Seconds (*vid. Newton Princ. Mathem.* p. 414.) which is twice as large as Mr. *La Hire's*; we shall find yet more certainly, that no considerable Error is committed in ascribing too great a Magnitude to the Sun, tho' that includes in its Semidiameter above 80, and in its Magnitude above 500,000 times that of the Earth.

Wherefore, supposing (as we have done, *Seçt.* III.) that the Sun is 100,000 as big as the Earth, we may be sufficiently assured, that we rather make it too small than too great; since the Parallax in this Case of about 21, is at least bigger than 20 Seconds, and admitting with Sir *Isaac Newton*, the apparent Semidiameter to be  $16\frac{1}{8}$  Minutes, we find the Sun's real Semidiameter to be barely  $46\frac{1}{2}$ . And that no Error is committed here in allowing too much to the Sun, as appears from hence, That the Observations (as Sir *Isaac* himself owns in the Place above) of *Kepler*, *Ricciolus* and *Wendelinus* don't allow the Parallax to be much greater than 20 Seconds; tho' they have not us'd the accurate Method of *Cassini* in their Observations, which renders this Parallax yet much smaller.

Again, because (as appears by *Seçt.* IV.) *Wendelinus* himself, after his Method, makes it 15 Seconds, which is so much less than 20.

Lastly, The Testimony of the so often prais'd Sir *Isaac Newton*, is of great Weight in this Place, who making the Parallax to be 20 Seconds, says, That he chooses rather upon that Occasion to make it too big than too little; whereby he does  
not

not obscurely insinuate, that the same ought really to be taken something smaller.

From whence then it again follows, that the Disagreement between the first and the last Astronomers does not prejudice the Truth of the Conclusions of the latter, about the determining the Sun's Magnitude; and that it is not too great a Concession to allow it to be at least 100,000 times as big as the Earth.

SECT. VI. *Convictions from the foregoing Observations.*

TO resume then the Thread of our Discourse: Can it now be imagined that such a dreadful Globe of Fire, which is above 100,000 times bigger than our Earth (and one might more truly say above a Million of times, according to the aforesaid Demonstration) has been produced by mere Chance, and for so many Ages continued to discharge those great Functions, of which all the Inhabitants of the Earth are daily sensible? And can any one persuade himself that a Sea of Fire, of so astonishing an Extent, could have been contained within its Bounds, and in the Order and State we find it in, without the continual Direction of a great and wonderful Power and Wisdom? Whereas there is no Matter known to Mankind, which with respect to us operates with more Fury, and, if it be in any Quantity, more ungovernable than Fire, of which there comes down to us daily (as the Burning-Glasses prove) so much from the Sun, either in, or with the Light thereof. And ought not the *Hypothesis*, that Chance, (or something else that is entirely ignorant of its own Actions, is the productive Cause of the Sun) makes every one, even as the boldest Atheist himself, live in a perpetual Fear that by so continual a Motion and Raging of such an  
uncon-

unconceivably great Quantity of Fire and inflamed Particles, or sometime or other, by the Descent of a much greater Quantity at once of this Matter from the Sun, along the same Way in which its Rays proceed at present, every thing might be set on Fire on the whole Globe; or that the Sun having consumed the Food of that Fire, might change its Nature, and cease to communicate its Warmth and Light to us; by which Means the whole Earth would be turned into the most dismal Dungeon that any one can possibly conceive. How much more easy then and happy do these Men live, who acknowledging the Maker thereof for an Almighty God, and their Gracious Benefactor, know that every thing, and even this dreadful Globe itself, of Light and Fire, can only stir and move according to the Good Pleasure of him that is the Lover of Mankind; and who, to deliver us from such a well-grounded Apprehension, has declared expressly in his holy Word, *Gen. viii. 22.* That *while the Earth remaineth, Seed-time and Harvest, and Cold and Heat, and Summer and Winter, and Day and Night shall not cease*; which Promise has been made good for so many thousand Years.

SECT. VII. *The Sun's Distance from the Earth.*

Now if we pass on from the Magnitude of the Sun (of which I hope those that understand what has been already said are fully convinced) to its Distance from the Earth, to the end that we may likewise therein rectify those mistaken Notions, which even from our Chiklish Years we have conceived about it, and which we can scarce fancy to be more than the Space of a Mile from us, an unlearned and unexperienced Person will not be less astonished than he was before, when he hears

us declaring, that we do not make too large an Allowance for the Sun's Distance, if we maintain for a certainty, that it amounts to above 1000 Semidiameters, or half Thickneſſes of the Earth.

That the Sun is very far from this Globe may be proved by the Sun-Dials and otherwise, which we ſhall now paſs by, only ſhewing, as we have done before in *Seſt.* IV. that the Diſagreement of Astronomy, with reſpect to the various Diſtances of the Sun, are only occaſioned from hence, that the Moderns are furniſhed with ſo much better Instruments or Methods for obſerving the Sun's *Parallax* than the Ancients; ſo that the ſmaller this continually appears to be, ſo much the greater is the Sun's Diſtance from the Earth.

To ſet this Matter in a clearer Light, for the Benefit of thoſe that are not ſkill'd in Astronomy.

Let the Semidiameter of the Earth, AB, *Tab.* XX. *Fig.* 3. (as in *Seſt.* IV. *Numb.* VII.) be taken for an Unit, the Angle of the *Horizontal Parallax* of the Sun ACB in the Triangle ABCA, being likewise known by Observations: Then, ſince BAC is a Right Angle, the Diſtance of the Sun from the Earth, or from the Line BC, may be eaſily found by Right-lin'd Trigonometry: This Operation will be readily perform'd by ſuch as only underſtand that Way of Computing.

*Suppoſing then ACB to be the Angle of the Parallax:*

With <i>Tycho Brabé</i> of three Minutes,	}	1150
we find the Diſtance BC conſiſt of Semidiameters of the Earth to the Num-		
ber of — — —		

With *Ricciolus* of 30 Seconds, barely — 7000

With

With *Newton, Cassini, &c.* of 10 Se- }  
conds BC is full ——— ——— } 20,000

With *Huygens* between 8 and 9 Se- }  
conds, ——— ——— ——— } 24,000

And with *La Hire* of but 6 Seconds, }  
to full ——— ——— } 34,000

And if (as has been done before) we }  
suppose the Sun to be a 100,000 times }  
bigger than the Earth, the Parallax }  
ACB will be about 20 Seconds (com- }  
puting the apparent Semidiameter of the }  
Sun to be  $32\frac{1}{4}$  Minutes) and the Di- }  
stance from the Sun to the Earth will }  
amount to Semidiameters thereof, ——— } 10,000

Now since we can be assured from the so exact Observations of the greatest Modern Astronomers, that the Parallax ACB is not more than of 20 Minutes, we may conclude with the same Confidence as a Geometrician can measure the Distance of any two Places on the Earth, not indeed how great the true Magnitude of the Sun, and how far its Distance is from us; but it may be concluded by a Geometrical Certainty, beyond all manner of doubting :

*First*, That the Sun is *one hundred thousand* times as big as the Earth.

And, *Secondly*, That its Distance from us is not less than *ten thousand Semidiameters* of the Earth.

S E C T. VIII. *Convictions from the foregoing Observations.*

NOW since it is indisputably true, that if the Sun had been placed much nearer to the Earth than we find it, nothing less could have been expected than a Total Conflagration thereof; and in case it had been much more remote, the Earth would have refused to produce its Fruits for the Support of those that dwell upon it. Can any one imagine again, that it is without Design, that this great and terrible Fire among so many numberless Places that it might have possessed in the great Space of the Universe, with respect to the Earth, should be fixed just there only, where it can cause so much Good and so little Harm to this Globe? Now if so unhappy a Philosopher (who maintains that the Sun has by meer Chance only acquired just that Place which is so useful and advantageous to the Earth, and all that is upon it) be a Mathematician, let him compute how many Places (in which the Sun might have been put by the same Chance) are to be found in the vast Convex of the Starry Heavens, and how many thousand to one it would have been, but that the Sun might have been fixed in some one of them, where it would have been entirely usefess to the Earth.

S E C T. IX. *The Earth for Conveniency sake supposed to stand still.*

THIS seemed to be sufficient to serve for a Conviction to such as still doubted of the Wisdom of the Maker. But since Custom, that seems to cloud our Reason with Stupidity and Insensibility, causes most Men to look upon this surprizing Wonder like the Beasts without Attention, we must

must advise all those who still find themselves but little affected by the common Notices of what they see daily pass in the Sun, briefly to contemplate with us a few Particulars thereof, with respect to the Earth, in which (we here declare once for all, that) we design to use the same manner of Speaking and Figures that are agreeable with the Notions of *Tycho Brabé*, and are adapted to those Globes, by which a quiescent Earth and a Sun, moving about it are expressed. Those that embrace the other Hypothesis with *Copernicus*, namely, that the Earth moves about the Sun, may keep the same Meaning, and adapt it to their own Opinions, as they must do in the most, if not in all the Works of the greatest Astronomers; which, tho' they defend the Opinion of the Earth's Motion, yet in the Calculations concerning *Spherics*, or the Intersections and Angles which the Circles make, do likewise make use of the same Figures and Expressions as are founded upon the Immobility of the Earth; as is well known to those that have read their Books, and even the Writings of *Copernicus* himself.

SECT. X. *The Sun's Diurnal Motion.*

Now if any Body were to have his Dwelling upon the Globe of the Earth *p e m f*, *Tab. XVI. Fig. 1.* and would make himself and all other Men happy, would not his first Care be (in order to avoid living in perpetual Darkness) that the said Globe should be enlighten'd? Now this is performed by the Sun (for Instance) at E.

But when this is done, if the said Sun E stood always immoveably over the Point *e*, it would be there always Day, and exceeding hot; but on the contrary it would produce a perpetual Night and continual Cold at *f*, both which would be

very inconvenient; forasmuch as in the last Case, tho' the Fertility of the Earth were not thereby diminished; yet all Pleasure, and in the first Case too, our most agreeable Rest would be obstructed.

To prevent all this therefore, it seemed again necessary, that this Sun should move round the Earth in such a Circle as *ETFSE*, in order to enlighten the same, and render it fruitful on all sides, and not to stand always still against one part of it: now this happens by the same Sun's moving round the Earth every twenty four Hours.

**SECT. XI.** *The Sun's Annual Motion, Declension, and the Seasons of the Year.*

**BUT** now altho' the Sun should daily enlighten and warm the Earth, yet if it were not to move in the aforesaid Circle *ETFSE*, this ill Consequence might again be expected from it, namely, that every thing upon the Earth, within the Segment of the Circle *ef*, would be scorched by its Heat: and other Parts of the Earth upon which the Rays of the Sun fell more obliquely, would be render'd barren by Cold. Wherefore, that the greatest part of the Earth might not remain useles, 'twas requisite again, that the Sun in its Circulation should be serviceable to more parts of the Earth; and this again we see performed by the Sun, when it *recedes* or *declines* from the *Equator EF* on both sides, to *A* Northward, and to *C* Southwardly, whilst it always moves in the Circle *AYD*, which the Astronomers call the *Ecliptic*, or *Sun's Way*. In this Circle it moves daily about one Degree, or the 360<sup>th</sup> part of a Circle from *West* to *East*, whilst in the same Space of Time it circulates from *East* to *West* at an equal Distance from the *Equator EF*, of which



which circular Motions the two extream ones, AB and CD, are here described; the last of which it performs in one Day, and that in the *Ecliptic* AYD, in 365 Days, or in a Year; and it is this Diurnal Motion that produces Day and Night, and the Annual, the four Seasons of the Year; So that for Instance, 'tis Summer upon those Parts of the Earth, *a* and *g*, when the Sun is at A in its Way AYD; and Winter when the Sun is at D; and Autumn and Spring when it is upon either Side of the Globe, in the middle between A and D.

SECT. XII. *The great Use of the abovesaid Motions.*

Now by these Motions, besides the preventing those great Inconveniencies, which would surely come to pass, if one continual burning Season, or an all-congealing Cold should always prevail in the same Region of the World; we find that most of the inhabited Places of the Earth are enlightned and warmed, according to the Manner and Measure that is most agreeable to the Nature of the People and Fruits that belong to it: This Diversity of Seasons, and Distribution of Heat and Cold, being also the Cause that some Lands are disposed and adapted to produce Spices, and some particular Kinds of Fruits, and other Countries others; whilst in the mean time this general Benefit is enjoyed by all Mankind, though dispersed over the whole Face of the Earth, by the Means of Trade and Shipping, by which every Nation may abound with those Commodities that are not the natural Produce of its own Land.

SECT. XIII. *Convictions from the foregoing Observations.*

BEFORE I proceed any further, let me ask those Philosophers, who deny the Wisdom and Goodness of the Supream Director of all things, Whether upon seeing any Royal or Princely Garden, they would ever pretend to say, that no Art nor Method had been used therein by the Gardener; tho' they should observe, that in order to cause those Plants to grow, which could not bear the Coldness of the Climate, Glass-Cases, and Places with Stoves and other Conveniencies, had been prepared to make 'em enjoy as much Warmth as possible; whilst on the other Hand, Arbors and shady Places were provided for other Plants that could not bear much Heat? And whether they would not be convinced upon seeing the great Variety and ingenious Disposition of the Plants, Flowers and Fruits in such a Garden; that it was not chance, nor an ignorant Cause, but the Skill of a judicious Director, which had exerted itself in all these things, and whose Design was to cause the Master of the Garden by such a costly *Apparatus*, and by contriving so many different Degrees of Heat, to reap the Benefit of his Labour, and to enjoy the Refreshment of those Fruits which his own Climate and Air were not able to produce?

And can any one that is admitted to contemplate the Agreeableness of such a Garden, tho' he should not share in the Fruits thereof, think himself obliged to thank the Owner for his Goodness, in shewing him the Secrets of his Art, and the wonderful Uses of the Plants; and yet be no ways affected with the Goodness of the Great Creator of so glorious a Body as the Sun is; by the Warmth of which, the whole Earth is turned  
into

into a Pleasure Garden and a fine Park, as may appear in *Tab. XVI. Fig. 1.* where the Torrid Zone, *a, b, c, d,* represents the Orangery, or Place in which those Fruits that require the greatest Heats are produced; whilst others, that are contented with a more moderate, or even a cold Air, do meet with the same in the two temperate Zones, *a, g, b, b,* and *c, d, i, k,* or even farther towards the Poles in the Frigid Zones, *g, p, n,* and *i, m, k,* as far as the same remain fruitful. Thus we see, that there is not only a particular Climate appropriated to such various Sorts of Plants and Trees, but that which renders the Obligation which all Men lie under to the adorable Director of all these things still greater, is, that his bountiful Mercy does not only display therein a wonderful Wisdom even to the cloying with Pleasure those that seek for the same; but likewise, that the Fruits produced thereby seem to be made for no other Purpose, besides the Honour of the Creator, than for Medicines to Men in their Sickness, and for Food and Refreshment to those that are in Health; and in general, to render them happy in innumerable Instances, in which they are sensible of their Use and Convenience.

SECT. XIV, and XV. *The Morning and Evening Twilight.*

BESIDES what has been already shewn to be so wonderful in the Direction of the Sun in its daily and yearly Course, let an Atheist judge again, whether it is without a determinate End and Purpose, that the Rays thereof passing from the Sun, through a thicker Medium, are refracted and carried away from their rectilinear Course, in order to produce the Twilights of Evening and Morning; whereas

whereas otherwise, upon the Setting of the Sun in all Places, a bright Day would be immediately changed into a Pitch-dark Night? And it may be easily perceived, that it is so ordered on purpose to be useful to Men, the Organs of whose Sight would be very much prejudiced, if the Transition from much Light to much Darkness were made all at once: But they that would be more fully informed in this Matter, need only look back to what we have said in the 17th Contemplation about it.

That which may be farther observed here, is, with how much Reason God, to convince *Job* of the Narrowness of his Understanding, has taken a Proof thereof from this Refraction of Light in the following Words; Chap. xxxviii.  $\psi$  12. *Hast thou commanded the Morning since thy Days? And caused the Day-Spring to know his Place?* Which last Words are translated by *Pool* and others. *Do you know perfectly the Place of Twilight?*

To make this more intelligible to those that are unexperienced in Mathematicks, we have shewn above, in *Tab. XIV. Fig. 3.* that the Sun *A* being under the Horizon *EY*, and casting its Rays *AH* upon the Air at *H*, the said Rays do not proceed directly, and in a strait Line to *D*; but by being inflected, and making an Angle *AHF*, they are turned aside to *F*, and refracted or broken at *H*, and thereby produce Day-break or Twilight to those that live at *F*. Now it is known to every one by numberless Experiments, that according to the greater or lesser Thickness or Density of the Air, which varies in different Places, and in the same Place too, at different times, for many Reasons, the Refraction does likewise differ: And therefore, that the Twilight, with respect to the extreamest Parts where it is seen upon the Earth, or in the Air, cannot be determined by any Body;

dy; so that the said Question seems to carry this Meaning along with it. *Did you ever truly understand the different Thickness of the Air, both in your own and other Climates of the World, or the greater or lesser Refraction proceeding from thence, and consequently the Variations of the Morning and Evening Twilights, which are the Result thereof; or have you any Command or Direction over it?* To which Proposition no Mortal will ever be able to return any other Answer, than that this has always been mysterious and impracticable to him; to convince holy *Job* whereof, was the Design of the Almighty.

Besides what has been just now said, there may be still added these Reasons, why 'tis impossible for Men to know exactly the Place of the Twilight: *First*, Because it seems necessary to be supposed, that the Sun is encompassed with a kind of an *Atmosphere*, or Circle of Vapours (as the Earth is surrounded with Air) which upon the Account of the Sun's Nearness, does always shine, and is enlighten'd with the Fire thereof. *Secondly*, That the Sun shining upon the Particles and Vapours floating in the Air, the Rays are sent back from some of 'em, as it were from a Looking Glass by Reflection, to the People who begin already to enter into Night; both which contribute very much to the Production of the Morning and Evening Twilight: See concerning this, *Gregory's Astronomy*, p. 127. where that great Mathematician (as if he intended to corroborate our Interpretation) uses the following Expression: *For these Reasons the Bounds or Place of the Morning and Evening Twilights are not so certain: Besides which, he alledges several other Causes of this Uncertainty.*

SECT. XVI. *The Weakness of our Conceptions.*

NOW forasmuch as all the great Services which the Sun renders to Men, Beasts and Plants are not to be number'd; forasmuch as we see them daily renewed; forasmuch as if we had been blind before, or remain'd always in Darkness, we should be struck with Wonder, and, as it were, transported at the Glory of the Sun's first Appearance: I have often stood amazed, how it was possible, that not only the Atheists (who act herein according to their Principles) but likewise others that acknowledge a God, and that pretend to worship him upon other Occasions, are so little affected with all the Advantages that accrue to them from the Sun: For instance, how few are truly thankful for this great Benefit, that God causes the Sun to rise in the Morning and enlighten the World, and to set in the Evening and produce the Night, by the Shadow of the Earth, in order to give Rest to all Creatures that have been tired by the Labour of the Day; and so in other Matters.

But particularly even those who are now entirely convinced of the Magnitude of the Sun, and its great Distance from the Earth, by the Mathematical Demonstrations of the Astronomers, as well as by so many Places of the Holy Scriptures; such as *Pf. lxxiv. v. 16. Thou hast prepared the Light and the Sun.* And *Pf. cxxxvi. v. 7. To him that made great Lights;* and many others, have seen that the Spirit of God himself has appointed this great and glorious Body for a certain Proof of the infinite Power of the Maker and Ruler thereof; and yet they hardly seem to have formed a right Notion of it. Besides Custom, the Weakness of our Imagination seems to be the principal

principal Cause thereof, which is unable, as well by reason of the Smallness of many Creatures that we are forced to view with Microscopes, as because of the Greatness of these heavenly Bodies, to represent them properly to us: And tho' no Body that understands Demonstration can doubt thereof, yet every one will find how defective his Imagination is in forming just Ideas of their real Greatness or Smallness: Of this we have no Occasion to produce any Proofs; let every Man only examine himself, and see whether he does not discover within him, what many of the greatest Mathematicians are obliged, with Shame to confess, that they themselves experience concerning this Matter: See what Mr. *Huygens* says about it in his *Cosmographos*, p. 124, and 125, who, to obviate this Weakness of the Humane Imagination, endeavours to make use of another Means, to impress more strongly upon our Minds the Greatness of the Works of our adorable Creator, and of the Distance of the Sun from the Earth; shewing, that if we suppose with him, that the said Distance amounts to 12000 Diameters of the Earth (which yet is much less than what the Modern and most Accurate Astronomers do with good Reason maintain) a Bullet shot out of a great Cannon, and moving in an equal Degree of Velocity, will be 25, or at least 24 Years in passing from the Earth to the Sun.

SECT. XVII. *How much Time is required for a Cannon Bullet to pass from the Earth to the Sun.*

Now that what has been advanced by Mr. *Huygens* does not exceed the Truth, will appear:

I. Because, according to the most exact Mensuration by the *French* Mathematicians, a Degree of a Great Circle upon the Globe of the Earth amounts

amounts to 57060 *Toises* or Fathoms of six Foot; from whence it follows, that the Diameter thereof amounts to 6,538594 of the like Fathoms, according to the said Mr. *Huygens* and *Whiston* in his *Præleſt. Aſtron.* p. 13.

II. This being multiplied by 12000, the Distance of the Sun from the Earth, amounts to 78,463.128,000 of *French* Fathoms.

III. Now by the Experiments of *Mersennus*, a Cannon-Bullet advances in a Pulse, or the Second of a Minute, above a hundred of the aforeſaid Fathoms, it therefore requires 784.631,280 Seconds to paſs with the like Swiftneſs from the Earth to the Sun.

IV. This Number is ſomewhat ſmaller than 788.940,000 which are the Sum of the Seconds in Twenty-five Years, if one allows to each of 'em 365 Days and 6 Hours, as may appear by the Calculations of the ſaid Mr. *Huygens*.

SECT. XVIII. *How much Time is required for a Ship, or any Living Creature that can run Fifty Miles in a Day and a Night, to paſs from the Earth to the Sun, and Conſequents from thence.*

NOW if the Swiftneſs of a Cannon-Bullet ſhould too much dazzle any ones Imagination; let him ſuppoſe a nimble Animal, ſuch as a Horſe, a Deer, a Bird, as alſo a Ship, either of which, if they can advance Fifty Miles every Twenty-four Hours, will require at leaſt a 1000 Years, either to run, fly, or ſail, ſuch a Space, as is between the Sun and the Earth; which may be eaſily computed, if one again ſuppoſes:

I. That the Sun is diſtant from the Earth 12000 Diameters thereof.

II. That a Degree, according to a Pilot's Calculation, being fifteen *Dutch* Leagues, the Circumference



ference of the Earth will amount to 5400, and its Diameter to 1718 *Dutch* Leagues.

III. This being multiply'd with 12000, the Product of *Dutch* Leagues between the Sun and Earth, will be 21.616,000.

IV. This being divided by 50, or the Miles that a Ship will sail in a Day, or a Horse run, the Amount will be 412,320 Days, or about 1129 Years.

I thought I could not do amiss in being something the more large upon this Subject, and in shewing the Sun's Distance from the Earth after more than one manner; since Mankind are wont, upon this Occasion, to represent to themselves a Giant like a Dwarf; and the great Firmament, and those glorious Bodies which it contains, and especially the Sun, with respect to its Magnitude and Distance, incomparably smaller than they really are, and consequently make the dreadful Power of the CREATOR, contemptible instead of wonderful and infinite.

SECT. XIX. *The Swiftnes of LIGHT.*

LET the Atheist now go on with us, and contemplate that Wonder of all Wonders, that surprizing Creature the LIGHT, in its Properties only, so far as they are known to us, and in the first Place its unconceivable, and (if it had not been proved experimentally, its altogether) incredible Velocity.

It may perhaps appear strange to many, and even not to be admitted by most, if we should affirm that Light requires some Time for the Parts of it to pass successively from the Sun to us, and in that manner to be emitted from all Parts of that Glorious Body: Forasmuch as the chief Philosophers of the last Age, and many others

others of this, to whom the latest Observations of the Astronomers are not yet known, have thought, and with great Appearance of Truth too, that Light moved much after the same manner as a Stick lying between the Sun and us, whereof one End being protruded from the Sun, the other in an instant, and without any Space of Time, would be likewise moved; so that properly, and according to this Hypothesis, the Light does not come down to us from the Sun, but that which is near and about us is only put into a continual Motion by the Sun, or by the Intermediation of their suppos'd cælestial Matter. But they that are of this Opinion, will be yet much more shock'd, if we should tell them, that this Light is not only derived to us continually from the Sun, and that it requires some Time to pass to us, but even that it is protruded with so great a Swiftnes, that it does not take up more than half a Quarter of an Hour, or about  $7\frac{1}{2}$  Minutes to pass from the Sun to us, that is to say, to run so many Millions of Miles.

SECT. XX. *An Experiment to prove that Light really moves and comes from the Sun.*

AN actual Proof that Light moves, and that even when the Rays of it are collected in any Quantity, it will protrude Bodies it meets in its Course, and, as it were, blow them away, may be found in the History of the *Royal Academy of Sciences*, 1708, p. 25. where Mr. *Homburg* relates, That a Light Matter, such as the *Amianthus*, or Plume-Allum, being suddenly brought into the Focus of a Burning-Glass, upon a Wood-Coal, was driven off by the concurring Rays of Light; and that the Spring of a Watch, one End of which fasten'd in a piece of Wood, being like-  
wise

wife placed in the Focus of a Glass of twelve or thirteen Inches, the Rays struck against the loose End of it, and caused it to move backwards and forwards, just as if it had been thrust with a Stick.

Now this does undeniably prove a great Swift-ness of Light; yet this amazing Course of it, as it surpasses all Imagination, so with many would it exceed all Appearance of Truth, were it not that the ten Years Observations made by Mr. *Romer*, upon the Eclipses of *Jupiter's Satellites*, had put this Matter so much out of Dispute and Doubt, that the greatest and most accurate Mathematicians have been forced to admit it upon the Strength of those Experiments.

It shall suffice here, that we may not swell this Discourse too much, to produce only the Testimony of Sir *Isaac Newton*, tho' we could likewise add many others; these are the Words of that Gentleman in his *Princ. Philos.* p. 231. *Prop. 96. Lib. 1. in the Scholium.* *For that Light is pushed on successively, the Parts of it following each other, and that it passes from the Sun to the Earth in the Space of ten Minutes (in the second Edition he has alter'd it to seven or eight Minutes) is now certain by the Appearances of Jupiter's Satellites, and confirmed by the Observations of several Astronomers.*

And when afterwards he published his *Opticks*, which are proved and illustrated by a Number of wonderful Experiments, we find him speaking after this Manner, in the Eleventh Proposition of the Second Book of the Third Part, p. 236. *The Light is transmitted in a certain Space of Time from the illuminating Body, and employs about seven or eight Minutes in its Course from the Sun to the Earth:* Whereupon he adds the Proof, the first Words of which are, *This was first observed by Romer, and afterwards by others, by Means of the Eclipses of*

**Jupiter's Satellites:** In his second Edition of his *Opticks*, he only allows *about seven Minutes* for this Passage of the Light.

They that desire to see this more largely proved, may consult Mr. *Huygens*, in his *Treatise of Light*; Mr. *Whiston* in his *Prælect. Astronom.* and others. Besides, that the Impossibility of the contrary Hypothesis has been already shewn both by *Newton* and *Huygens*.

It is sufficient for us, since we cannot stand here to describe the Particulars of Astronomy, to shew that this has been proved to be an uncontestable and certain Argument by the most accurate Inquirers into the Nature of Light, and that the boldest Atheists have no Reason to doubt thereof, unless they understand nothing of Mathematicks, or are ignorant of the latest Discoveries about the Properties of Light; or if they would be pleased to read the aforementioned Astronomical Lectures of Mr. *Whiston*, p. 229, and 230, where the *Rectilinear* progressive Motions of the little Particles of the Light are largely handled and proved beyond all Doubt; and where he shews, according to the nicest Observations, that in half a quarter of an Hour's time, the Light passes thro' all that Space that is between the Sun and the Earth. And this being allowed, let them reflect with themselves, whether it be credible, that it is by meer Chance, and without any Direction, that Bodies protruded with such an amazing Swiftnes, can always obey so many Laws without once varying in their unconceivable Progress, as it has been observed with respect to Light upon so many Occasions; of which more hereafter.

SECT. XXI. *What would be the Consequence, if the Rays of Light should become a Solid Body, and the Parts thereof adhere to each other.*

I SHALL here add, that I have been exceedingly affected with the Consideration of the dreadful Velocity of Light, as often as I thought that if once so many Particles thereof should adhere to each other, so as to compose a little Body, weighing no more than the tenth part of a Grain, they would exert as great a Force by the Swift-ness of their Motion, in striking upon any earthly Body, as a Bullet of twelve Pound Weight shot out of a great Cannon.

Now that it is not impossible that Light should become a solid Body, seems to be proved by that Matter which we at present call a *Phosphorus*, which seems to consist altogether, or for the most part, of a combined Fire or Light; forasmuch as if we put the same into Oil of Cloves, the Light thereof cleaves to the Oil, and causes it to shine, as is known to the Chymists.

And now, that no body may think such a dreadful Force improbable, which we suppose to be in the descending Light, in the aforesaid Circumstances, let him suppose:

I. That Light passes in half a Quarter of an Hour, or 450 Seconds from the Sun to the Earth, which has been shewn above to mount to the Number of 78,463,128,000 *French Fathoms*.

II. It follows then, that this being divided by 450, the Light passes thro' 174,362,506 thereof in one Second or Pulse. Let us suppose it, for the sake of a round Number, to be just 174,362,500.

III. Now a Twelve-pounder Shot out of a Cannon is found to advance in the same time a hundred of these Fathoms.

IV. And it is manifest from the *Laws of Mechanicks* and the *Doctrine of Percussion*, that the *Force of Projectiles*, with respect to their *Course* and *Percussion*, are in the same *Proportion* to each other, as their *Weights* multiplied with the *length of the Way* which they make in the same *Time*.

Now for the sake of those that do not understand *Mathematicks*, we shall speak a little more plain, and say, that a *Bullet of six Pound*, which in a certain *Time* runs the *Distance of 200 Fathom*, has twice as much *Force*, as a *Bullet of twelve Pound*, that runs but *50 Fathoms* in the same *Time*; for 6 times 200 makes 1200, and 12 times 50 is but 600, or the half of 1200. After the same manner, a *Bullet of 12 Pound* running a *100 Fathom*, in a certain *Time*, has as much *Force* as a *Bullet of 6 Pound* that runs *200 Fathoms*; of *3 Pounds* and *400 Fathoms*; of *2 Pounds* and *600 Fathoms*, in the same *Time*, &c. forasmuch as the *Weight* of each of these *Bullets* being multiplied with the *Way* that they make in the same *Space of Time*, does always produce the like *Number of 1200*.

V. From whence we may infer, That in case an *Aggregate of Light* by its *Velocity*, does act with the same *Force* as a *Bullet of 12 Pounds*; then in order to find the *Weight of the Light* necessary thereto, this *Rule* will have *Place*.

Wherefore as the *Length of the Way* (or as *174,362,500 French Fathoms*) which the *Light* goes in the *Second of a Minute*, is to the *Length of the Way* that such a *Bullet* runs in the same *time* (or to a *100 of such Fathoms*;) so is the *12 Pound-weight of the Bullet* to the *Pounds*, or rather to the *Weight of this Body of Light*, that has the same *Force*.

VI. Working this *Question* by the *Rule of Three*, it will appear that the *Weight* which the  
Light

Light will have upon this Occasion, will be  $\frac{12}{1743625}$  of a Pound.

And supposing a Pound of 16 Ounces, to contain 7680 Grains, and those Ounces to be *Troy-Weight*, the Weight of this Body of Light will be  $\frac{92106}{1743625}$ , or about  $\frac{1}{18}$  of a Grain, as is said before.

SECT. XXII. *Convictions from thence.*

Now in order to be convinced not only of the Presence, but likewise of the Necessity of a Divine Direction, since this dreadful Swiftnes of Light is known, and since we find by Experience, in thousands of Bodies, that Light will adhere to them, and become a solid Body, and they being kindled, it will appear again; let an unhappy Infidel once more ask himself, by what Law or Necessity of Nature it happens, that this Light never comes to be turned into a little solid Body, whilst it is in the Sun, and so descend to us with its usual Celerity; since Water is converted to Hail in the Air, and the Spots in the Sun seem to represent such a Cohesion of Parts. Certainly if Chance only had Place here, we cannot give the least Reason why it should not so happen, or why a dreadful Storm of these collected and compressed Particles of Light, should not overspread the whole Earth with utter Destruction in an Instant.

I shall only observe farther, in what dismal Apprehensions the haughty Atheist is forced to live continually, on account of these and other Phænomena of Nature, which, according to their deplorable Maxims, may daily befall them; and the opposite good Fortune of those, who, relying entirely upon the gracious Providences of

the Director of all Things, know that nothing can befall, or touch them, without the Will of him who loves them as his Children.

SECT. XXIII. *Light runs in strait Lines.*

ONE of the Properties of Light is its Motion in Right Lines, from whence, according to all Experiments, the Separation between Light and Darknes is justly deduced, and so likewise are the Shadows in *Perspective*.

To give an Instance thereof: It is known that the Rays (*Tab. XX. Fig. 3.*) proceeding from the Points of the Sun, A and B, and those that lie between, if they run directly forwards according to the Lines AP and BP; do form the Cone of Shadow, or Pyramid, CDP; whereas, on the contrary, if the Light did not move in strait Lines; but in all kind of Curves, as Sounds are propagated, there would be no Darknes or Shadow where the Light could have no Access, and consequently no Separation between Light and Darknes.

SECT. XXIV. *Experiments to prove that Fire is produced by Light.*

ANOTHER Property of Light is, that it is either Fire itself, or that it carries a great deal of Fire with it; and they that have a Mind to be surprized with the Powers and irresistable Motions that do appear in this Fire, and by which it is disposed (when united in any considerable Quantity) to consume every thing in the most dreadful Manner, let them take an Occasion to view the Force of the new-invented Burning-Glasses of Messieurs *Hartsoeker* and *Tschirnhaus*, or to read the Effects thereof. Lead and Pewter of a considerable



siderable Thickness are immediately melted by the said Burning-Glasses; wet Wood will burn in an instant; Brass and Copper, and even Iron Plates, will glow and melt presently; and many People know how much time is requisite to cause hammer'd Iron to flow in the hottest melting Furnaces. Bricks, Pumice-stones, and earthen Vessels even full of Water will be dissolved and vitrified, and the Water at the same time almost boiled. *Asbestus*, or *Plume-allum*, (which, according to the Testimony of *Kircher*, will even bear the Fire of the Glass-Houses without any Alteration) as also Gold, upon which all the Powers of our common Fire have been in vain employed hitherto, (and of which mention is made above) are turned to Glass in the Focus thereof. They who desire to see a more particular Account of these Matters, may consult the *Act. Lips.* 1687. p. 52. 1688. p. 206. 1691. p. 518. and *the History of the French Academy of Sciences*.

SECT. XXV. *Convictions from hence.*

Now let an Atheist who knows from all this, that the Rays of the Sun do either consist of so devouring a Fire, or do carry a great Quantity thereof along with them; or, if he has ever observed the terrible Force thereof in its Effects; I say, let such a Man first represent to himself the almost incredible Velocity with which it comes down to us, and compare therewith the Force protruded by a little Flame of a Lamp, with which those that blow Glass do make it glow and melt, when they blow against it with any kind of Swiftnes; and then let him tell us, whether he can think, without Uneasiness, that this great *Solar* Body transmits Fire to us with so terrible a Velocity, and that it is only owing to

meer Chance that there does not come down a greater Quantity of this dreadful burning Matter, and overturn and destroy the whole Globe of the Earth with an unextinguishable Flame. And if he imagines that this Earth is secured by fixed and necessary Laws of Nature from being consumed with Fire, how can he prove that since one Day is fair, and there is scarce a Cloud to be seen in the Sky, but the next is continually rainy and stormy; may there not likewise such an Alteration happen in the Sun to morrow, whereby every thing shall be burnt and consumed? There is nothing more required to keep such an Infidel in a continual Fear (if he be true to his own Principles) than the Consideration of that Danger with which he is threaten'd every Moment, if the Light of the Sun were moved by meer Chance only, and without a wise and merciful Direction.

SECT. XXVI. *The Quantity of Light.*

Now let a Philosopher, who seeks for his unknown God in the true Disposition and Structure of the Things of this visible World, contemplate with us the amazing, and scarce conceivable *Quantity* of this *Light*, which is continually and incessantly transmitted from the Sun. We have said something upon this Subject before, when we treated of the Fire in the Air, and so far as it related to Light; but in order to be yet more fully convinced thereof, it is certain by Experience, that this Light fills our whole Air, and all that Space that is between us and the Sun at least, that, excepting the Shadows, there is no Place, tho' never so small, where it does not shew itself; [We express ourselves thus, to the end that no Body may except against the Word *fill.*]  
We

We can perceive it in the two lowest Planets *Mercury* and *Venus*; in the *Moon* which moves about the Earth; and even in the three uppermost Planets, *Mars*, *Jupiter*, and *Saturn*: From whence it is farther apparent, that the Light does sufficiently fill all those Places to which it extends itself, since wherever the Eye, or the Sun also, and those other heavenly Bodies may be placed, either the Sun itself, or its Light, which falls first upon the Planets, and is from thence reflected to us, may be seen, unless some intervening dark Bodies prevent the same.

Now if any one would examine how great that almost inconceivable Space is, which is continually filled with the Light proceeding from the Sun, (to say nothing here of the fixed Stars) let him suppose with the modern Astronomers, according to the Table by which Mr. *Huygens* made his *Automaton*, p. 447. that the Distance of the Earth from the Sun with respect to that of *Saturn* likewise from the Sun, is as 100 to 951; that is to say, *Saturn* is about  $9\frac{1}{2}$  times farther from the Sun than the Earth. Now 'tis plain enough, according to the modern Experiments, that the Distance between the Earth and the Sun amounts to about 12000 whole, or 24000 Semidiameters of the Earth, and therefore that the Distance of *Saturn* being  $9\frac{1}{2}$  times as great, it amounts to 228,000 Semidiameters of the Earth: For which Reason a Globe that would fill the Space between *Saturn* and the Sun, would contain 11,852.352,000,000,000 Globes of the Earth; these Globes being to one another as the Cubes of their Semidiameters: So that now every body that considers this almost inexpressible Number of Globes equal to that of the Earth, that are requisite to compose one only equal to the Orb of *Saturn*, will easily agree, that the Space which is filled with the Light of the  
Sun,

Sun, may be justly termed in a manner unconceivable.

But if we go farther, and in order to demonstrate the Quantity of Light, consider together with this Vastness of Space, the Swiftnes of the Light, which, as we have shewn before, passes from the Sun to us in  $7\frac{1}{2}$  Minutes, or about the eighth Part of an Hour, it will appear thereby, that it passes from the Sun to *Saturn*, or to the utmost Part of the Orb (a Sphere being described upon its Distance from the Sun as a Semidiameter) in  $9\frac{1}{2}$  times so many Minutes, that is to say, in  $1\frac{3}{4}$  Hour; at least, if it be supposed that Light moves every where with the same Degree of Velocity; for which Reason this great Orb will be emptied again in less than five quarters of an Hour, if the Light passes thus swiftly on; and therefore there must proceed such an unspeakable quantity of Light from the Sun, as shall suffice in 24 Hours to fill so great an Orb about twenty times.

SECT. XXVII. *Conviction from thence.*

NOW I leave it to an Atheist (who would not dare to maintain in the presence of wise Men that his Candle which served to Light his Chamber in the Evening, came there by Chance) to judge himself, whether this glorious Sun, this wonderful Fountain, from whence for so many thousand Years there daily flows such an unconceivable quantity of Light, can be believed by him to be produced without Wisdom; and whether all the Benefits which it continually occasions to those that inhabit the Earth, cannot demonstrate to him that a great Power (which ought justly to be dreaded by his Enemies) together with the Will as great to do Good to Mankind, had

had place in the Production of the Sun: And whether so prodigious a Body, with continual Streams of Light flowing from it, and which by its dreadful Velocity seems capable to hurry all things away with it, has been able to serve for warming and enlightning Mankind, and by fertilizing the Earth, to preserve them alive, without a wise Direction and Government, for so many Ages?

Let it not be objected here, that the Sun by constantly illuminating a Sphere as big as the Orb of *Saturn*, or bigger (since it is credible, that the Light of the Sun diffuses itself beyond *Saturn*) and filling it so often with Light, and by having lasted as many Years as the World, may seem to have almost consumed all its Light; and so if not quite wasted, yet must be greatly diminished, since that is contrary to Experience: For in answer thereto, besides that Nobody can be perfectly assured, that Light does not circulate as the Blood in Animals, and after having performed its Course, comes back to the Sun again; which *Cartesius*, probably to avoid this Objection, seems to have thought; I say besides this, the Particles of Light may also be conceived to be so very small, that notwithstanding they do so far fill this whole Orb, that the Interstices or Spaces that are between, may remain entirely unobserved by us; yet being taken all together, they may not perhaps amount to the quantity of one Grain of Sand; for which Reason there could be no Diminution perceived in the Body of the Sun in as many more Years or Ages.

Now as wonderful, and perhaps as incredible too as this may appear to many, it is nevertheless well known to the Mathematicians, that the great Space of which the Starry Heavens shou'd be supposed the upper Superficies, might be filled in such manner with corporeal Particles, that no  
one

One Ray of Light, how fine and slender soever, if it had but a determinate Magnitude, could be able to pass between the same, and consequently the said great Space would be absolutely opaque. All which corporeal Particles, if they were joyned together, would nevertheless not only not make the quantity of one little Grain of Sand, but even not of the smallest Part thereof, provided its Magnitude were likewise determinate. See Dr. Keil's *Introduction*. p. 54. and 55.

SECT. XXVIII. *The Usefulness of the Divergency of Light.*

BUT if an Atheist should consider this continual and swift Stream (as it really is) proceeding from the Sun, not only as it brings Light always with it, but likewise an actual Fire; he must be forced to confess, according to the Experiments of the Burning-Glasses, that if this Light and Fire should descend to us in such a close and compressed Body as we find it is when the Rays of it are collected in the *Focus* of the said Glasses, the whole Globe of the Earth, with every thing belonging to it, would soon be reduced to a more dreadful Glowing, than Metals put into Fusion in a Furnace. Now it is sure enough, that this fiery Light is more hot and destructive near the Sun, than in the aforesaid *Focus*; so that in order to convert the Earth into a glowing Ocean, of which one can hardly think without trembling, nothing more is required, than that the Light should come down quite to us with its Rays, as compact and close united to each other, as it really is near the Sun.

This being laid down, let him seriously weigh with himself, whether he can think it to come to pass without Wisdom and Direction, that there

is such a Motion communicated to the Rays of Light, and such a Law prescribed to them, which they have strictly obeyed hitherto for so many Ages, without once receding from 'em, tho' they themselves are entirely ignorant thereof, and whereby the Earth, and even the Universe itself have still been preserved from this all-consuming Fire. The Laws we mentioned to which Light is subject, are, that as soon as it comes from the Sun, the Rays of it are scatter'd and divided from each other, and continually more and more so, the farther they proceed in Right Lines. This the Learned express by the Term of the *Divergency* of the Rays.

Of this we have spoken before, when we treated of the Business of Vision, or Sight, and of Fire; and to avoid Repetitions, we should have passed it by here, were it not that from this Divergency or Separation of the Rays of Light, there seem'd to result a Proof, which is alone sufficient to cause an Infidel to see with indisputable Clearness, that there is a God that governs this now so beneficial and useful, but otherwise so terrible, Substance of Light and Fire, and thereby preserves from unavoidable Destruction, every thing that has Life and Being upon Earth.

SECT. XXIX. *The Properties of the Divergency of Light.*

WE shall only add the following Considerations to what has been said before upon the same Subject, to the end that those who are not versed in Opticks, and other parts of Mathematicks relating to Light, may have plainer Notions thereof: Let it be then supposed (*Tab. XXI. Fig. 2.*) that S is a Point in the Sun, from whence the Rays *S a A*, *S c E*, *S c C*, *S d D*, *S b B*, &c. in  
their

their Progress from S to A, C, D, E, continually diverge or recede from each other: Now there need not be much Pains taken to shew, that the same Rays, which at the Distance SB, fall upon the Plane Circle AECD, when they are nearer to the Sun; and for Instance, when they have proceeded no farther from it than *Sb*, are all within the Circumference of a smaller Circle *aecd*; and consequently, that the Fire of which these Rays consist, or at least which accompanies them, is so much thicker, or pressed together in the little Circle *aecd*, than in the great one AECD, as this last is bigger than the former; or to speak in the Language of the Mathematicians, the Heat which the little Circle *aecd* undergoes, is so much greater than that which the bigger Circle AECD feels from the same Rays, as the Square of the Distance of the great Circle, or of SB or SA, &c. is greater than the Square of the Distance of the little Circle, or of *Sb* or *Sa*; that is to say, when SB is twice as great as *Sb*, the Heat at *aecd* is twice two times, or four times greater than at AECD; and so if SB be 100, and *Sb* 5, their Squares are 100 times 100, and five times 5, or 10,000 and 25; and consequently the Heat at *aecd*: Is to the Heat at AECD :: As 10,000 : To 25, or as 400 to 1, which is likewise confirmed by Experience.

From whence it is then manifest, that if one knows how much one Place is nearer to the Sun than another, one may likewise, according to this Rule, make an exact Calculation how much more Heat is produced by the Rays of the Sun at one Place than at another upon Occasion of their Distance; and generally that 'tis true, that by how much the nearer any thing is to the Sun, so much the greater Heat it must undergo from the united  
and



and compacted Rays thereof; as also the farther it is from the Sun, the less will it feel of its Heat.

Now as this is known to be true by all Mathematicians, let an unhappy Atheist consider in his Retirement, whether he thinks it can be by Chance, that a glowing Sea of Fire above 100,000 times bigger than the whole Globe of the Earth, is about the Sun at S, the burning Rays whereof SB, SA, SE, SC, SD, &c, come down with so unspeakable a Swiftnefs incessantly (and therefore in such a Number as is hardly to be conceived) upon the Earth ADCE; and yet that this terrible Fire does not immediately, and in the most dismal manner consume every thing upon it.

'Tis true indeed, that the Distance SB, which is between the Earth B and the Sun S, being of the Length of 12,000 Diameters of the Earth, may contribute something thereto; but yet this beautiful Globe is by no means preserved from the aforesaid terrible Destruction by this only. To understand which, let it be supposed, that there comes down from the Point of the Sun S upon the Earth, the Rays Sa, Se, Sb, Sc, Sd, &c. without *Diverging*, or in parallel Lines, and closely joyned together; or (to render the Notion thereof yet clearer) that the said Rays being near the Sun at the Point B, are diverged and separated from each other as they go, but proceeding farther, lose their Divergency; and descending down in their Parallelism, or Equidistance, from the circular Column *acmk*, it is plain that all of 'em will fall upon the Circle *km*, and there produce a Heat, which is so much greater than that which would be perceived in the great Circle AECD from the same diverging Rays, as this last Circle is bigger than the little one *km*.  
This

This appears from the Burning-Glasses, the Force of which does only consist herein, that the Rays are collected into a smaller Compass; so that they give a clear Proof of this Truth, that the Rays of the Sun being collected into a narrower Compass, even at so great a Distance from the Sun itself as is the Earth, are yet capable of producing a terrible Heat. From whence then it does follow certainly enough, that it is not so much the Distance of the Sun, but the Divergency or Scattering of its Rays more and more, which chiefly diminish the force of Burning; and that the said Distance or Remoteness does hardly contribute more towards preserving the Earth from an entire Conflagration, than by the dissipating and separating the Rays more and more from each other, in proportion to the Length which they run.

SECT. XXX. *Two great Uses of the said Divergency.*

FROM this Divergency of the Rays of Light from all Points whatsoever (which must be considered as a Wonder by all Men) we may deduce these two Advantages, which the adorable Creator bestows upon us, and which we have before already hinted:

*First*, That the Earth is thereby secured from being consumed by the Sun.

*Secondly*, That by such Divergency all Bodies are enlighten'd on all Sides by the Rays that are scatter'd upon 'em, and thereby render'd visible to every one. Thus we find in *Vol. I. Tab. X. Fig. 1.* that the Rays of Light KP falling from the Candle K upon a Point P (for Instance upon the Point of a Needle) separate themselves from one another there, as well as at the Candle itself, and by that Divergence render the said Point visible all round about it.

SECT.

SECT. XXXI. *Refractions and their Uses.*

BUT forasmuch as (*Tab. X. Fig. 3.*) these Rays from A, diverging and filling the Space AST, the same would also happen from all the other Points N, L, M, B, &c. of the Object AB, and therefore the same Rays diverging, for instance, from B and A, will be entirely mingled with each other at SOT, and so represent to the Eye at ST a confused Light of all the surrounding Objects, but no distinct View of any one; there seemed therefore something to be still deficient to render the Light compleatly useful to us; and that besides the rectilinear and divergent Motions of Light, there was yet another Law requisite, by which all the Rays proceeding from A or B might be again inflected towards each other, and gather'd together in so many particular Points *a* and *b*, which has been already proved to be the sole Cause of distinct Vision.

Besides this, to the end that the Light may be as useful to us as possible, since the Sun when it sets would turn the perfect Day in a very small space of Time into thick Darkness, and when it rises, would change a Night, as dark as Pitch, in a few Minutes into a bright Day; by which means our Eyes passing so suddenly from one Extreme to the other, might be much prejudiced and weaken'd, as Experience often shews; there seemed to be a Means necessary to cause the Brightness of the strong Light of the Sun to advance and recede gradually; and this is brought about by the Morning and Evening Twilights.

Now I would ask an Atheist, who pretends not yet to be able to discover the wise Purposes of him that has prescribed such Laws to the *Light*, and which it strictly obeys, Whether he could

have found out a better way to avoid the above-mention'd Inconveniencies, than by enduing *Light* with the Properties of Refraction, whereby, as we have already shewn, the two aforefaid Difficulties may be obviated? And since they are actually prevented by this Method, what Reason has so unhappy a Philosopher to deny the Wisdom of the Creator and Ruler of so glorious a **Body**?

SECT. XXXII. *The Proportion of the Angles made by the refracted Rays.*

Now to shew that these Refractions of the Rays of Light can't be ascribed to mere Chance, let (*Tab. XXI. Fig. 3.*) a Ray *SO* proceed from the Sun *S* to the Superficies of the Water *FG*; and suppose from the Center *O* a Circle *FBGP* described as large as you will, it is experimentally true, that the Ray *BO* does not proceed strait forward to *R*, but at *O* makes the Angle *BOP*; for which Reason the same Ray being thereby refracted, proceeds from *O* to *P*, according to *PO*, which is termed the refracted Ray.

After the same manner the Ray *bO*, does not proceed strait forwards to *r*, but breaks at *O* *p*: Now whether these refracted Rays *OP* and *pO* do likewise run in strait Lines, or else as often as they meet with fresh Resistance or Reverberations are again inflected, we don't here determine.

Now I leave any one, that is reasonable, to judge whether he imagines it possible to happen without the Direction of an intelligent Being, that all the Rays *OS*, *Os*, and all others that with different Obliquity fall upon the Water *FG*, (as here at *O*, with so dreadful a Velocity, with which they are protruded, and being entirely ignorant of all things else as well as of themselves) can observe such a Law without once departing

parting from it, that their broken or refracted Rays,  $OP$ ,  $Op$ , do exactly ever take the same Way; that (supposing the Lines  $AB$ ,  $DP$ ,  $ab$ ,  $dp$  to be all at Right Angles to  $ad$ , which is likewise at Right Angles with respect to  $FG$ ) the said  $AB$  and  $PD$ , as also  $ab$  and  $pd$ , will always have the same Ratio to each other; so that to speak more plainly, as  $AB$  is two or three times as long as  $PD$ , in all the other incident Rays, as here at  $bo$ ,  $ab$  will be twice or thrice as long as  $pd$ ; nor will there be, in so many Millions of Rays that fall in such various Obliquities upon  $FG$ , and penetrate into the Water, one single Ray to be found, notwithstanding their surprizing Swiftness, that don't perfectly follow this Rule, at least if all the Rays are of the same Kind.

SECT. XXXIII. *The Structure of the Eyes with respect to Light.*

AND as when we treated of the *Eye*, we mention'd the Properties of Light as an uncontestible Proof of the Wisdom of the Creator; so whilst we are here speaking of Light, we shall briefly apply the Structure of the *Eye*, so far as it relates to Light, to the same Purpose; and the most obdurate Atheist, unless he absolutely refuses to listen to any convincing Proofs, is intreated by us, that he would again attend, to what we have said in the Contemplation about *Vision*.

SECT. XXXIV. *The Power of Bodies to reflect Light.*

BUT now tho' Light should fall upon the *Eye*, and tho' the *Eye* were furnished with all the afore-said Qualities for receiving the same; yet that

whole Disposition, and all those Properties would be in vain, and the noble Globe of the Earth would be of no more Advantage to the Inhabitants, than it is to any Body now who is stark blind; unless, besides all this, the Bodies upon which Light falls, had the Faculty of causing the same to rebound back from them, and to *reflect* the Rays thereof to all Places round about them.

Now since this Property occurs in almost all visible Objects, will an Atheist say, that this was likewise by Chance, or deny that the great End thereof was, to render Bodies visible?

And if it should appear to him too absurd to ascribe all this to mere Chance only, let him then tell us, what Necessity there is in the Combination of Causes, why almost all Bodies do enjoy this reflecting Power, with respect to Light; whereas there are many which in relation to others that strike upon or against 'em, do not exert such a Power, nor drive them back again with any Repercussion. Thus we see, for Instance, That every thing which falls with any Degree of Swift-ness upon soft Clay, remains sticking in it, and is not reflected; and yet the contrary happens when those exceeding swift Particles of Light fall upon the same; for how small soever they be, they rebound from it, and thereby render the Clay visible. We might relate many more Wonders concerning this Matter, which we shall pass by here, having occasion to say something of them hereafter.

SECT. XXXV. *The AIR Invisible.*

MOREOVER, since this Property of Reflecting Light, is in a manner common to all Bodies, excepting perhaps such as are black, (which by many is supposed to be occasioned, because Bodies so tinged do not reflect any of the Rays of  
I
Light

Light that fall upon them, for which Reason they have no other Idea of this Colour but as of mere Darknefs.) Now must we not herein confess a wise Disposition of the Great and Gracious Creator, who, notwithstanding that he has made Water and many other fluid Matters visible, yet seems to have excluded the Air only, for the most part, from that Faculty, notwithstanding that that also in itself is visible like other Bodies, and seems to be very well adapted thereto by its Elastical and other Properties, as appears when we compress a great Quantity of Air in the Pump, and then suddenly let it out again by the Cock? Now let an Atheist ask himself, whether this can appear to him to be so order'd without any Design or Purpose? And since the Air it self being thus visible, and so far capable of stopping the Course of Light, would cause us to live as it were in a continual Fog, and hinder us from seeing conveniently most of the Objects about us, whether he does not observe, that this same adorable Wisdom does here interpose after a wonderful Manner for the Benefit of Mankind?

SECT. XXXVI. *The Wonders of Reflection.*

AND to this end that many miserable Philosophers, who think they understand so well the Laws of Reflections and Refractions, should not imagine that there are not more Wonders concealed in the same, and that their Understanding does perfectly extend itself thereto, let them give a satisfactory Reason of the Appearances mention'd by that accurate Philosopher Sir *Isaac Newton*, in his *Optics*, p. 238, and 346, *last Edition*; and tells us what is the Cause that the Light passing from a Glass, and falling with a certain Obliquity upon a Place from which the Air has been exhausted,

does not proceed on, but returns back again to the Glass; and that when the Rays fall from the Glass upon the Air with an Oblique Angle of more than 40 or 41 Degrees, the same are likewise entirely reflected; whereas if they fall with a lesser Obliquity, most of them will pass thro' the Air, so that the Light which passes thro' the Air upon the Glass, can make it self a way thro' the same, and yet the Light that passes from the Glass to the Air in the same Obliquity, seems unable to make it self a Passage in a Medium thinner, whereby to pursue its Course.

They that have a mind to see many wonderful Circumstances besides these, may consult the above-mention'd Places, and from the Experiments there related, may with Certainty enough infer, that we do not rightly understand the Nature of Light, with respect to its Reflections, whilst we only consider it as a Globe or Ball rebounding from any hard Matter.

At least it is evident hereby, that there are Laws in Nature to which the Light is subjected, of which perhaps none of the Naturalists, if they had not thus found them true by Experience, would ever have thought.

SECT. XXXVII. *Experiments shewing that Light may become a Solid Body.*

I MIGHT have here forbore to have enquired into certain Questions proposed by Sir *Isaac Newton*, in his *Optics*, p. 349. *Quest. XXX.* where that Gentleman seems to incline to the Opinion, that Light, besides its being the most active Matter in Nature, may likewise become the Substance of palpable Things, and be converted into a solid Body; but since Mr. *Homberg* has put this Affair out of doubt by several Experiments recited in the  
Memoirs



Memoirs of the *Royal French Academy*, 1705. p. 122, &c. it seems not improper to shew here likewise this Use of Light, And,

*First*, That Light penetrates almost all Bodies, even those that appear obscure to the Eye, and passes thro' the same, as is sufficiently known to such as make Use of good Microscopes, since almost every Object that has been viewed therewith, provided they are but thin enough, do in some manner become transparent.

The said Sir *Isaac Newton* tells us in his *Optics*, p. 223. That he has observed the same in a dark Chamber, when any Matter reduced to a proper Thinness, was placed before the Hole through which the Light would otherwise have passed; and he only excepts white metallick Bodies, which seem to reflect all the Light falling on them.

*Secondly*, If we suppose Flame to consist for the most part of Light, we see that it turns to a solid Body in the burning of Chalk, and especially in the making of *Minium* or Red-Lead from Lead-Ashes, which after having burnt and glow'd a great while, become more heavy.

Mr. *Homburg* likewise relates, that if Quicksilver, being reduc'd to the utmost Fluidity by Steel and Antimony, be put over a Fire in a Glass, the parts of the Fire will penetrate it thro' the Glass, and which may therefore be deemed a Light without any additional Mixture, will change it into a Powder heavier than the Quicksilver was at first, and be of such Proof against Fire, that it will bear glowing at least 24 Hours without any Evaporation; and when driven with a very violent Fire, it may indeed evaporate into a Smoak, but will however leave a little Parcel of itself behind, which being formed by this Light in the Quicksilver, will assume the Qualities of a solid

and malleable Metal: This may be farther confirmed by the Experiments made on the like Occasion by Mr. *Boyle*, by which he shews how some Bodies, shut up on every Side in Glass, become more ponderous by the Fire or Light that passes through the Pores of the said Glass: But this is proved yet more plainly, and beyond all Dispute, by the following Experiment of the said Mr. *Homburg* in the abovemention'd Place, who having reduced four Ounces of *Regulus Martis* to Powder, placed it about the Distance of  $1\frac{1}{2}$  Foot from the true Focus of the Burning-Glass of the Duke of *Orleans*, stirring it about from time to time with an Iron Spoon; by the Heat of this Light there ascended a great Smoak from the said *Regulus* for the space of an Hour, and then it ceased: And though one might expect, that by the loss of all those Particles which evaporated in Smoak, the Weight whereof would have been diminished; yet on the contrary he found that the Weight of it was increased  $1\frac{1}{7}$  quarter of an Ounce, and some Grains, that is to say, about a tenth part of the whole.

Afterwards he placed the same in a greater Heat, or in the real Focus, which put the *Regulus* into Fusion, and then it weighed no more than  $3\frac{1}{7}$  Ounces; so that he reckons that this loss of the half Ounce happening by the Evaporation and Smoaking, one may safely affirm, that the Light had first augmented it with almost the Weight of a whole Ounce, which by melting, and the Operation of such great Heat was dissipated again.

Now whether this last Calculation be just or not, it plainly follows from hence, that this *Regulus* had in the first of those Experiments gained by the Rays of Light, the Weight of almost half an Ounce over and above all that evaporated in Smoak;

Smoak; which clearly shews, that Light can conjoin itself to solid and palpable Bodies, and increase the Substance thereof.

But the Reader is desired to consider this as the first Sketch of a new Discovery: And I shall not endeavour any farther here to determine, whether we ought with those great Men above-mention'd, to consider Light as the chiefest and most active Principle in Nature. This however seems to be uncontestably true, that Light is either a pure and uncompounded Fire, or carries such a Matter along with it; and how much ought to be ascribed to the Activity of Fire is sufficiently known to every one. Experience likewise teacheth us, how much all Plants and Animals depend upon the Influence of the Light of the Sun; inso-much, that if it cannot be said to be the only active Principle in Nature, at least it may be certainly reckon'd among the chiefest.

SECT. XXXVIII. *Optical Experiments passed over.*

I SHALL not amuse my self here to rehearse the common and known Experiments about Light, which the Science of *Optics* suggests as so many Wonders, though they furnish us with one of the greatest Proofs to demonstrate that there is a God who directs this miraculous Matter of Light, rendering it subject to such Laws, notwithstanding the amazing Velocity of its Motions, that even the greatest Mathematicians must stand astonished, when they see, all that true Argumentation can deduce from it, performed by the same. Thus we see when it falls upon the Superficies of a Looking-Glass, that it paints the Object from whence it flows, as if it was behind the said Looking-Glass, where the Image is represented erect equally large, and at the same Distance as the  
Object:

Object: If it falls upon Spherical Convex-Glasses, it likewise makes behind the same a nearer and direct Image upon the Glass; and upon Spherical Concave-Glasses the Image will be sometimes erect, sometimes inverted, now greater, then smaller; one while it will appear before, another while behind the Glass, which may be shewn almost by Refraction in so many Changes, thro' Convex and Concave Glasses.

SECT. XXXIX. *A Dark Chamber, and Convictions from thence.*

Now if any Body would with small Expence try an Experiment about the Operations of Light, let him make what they call a Dark Chamber, of which mention has been already made in *Contempl.* XII. by which means he will see upon a white Paper, or a Piece of Linnen held in the Focus of the Glass that is fix'd in the Window, the Pictures of every thing that is on the out-side of the Chamber, which will produce a very pleasing Prospect, especially if the Chamber looks upon a Flower-Garden; for then one may see the Flowers in all their Colours and Figures, painted upon the Paper, and their Motions occasion'd by the Wind; and if there be any Men or other Creatures in the Garden, it will be a natural Moving Picture.

Now since every one can judge by a Picture of the Art and Skill of the Painter, and can be assured by the exact Representation of the Object after the Life, that the Man who drew it was a great Master of Painting; let a miserable Atheist but only contemplate with us these Pictures formed by the Light, and tho' he were himself a very skilful Limner, let him tell us whether he, or any Man besides in the whole World, could copy a  
 Piece,

Piece, not only so very like, with such noble Colouring, so nicely adapted to all the Rules of a Mathematical Perspective, but also with all its Motion, as he may observe to be done in an Instant by the Rays of Light: And in case he be obliged to own, as to be sure he must, that it exceeds all human Power, what Reason can he give with the least Shew of Truth, why he should not confess an understanding Artificer in a Work which exceeds the Skill and Power of all human Invention: Whereas in other Works of much less Excellence, a Man would be justly esteem'd a Fool, if not mad, who should maintain, that it had acquir'd its Figure without any Knowledge? The rather since we see that the Rays which represent the Colours each of 'em so distinctly in the Chamber, pass all of 'em together thro' this little Hole and Glass; and altho' they be so numerous, and coming from the Objects, yet are they not jumbled and confounded with each other in this little *Defilee*, thro' which they pass together; a thing that is not easily to be credited, if we had not ocular Proof of it. And cannot then an unhappy Sceptic discover yet, an over-ruling Power and Wisdom in this Direction of Light? What can be further done to extricate him out of this miserable Blindness?

SECT. XL. *The Properties of the Rays of Light, with respect to Colours.*

BUT before we take our leave of Light, we shall add something which seems to surpass even Wonder itself. Could any Body believe, when he looks upon the bright and untinged Light of the Sun, that the same can be divided and distinguished into so many different sorts of tinged or dyed Rays, as the Great Creator has been pleased

fed to communicate of primary Colours or simple Tinctures, or as the Learned call them, *Homogeneous Colours*?

And yet Experience teaches the same, as also that each of these coloured Rays suffers a particular Quantity of Refraction, and that the white, or rather the clear Light, is thereby split into different Parts or Kinds of Rays, which appearing singly, shew a *red, yellow, green, blue* and *purple* Colour; on which account these Rays are named by Sir *Isaac Newton*, *Red, Yellow, &c.* each of 'em according to their particular Colours, forasmuch as they are natural to them, and cannot be altered by any subsequent Refraction or Reflection.

Moreover, since all unmix'd Rays of the Sun do represent a certain Colour, and the whole Substance of Light consists of the said Rays, it seem'd to be hardly possible, but that all these Tinctures jumbled together, must occasion an Obscurity to our Sight; forasmuch as Blue, Purple, Red, and other Rays, are far short of that Brightness which occurs to us in the pure Light of the Sun or Day; and yet we find that all these colour'd Rays that proceed from Light by Separation, being collected and mix'd with each other, do entirely lose their respective Tinctures, and together produce a clear and transparent Light, entirely like that untinged Light that comes down to us from the Sun: Which new constituted Light may be again, as before, divided into its colour'd Rays, which, if one will, being mix'd together again, shall, the second time, represent an uncoloured Light, clear and transparent; concerning all which, the first Discoverer, Sir *Isaac Newton*, has treated largely in his *Optics*.

Now I ask an unhappy Atheist, whether he can believe that Light has acquir'd these Properties either by Chance or ignorant Causes? Or  
whether

whether he must not acknowledge, that those Men argue much more justly, who conclude from hence, that the great and gracious Benefactor of Mankind has produced all these differently colour'd Rays, to the end that the Beholder may be so much more agreeably affected and refreshed with the Sight of God's Creatures; and that he has placed in them the last Property, whereby all of 'em being mingled together, do compose a clear and transparent Light, to the end that the Obscurity of the Colours may not embarrass human Eyes?

Besides, his Wisdom and Beneficence must be acknowledged herein, that in the Parts which compose different colour'd Bodies, he has placed such a Disposition, whereby one Body, when this compounded Light falls upon it, is adapted to reflect only one, or some particular kinds of Rays; for Instance one, only Red, another, only Yellow, a third, both of 'em equally, and no other (by which a kind of a Gold-colour between Red and Yellow is generated) I say, to reflect these in a greater Quantity, by which means each Body, according to one or more sorts of Rays, which it reflects, either Simple or Compound, represents its particular Colour, and from thence is denominated Red, Yellow, &c.

How strange soever this Language might have been to all former Philosophers, yet the same is at present put out of all doubt by the afore quoted *Optics* of Sir *Isaac Newton*; who tho' he may be justly reckoned by every Body amongst the most famous Mathematicians of the World, yet to set an Example to these less experienced Gentlemen, that they should not too much rely upon Conjectures and Hypotheses, has proved the same to be unquestionably true, not by Demonstrations founded upon Arguments, but by manifold and exceeding

exceeding nice Experiments. Now those that have a mind to read and try the same, may meet with 'em in the aforefaid Treatise of *Optics*, especially in the *First Book*.

SECT. XLI. *The Division of Light in Island-Crystal.*

BESIDES the above-mentioned Divisions of Light, whereby it is split into various-coloured Rays, Mr. *Huygens* in his Treatise about *Light*, p. 61. and Sir *Isaac Newton* in his *Optics*, *Query 25*. p. 328. do shew us another Division or Splitting of Light, which it undergoes when it meets with *Island-Crystal*; upon which, as soon as a Ray of Light falls, it is divided into two other Rays that preserve however the same Colour.

Of these Divisions or Splittings of the Substances of Light into several other Parts, as well tinged in the first Case, as simple or untinged in the second, I don't know that there was ever the least mention made, or Track to be found among the ancient Naturalists; nor that this Matter has been put out of doubt sooner than in the last Age by accurate Inquiries and undeniable Experiments.

SECT. XLII. *The Usefulness of the Moon.*

Now let the Reader return with us to *Tab. XXI. Fig. 4.* and suppose the Sun to be represented by AB, and the Earth by CD, in which Situation, as we have said before, the Shadow of the Earth, or the pyramidal Figure CPD makes the Night, it will not be then difficult for him to fancy the great Darkness in which those that dwell at T must be involved; forasmuch as not  
the



the least Ray of Light flowing from the Sun A B, can come to them directly, or in a strait Line.

Now if you will please to observe, that the Moon M being opposite to the Sun A B, is at Full to those that live at T, that is to say, they see its whole enlighten'd Side; you will tell us whether you can think there is any Gratitude in those People that shall deny their great Obligations to Him who has furnished them with this Light of the Moon in such their Darknes.

S E C T. XLIII. *Convictions from hence, and the Eclipses.*

NOW the only Evasion that such People can make, is, that all this happens by Chance, or by necessary Causes, and consequently that no Thankfulness is due: But if the Gracious Creator of the Moon had no Wisdom, nor the Benefit which Men enjoy from the Light thereof, is not to be reckoned one of his great Views and Designs, how will they account for the following Particulars?

I. That the Light of the Sun has a Property when it falls upon any Bodies (as here from N, the Center of the Sun, upon M the Moon) to rebound back from it again, and to produce a reflected Ray MT; by which Means those that would otherwise remain in the midst of the dark Cone CPD, are enlightened. Now, that without this Faculty of Light, there could be no Rays reflected from the Moon to our Earth, is plain enough.

II. Why is the Moon M, which is much smaller than the Globe of the Earth, placed at no greater Distance from it; so that (as we see in *Saturn*, and other great Planets) its Breadth and Diameter disappearing almost out of Sight, would be

be incapable to communicate any Light to us that could be useful? And is there here no wise Purpose? And since the Universe is so large, why is this Place, among Millions of others, just chosen out, whereby it is best befitted to render such Service to those who inhabit the Earth?

III. How comes it, that the Moon is not of such a Contexture as our black or dark coloured Bodies are; by which means it would be able to give little or no Light to us?

IV. Why is it not a convex, globular and smooth Body; like Looking-Glasses and other polished Things, when (as those who understand *Optics* know) there would be no more than one Point, or at least a very little part of the Moon visible and capable of enlightening us?

V. Why does not the Moon move according to the Line GHFS, which lies in the Plane of the Sun's way Nn; by which means the same at G being opposite to the Sun, would never be seen Full, but would always be obscured and eclipsed by the Shadow of the Earth CPD, and on the contrary, the Moon being at F when it is dark or new, the Sun AB would be always either totally or partially covered and eclipsed thereby, at least the World reaps this Benefit by the Declination of the Moon's Way MHR S from the Plane of the *Ecliptic*, or Sun's Way Nn, or GHFS, that the Places lying near the Poles may be enlightened by the Moon, whilst the Sun being still under the Horizon, occasions such a long and dismal Night?

And moreover, does there appear no Wisdom therein, by which this continual Monthly Sun (as one may call it) is secured, to the end that Mankind may not be so often deprived of the Use thereof? How comes it then to pass, that the Moon's Way SMHR has just such an Obliquity

quity with respect to the Plane of the Sun's Way, or GHFS, that *First*, The most part of the Time that the Moon is at M, or directly opposite to the Sun, it is freed from the Shadow of the Earth CPD, and consequently from its Darkness, and that all that part of it that is turned to us, is seen at Full, and in its entire Lustre: *Secondly*, That when the Moon is at R, that is, in Conjunction with the Sun, and is seen at E, it is not hid from those that dwell upon the Earth?

VI. But farther, since now the Planes of the Sun's and Moon's Way HFSG and HMSR (placed in respect to each other after the manner of two Hoops laid obliquely upon one another) cut each other at two Points H and S; it follows, that when the Moon is not in its own Way at M, but at H or S, it will then be in the Plane of the Sun's Way: And when it happens at the time that the Sun is not at AB, but is directly opposite at *ab* to the Moon at H or S, and that the Sun and the Earth are in a Right Line *nK*; it may be easily gather'd from the Figure, that when the Night-shade extends itself to EKT, the Moon being at H, will be thereby eclipsed and obscured; but when it is at S, it will then hide the Sun at *ab*, and so cause a Solar Eclipse to those that dwell at S.

SECT. XLIV. *The Advantages of Eclipses.*

BUT here seems an Objection to stand in our Way, namely, that if Light be so agreeable, and Darkness so terrible; and if all this be so order'd, by a wise Governour of the World, why do these *Eclipses* or Obscurities of the Sun or Moon come to pass, since Night alone seems sufficient to fur-

nish Man, tired by the Labours of the Day, with refreshing Rest?

Now to answer this, and to shew that in Eclipses likewise, how dark soever they may be, the most adorable Wisdom of God is displayed, we need alledge nothing more than what is already known to Astronomers from the Uses thereof.

- And, *First*, that in the inquiring into the Course of the Sun and Moon, these visible Signs are oft-times so many Evidences, whereby we may know whether what has been said thereupon, in other Cases, is well grounded or not: Of this you may meet with many Instances among the Astronomers, which we shall not here relate.

*Secondly*, They administer Proofs of many natural Truths, which might not have been discover'd to us, without these Eclipses, or at least not so easily.

Thus we know that the Moon is less than the Sun, or even than the Earth itself, without any Calculation, only from hence, that (*Tab. XX. Fig. 2.*) the Earth's Shadow *ALZ* running like a Pyramid into a Point at *L*, is for that reason every where smaller than the Earth itself; or the Line *HK* is always shorter than the Diameter *AZ* of the Earth; and because the Moon *V*, passing thro' this Shadow, from *H* to *K*, is not only darken'd, but even remains frequently hid a long time in the same; which 'tis plain would never happen, if the Moon were only of equal Magnitude with the Earth.

From whence it likewise follows, that the Moon in itself is a dark Body, as least it is far short of the Clearness of the Sun, even tho' we should ascribe to the Moon itself that Flame-Colour which it sometimes shews in its Eclipses, as many have thought.

From

From hence it also appears that the Moon receives its Light from the Sun; forasmuch as when it has passed thro' the Earth's Shadow, and *Penumbra* after its Eclipse, it appears again in full Lustre as soon as ever the Rays of the Sun can fall upon it.

Moreover, the Eclipses of the Sun teach us, that the Moon is not only a dark, but likewise an untransparent Body, which appears by its hiding or covering the Sun.

Many such Observations might be shewn from these Eclipses; 'tis enough for us to have represented some of them, by which the Benefit thereof is proved in the Examination of the Creatures.

Yet if there be any Body that is not sufficiently convinced from hence, and it appears to him too small a thing, that the Inquirers into Nature are only benefited thereby (tho' the Honour and Wisdom of the Creator is best supported and magnified the same Way) yet he cannot avoid owning the great Use and Service thereof in other Occasions also; for since these uncommon Signs of the Heavens having been observed by all, or at least by many Men for many Ages, have been accurately noted by some, together with the Time when they happened; and forasmuch as those Times of the past Eclipses may be likewise determined by Posterity, with the Help of Astronomical Calculations, it will easily appear from hence, that those Eclipses are, as it were, fix'd Land Marks in the Series of Ages and Histories; from whence again, as from an undisputable Root of Time, a new Chronology may take its Date, and others in which there is any Uncertainty, be likewise rectified thereby.

But the Usefulness of the Moon's Eclipses appears yet more particularly in determining the

Longitude of the Earth; infomuch, that the Truth of many Maps and Descriptions of the Earth may be examined and corrected thereby, as has oftentimes actually happened, which is not only of very great Advantage to Geographers, but also of the utmost Importance to so many Sea-faring People, whose Preservation and Lives too often depend upon the Goodness or Badness of a Chart.

After having understood this right, it does not seem necessary to prove by more Circumstances, that the above-mention'd Objection will fall of itself, and that the Eclipses of the Sun and Moon are of great Use to Mankind.

Besides, that though we should not be able to shew all the Uses thereof, yet this is no Proof of any thing's being unprofitable, since such a Reason has no other Foundation than in the Ignorance of Men.

SECT. XLV. *The Light of the Moon is without Warmth.*

BUT to proceed: Is it not a Wisdom that has made and ruled the Moon with a Design of doing Good to Mankind? forasmuch as there is hardly any Light known to us which does not warm at the same Time that it shines; and since the Rays of the Moon seem to be no other than those that are transmitted from the Sun to it; and then reflected back to us. How comes it that the Moon-Light was neither *hot* nor *cold*, even then, when the Rays thereof were collected by a great Burning-Glass into one small Space or *Focus*, which (according to the Experiment of *Dr. Hook, Act. Lips. 1707. p. 153.*) was 500 times smaller than what they filled in their natural State. Thus we see likewise in the Experiment

of Mr. *La Hire*, in the *Memoirs of the Royal French Academy* 1705. p. 455. that the Rays of the Full Moon in *October*, collected by a Burning-Glass of 35 Inches broad, in its Focus, into a Space three hundred and six times lesser than what the same would have filled in their natural State, did not produce the least Alteration in a Thermometer (in which the Liquor was moved by Air, and which discovered the smallest Increase of the Warmth thereof) tho' the Ball of it was held for a while in the said Focus: And we likewise find by the said *Ast. Lips.* 1697. p. 429. that the so famous Burning-Glasses of Mr. *Tschirnbaus* produced indeed a greater Brightness by the Rays of the Moon in the Focus, but not the least Warmth. Now could ever any Body have imagined that the Rays of the Sun collected by a Burning-Glass, or reflected from the same, will burn so terribly; and yet that the same Rays rebounding from the Moon to us, do not appear to bring the least Warmth along with them, notwithstanding that by this kind of Glasses the Brightness of the Moon-Light is very much augmented in the Focus as well as that of the Sun.

But we shall have Occasion to say something more of this, when we come to the Contemplation of *Unknown Things*.

Now how advantageous it is to hot Countries, that this Light of the Moon produces no Heat, is obvious to every one who knows that if it was otherwise, and that the Rays of the Moon were likewise hot, that part of the Earth would be barren, and soon burnt up, since the descending Dews of the Night, by which it is now moistned, would then cease to fall down, and this Fire of the Moon would draw its Vapours upwards. Moreover, if the Night Air were not fresher and cooler, and that the Rays of the Moon

kept the same in a continual Warmth, it is plain enough how prejudicial it would be to the Health of all Men, and the hot Parts of the World would suffer great Inconveniencies thereby.

SECT. XLVI. *The MOON'S Magnitude and Distance from the Earth.*

I KNOW not whether it is necessary to shew in this Place, how much the Moon is smaller than the Earth, and how much the Light thereof (which in itself is hot, yet) by reason of the Distance is weaker, and less warm upon the Earth than at the Moon itself. But since the preceding Figures may be of use to us in this Matter, and the Grounds of this Calculation depend on that of the Sun, we shall briefly touch upon the same.

I. Let AB (as before in *Tab. XX. Fig. 1.*) be the Semidiameter of the Earth, and DC now be that of the Moon; then will the Angle ACB of the Moon's horizontal Parallax, when she is *New, or Full*, according to Sir *Isaac Newton*, be at a Medium ————— 57 Min. 30 Sec.

And its apparent Diameter }  
DCG, according to the } 31 Min. 30 Sec.  
same ————— }

The half of which therefore }  
for the Angle DBC, is } 15 Min. 45 Sec.

In the Fourth or last Quarter of the Moon, and at a middle Distance likewise from the Earth, Sir *J. N.* again supposes,

The Horizontal Parallax, or }  
the Angle ACB ————— } 56 Min. 40 Sec.

The apparent Diameter, or }  
the Angle DBG ————— } 31 Min. 3 Sec.

The half of which for the }  
Angle DBC is ————— } 15 Min. 31 Sec.

Now



Now since A and D are Right-Angles, made by a *Tangent* and a *Semidiameter*, if we take the Earth's *Semidiameter* AB for an *Unit*, we shall, by plain *Trigonometry*, find BC, or the Moon's *Distance* from the Earth to amount to ;

At *New* or *Full* barely 60 *Semidiameters* of the Earth.

And at the *Quarters*, barely 61 of the same.

So that the middle *Distance* is about  $60\frac{1}{2}$  thereof.

2. Now to discover the *Magnitude* of the Moon ; we first find its *Semidiameter* DC by *Trigonometry* aforesaid, amounting at *Full* or *New* to  $\frac{2}{3}\frac{1}{4}\frac{5}{6}$  or  $\frac{6}{5}\frac{3}{5}$ , and at the *Quarters* to  $\frac{2}{7}\frac{3}{4}\frac{1}{5}$  Parts of AB, or of the Earth's *Semidiameter* ; both which do not differ much from  $\frac{3}{4}$  Parts of the same.

From whence it therefore follows, That the Earth's *Diameter* AB, Is to that of the Moon CD, As about 11 to 3 ; consequently the *Body* of the Earth is to that of the Moon, as the *Cube* of 11 or 1331 to the *Cube* of 3 or 27, according to what we have said about the Sun. And therefore 27 *Globes* of the Earth are equal to 133 *Globes* of the Moon, or the Moon is  $49\frac{8}{27}$ , barely 50 times (to compute in round Numbers) lesser than the Earth.

This *Calculation* is accurate enough to build upon in *Things* of such a *Nature* ; and if it be not entirely exact, neither is it far short of the *Truth*.

With this likewise agrees the *Conclusion* of that Great *Astronomer* Mr. *Flamsteed*, who makes the *Diameter* of the Earth (as Mr. *Whiston* says in his *Prælect. Physic.* p. 292.) to amount to 7935 *English Miles*, and that of the Moon 2175 of the same : Which *Proportion* of 7935 to 2175, varies but little from the above-mentioned of 11 to 3.

SECT. XLVII. *Why the Light of the Moon is not Warm.*

Now if we suppose the Point S in the Moon, and the Point B on the Earth, (*Tab. XXI. Fig. 2.*) and farther, the Length *Sb* as the Moon's Semidiameter; and if we look back upon what has been said above concerning the diverging and spreading of *Light* at various Distances, as well with respect to its Heat as Shining; we shall find that in both these Cases the Force of the Light at *b*, is to that at B, as the Square of SB to the Square of *Sb*.

Now we have shown above, that as SB is  $60\frac{1}{2}$  Semidiameters of the Earth, or the Moon's Distance; so *Sb* is  $\frac{3}{11}$  Parts of one Semidiameter of the Earth, when it represents that of the Moon.

Now  $\frac{9}{121}$  is the Square of  $\frac{3}{11}$  or *Sb*, and  $3660\frac{1}{4}$  that of  $60\frac{1}{2}$  or SB; and consequently the first is to the second, as 9 to  $442890\frac{1}{4}$ , or, as 1 to 49210, omitting the Fraction. From whence it appears, that the Warmth of the Light which comes down from the Moon, is about 50,000 times less when it has reach'd us upon the Earth B, than it is at the Point *b*, when it has proceeded no farther than the length of one Semidiameter of the Moon, or *Sb*.

And this is the Reason, according to Mr. *Wbiston Prælect. Astron.* p. 108. why the Light of the Moon is not attended with any sensible Warmth by the time it has reach'd us here upon Earth. But forasmuch as Dr. *Hook* has collected the same into a Space 500 times smaller, and consequently render'd it 500 times as strong as the said Light is in its natural State; and therefore in such a Focus it is no more than 500 times stronger than at the Moon itself; yet, even in that case this Learned

ed Man could not perceive any sign of Warmth, notwithstanding that the Shining, or Light of the Moon (which deserves to be taken Notice of) was increased proportionably. I leave it to the Judgment and Observations of others, whether  $\frac{1}{1000}$  part of the Warmth of a hot Summers-Day with us, would be able to make any Impression even on the best Thermometer: For that the Rays of the Sun have much the same Power on the Moon, as on the Earth, is plain enough from the little Difference there is of both their Distances from the Sun.

And in this Experiment the Thermometer being moved by the Light of the Sun, it should seem that we are obliged to seek for some other Cause than merely the Distance, to which we should ascribe, that the Light or Rays of the Sun are reflected to us from the Moon, without bringing any Heat along with them, but leaving it all behind them.

Be that as it will, this is plain, that if the Moon should transmit to us so much Heat with its Rays, we should suffer many Inconveniencies from thence; which is now prevented by our great Creator, who directs all things with infinite Wisdom and Order.

SECT. XLVII. *The Cause of Ebbing and Flowing not inquired into.*

Now whether the Moon is the Cause of the Ebbing and Flowing of the Great Seas, and of the continual Motions of their Waves to the very bottom thereof, we shall neither dispute nor inquire into here; because we are not yet so far advanced in this Knowledge, as to be able to say any thing concerning it that may be free from every one's Objections, tho' we seem to be very far advanced in that Matter.

This

This is experimentally true, that the Waters in the deep and free Seas, (without taking notice here of other Impediments, concurring Causes and Circumstances) rise and swell up to the Places, or about those Places where the Moon is vertical, just as if they were driven thitherward by a Weight, or attracted or pressed by some other Power. Concerning which may be consulted the Writings of *Kepler, Newton, Gregory, Whiston, Varenius, De Stair, &c.*

We find the same happens likewise on the opposite Side of the Earth; wherefore the usual Expressions in which both these Appearances are comprehended, is, that when the Moon passes to the Meridian, the Water rises; when it goes away from thence, it falls. Others say, that it is certain by Observation, that the Water is at highest about three Hours after the Moon has been in the Meridian. See *Newton's Princip. Lib. III. Sect. 24.* and *Whiston. Prælect. Physic. Math. Sect. 96. p. 306.*

Let this Matter be as it will, it is certainly true by Experience, that if the Earth were cover'd all round with Water, it would appear Oval, by reason of the swelling of the watry Surfaces on each Side; and these two Protuberances of Water or Mountains, as *Dr. Gregory* terms them, move continually round about the Earth, if they be not obstructed by Land, Shoals or otherwise.

And as for that very ingenious Cause and Figure which *Des Cartes* produces, and whereby he would shew that it is always ebbing Water upon the Earth directly under the Moon; *Varenius* says in his *Geography, Lib. I. Cap. 14. Sect. 11.* that the same is contrary to Experience, and so it has been found.

However, leaving the Cause to every Man's own Opinion, this is the manner in which we must suppose the Motion of the Sea-Waters to happen,

happen; namely, that it is a *Swelling* and *Sinking* of the Sea, rather than a *Flux* or *Reflux*, or *Ebbing* and *Flowing*, according to the vulgar Notion thereof. See concerning the Alteration of these Expressions, *Varenius* in the same Place, *Seet.* 10. and *Gregory*, *Lib.* IV. *Seet.* 65.

SECT. XLIX. *Two Systems of the World.*

THERE are two Systems of the Heavenly Bodies, which at present pass for the chiefest, and according to which they are supposed to be moved. The first seems to be the most convenient with respect to the annual Course of the Planets, and is by many taken to be the true one, on account of its Simplicity: 'Tis that which we are wont to ascribe to *Copernicus*, who has revived the same from the Ancients.

They that would form a general Notion thereof, may suppose, (*Tab.* XXII. *Fig.* 1.) that the Sun stands still, and all the principal Planets move about it, according to the Orbits which they describe in this Figure. D is *Mercury*, the nearest to the Sun; C is *Venus*, next to and without which follows the *Earth* A, which upon this Occasion is reckon'd among the Planets, and about which the *Moon* B runs; E is *Mars*; F *Jupiter*, which has four Moons moving about it, after the same manner as *Saturn* H has five, and it may be six; and both of 'em carry their respective Moons about with them round the Sun. Beyond all these are the fixed Stars A P O X.

The Second System bears the Name of *Tycho Brahe*, and seems, in relation to the Planets, to be nothing else but the former a little varied in one Case only; and for no other Reason than because that of *Copernicus* supposes the Earth to move about the Sun, and consequently seems to contradict

dict the Scriptures, from which *Tycho* and his Followers make a Scruple of departing.

To understand this System, we must imagine, that the Earth A (*Tab. XXII. Fig. 2.*) stands still, that the Moon B runs round it; that next to it the Sun S describes its Course, and that all the Planets, with their afore-mentioned Moons, bear the same respect to the Sun, as in that of *Copernicus*: So that the Way of each of 'em surrounds the Sun, which continually moves about the Earth; and that all of them must be consider'd as simply moving about the Sun. The fix'd Stars are here likewise represented by APOX.

In both of 'em there is yet this Difference, that in that of *Copernicus* (*Tab. XXII. Fig. 1.*) the Sun S and the fix'd Stars APOX, standing as it were still, the Globe of the Earth A really turns round its own Axis, from West to East in 24 Hours, by which Means the whole visible Firmament, Sun, Planet, and Stars seem daily moving from East to West.

In *Tycho's* System, (*Tab. XXII. Fig. 2.*) nothing stands still but the Earth A; whilst all the above-mention'd Bodies are supposed to run round daily from East to West, besides the Course of each in its own Way from West to East. What Reasons may have induced other Astronomers to form one System from these two, I know not; since in that *Semitychonic*, the Simplicity and Convenience of the First, and the Agreement of the Second with the holy Scriptures, seem to be, if not quite lost, at least very much alter'd; for which Reason we shall say nothing of this latter, neither shall we dissuade any one that likes it, from embracing it, since we don't here undertake to dispute the Truth thereof, but endeavour to represent to Sceptical Philosophers, so much as we know to be true of it from Experience and unquestionable

Calcu-

Calculations, in hope to convince them thereby that there is a God.

SECT. L. *The Immensurable Magnitude of the Fix'd Stars.*

TO come then to the Matter : Let those who still doubt of a Powerful and Wise God, lift up their Eyes with us, and suppose this to be the first Time of their Life that they ever saw the Heavens adorned with so many glorious Lights ; and tell us, whether they should not be thereby convinced, that the same had a Mighty Creator, and that it was not by mere Chance that they had acquired their Origin and Lustre, no more than a Locket set with Diamonds, of which the most obdurate Atheist would not dare to affirm, that they were put together without the Skill of an Artificer ; much less would they affirm it of the Heavens, especially if they observe the immensurable Magnitude thereof, which is such, that the Astronomers have not been able hitherto to communicate any thing to us that can be more depended on than mere Conjecture ; nor have they been able to answer all the Questions concerning the Magnitude and Distance of the Fix'd Stars.

Thus we hear the great Observer of the Heavens, Mr. *Huygens*, in his *Cosmotheros*, p. 135. ingenuously acknowledging the same in the following Expressions: *But those who before us have endeavour'd to determine this immense Space, have not been able to conceive any thing certain, by reason of the great Exactness necessarily requisite in the Observations, and which exceeded the utmost Care and Diligence ; for which reason, the Method I have now chosen, seems to be the only one remaining, in order to attain to something that might be at least probable in a Matter of such difficult*

*ficult Inquiry:* Of which he gives the Reason a few Lines after, in this manner: *The Stars also of the first Magnitude, tho' view'd even by a Telescope, appear all so little, that one would take 'em for little lighted Matches without any Breadth, which is the Cause that no Measure of their Bigness can be found out by this sort of Observation.*

It will not be necessary to produce any other of the modern Mathematicians who are of the same Opinion, after the Testimony of an Astronomer, to whom the utmost Efforts of all the famous Men of Learning were well known, he being a Member of the *Royal French Academy*, and not only in himself a Discoverer of new and never before seen Lights and Phenomena in the Heavens, but likewise of an indefatigable Zeal and abundantly blessed with a temporal Estate, whereby he was enabled to make Experiments of all Things.

The Method which that great Philosopher took, in order to form some probable Conjectures concerning the Distance of the Stars, supposes however, that which has no certain Foundation, namely, That a Star (at least one of the first Magnitude, such as *Syrius*, or the *Great Dog-Star*) is as big as the Sun; from whence he infers, That the Distance of the Stars from the Earth is 27,664 times greater than that of the Sun from the said Earth: See his *Cosmographer*, p. 137. notwithstanding that he allows this last to be above 12,000 whole Diameters of the Earth.

#### SECT. LI. *Of the Parallax of the Fix'd Stars.*

ANOTHER Method of inquiring into this Distance with greater Certainty (if the Event had been favourable) has been some Years since set on foot by Messieurs *Flamsteed* and *Hook*, who  
thought



thought that they could deduce from their Experiments, that the Diameter of the Earth's Way about the Sun (according to *Copernicus*) made some Alteration of Sight with respect to the fix'd Stars, in Proportion as the Earth was so much nearer, or so much farther from them; whereby likewise the System of *Copernicus* of the Earth's Motion, seem'd to be proved at the same time. I shall not here rehearse the differing Notions of *Gregory*, *Whiston*, and others, about the same; but that from these Observations, even tho' they were true, the Distance of the Stars and Motion of the Earth cannot be proved, is sufficiently shewn by Mr. *Cassini*, in the *History of the French Academy* for the Year 1699.

So that these two last Methods, in which all imaginable Helps, known to the Moderns, are used, leaving the Matter still uncertain, there is no great Hopes of meeting any better, at least since the Globe of the Earth is no bigger, or (according to *Copernicus*) its Way about the Sun of a larger Diameter, that it may the better serve for a Foundation for measuring such a Distance. Now as long as the Distance of the fix'd Stars from the Sun or from the Earth remains unmeasurable, it follows from thence, that the Magnitude of the Starry Heavens, tho' one were to consider it as an Orb about the Sun or Earth, which cannot yet be proved from Nature, will always remain likewise immensurable.

Now that the Holy Scriptures speak here according to the strictest Truth, as they do likewise about many other Things of Nature, every Man must own, who will consider that Passage in *Proverbs* xxv. 3. *The Heaven for Height, and the Earth for Depth, and the Heart of Kings is unsearchable.* In like manner, when the said Scriptures would propose any Thing which surpasses all  
Mens

Mens Conception, they compare it with the Height of Heaven, as in *Pf. ciii. 11. As the Heaven is high above the Earth, so great is his Mercy towards them that fear him.* But the Expression of the Prophet *Jeremiah* is yet more full and emphatical, *Ch. xxxi. v. 37. If Heaven above can be measured, and the Foundations of the Earth searched out beneath, I will also cast off all the Seed of Israel* — From whence we may plainly enough infer, that since God was not pleased to cast off all the Seed of *Israel*, in which the Saviour of the World was comprised, as he expressly says, so neither is Heaven or the Firmament capable of being measured.

Let me now ask an Infidel, whether or no he does not here discover the Divinity of the Holy Writ? For unless He who dictated it were an omniscient God, and did know all the Counsels of Men, and even the Issues thereof to the End of Ages; how can it be imagined, that an Author of any Sense would venture positively to advance such an Assertion as this, concerning the Immensity of the Heavens; which, (notwithstanding the Zeal and restless Attempts of all Sorts of Men; notwithstanding the Charges and Expences bestowed by such great Potentates wholly and solely in this Inquiry; notwithstanding that Diligence whereby other Matters, which at first seem incredible, have been at length found out) remains good, even after so many Ages, to this Day; forasmuch as Heaven continues as much immensurable as ever.

It did indeed seem very probable to Philosophers, that a Method might in Time be found to measure not only the starry Heaven, but even the Stars themselves; when first great Mathematicians found a Means in *Astronomy* to make use of the Orb of the Earth (or the Orb of the Sun)

as an Instrument to measure Angles; and by their Pendulums, and Micrometers (as they call them) plac'd in the Focus of great Telescopes, became able to measure Angles in the Heavens, even to Seconds, or 60th Parts of a Minute: Whereas before, with the most costly and cumbersome Instruments, *Astronomers* could hardly measure to whole Minutes with any Certainty.

Nay, and what is more remarkable, is that farther Discoveries should be obstructed by the following Phænomenon; namely, that whereas all other enlightened Objects are magnified by Telescopes (the *Astronomers* principal Instruments) the fix'd Stars seen thro' them appear less than when seen with the naked Eye, and therefore can be of no Use in measuring the starry Heaven, as it might have been expected. When the Planets, which to the naked Eye appear no bigger than the fix'd Stars, by means of the Telescope appear very large and distinct.

I am sensible that the reason given for the Appearance is, that the Telescopes take off the spurious Rays that accompany the fix'd Stars; neither do I now dispute it, tho' the spurious Rays that make *Venus* twinkle, being taken by a Telescope with a small Aperture, that Planet still appears bigger. However, notwithstanding all this, it is certainly true, that in this Case the Telescope has an Effect quite different from what it has in other Cases. Concerning this, see *Dr. Gregory's Astronomy*, and other Authors, whereby it will appear that the Distance of the starry Heaven is not to be measur'd by any Mortal. So that this Word pronounc'd by the Creator, namely, *that the Firmament is unmeasurable*, continues in full Force, and shews the divine Original of the Heavens; thereby, as it were, setting Bounds to

the Labours of the following Ages, and giving Limits to *Astronomy*.

SECT. LII. *Whether the Starry Firmament be Solid or Fluid.*

NOW since such great Mathematicians have with so much Ingenuity owned themselves unable to measure the so vastly extended Magnitude of the Starry Heavens, which does in a manner surpass all human Imagination, how great Progress had there been perhaps made in the Science of Nature, if the Philosophers had behaved after the same manner, with respect to the Matter and Figure of which this starry Heaven consists, and if they had made the best use of that Time which young Learners employ in uncertain Conjectures and Hypotheses, without any Foundation, in making new and material Observations? Since it remains a Mystery to the greatest Astronomers, how the heavenly Bodies are framed and constituted. *Des Cartes* supposes 'em to consist of fluid *Vortices*, as is well known. *Sir Isaac Newton*, in his *Scholium* to the 53 *Proposition* in the *Third Book*, shews the contrary; and farther subjoins, that this Hypothesis is inconsistent with all Astronomical Appearances; concerning which *Mr. Huygens* may likewise be consulted in his *Cosmotheoros*, from p. 139 quite to the end, and in other Places; not to mention any more.

SECT. LIII. *Probable Reasons for its being Solid.*

THE Foundation of these Opinions, that the Heavens are a Solid Body, is principally, That the Distance of the Stars from each other, has remain'd in a manner the same without any Alteration

ration for so many Ages, which seems more agreeable to the Nature of a solid Matter, in which they are supposed to be placed, than in a Fluid.

THIS Conclusion seems likewise to be made with some kind of Probability, from the wonderful Observation related by Mr. *Huygens* in his *Syst. Saturn.* p. 8 and 9, and which we don't know to have been taken Notice of by any one before: His Words are as follows: " Astronomers place  
" three Stars close to each other in the *Sword* of  
" *Orion*; and when I view'd the middlemost  
" with a Telescope, in the Year 1656, there ap-  
" peared in the Place of that one (which is no  
" new thing) twelve other Stars, after the man-  
" ner as they are represented in *Tab. XXIII.*  
" *Fig. 1.* Among these, three that do almost touch  
" each other, and four more besides, appeared  
" twinkling as thro' a Fogg; so that the Space  
" about 'em seemed much brighter and lighter  
" than the rest of the Heavens, which appearing  
" wholly blackish, by reason of the fair Weather,  
" was seen as through a certain Opening and Se-  
" paration, thro' which one had a free View in-  
" to another Region that was more enlighten'd.  
" I have often observed the very same thing with  
" this, without any Alteration, and in the same  
" Place; so that it is likely that this Wonder,  
" whatever it may be in itself, has been there  
" from all Times; but I never took Notice of  
" any thing like it among the rest of the fix'd Stars;  
" for we do not find that the others, which were  
" formerly accounted cloudy (*Nebulosæ*) nor the  
" Milky-Way itself, have any Mist or Vapour  
" about 'em; nor if we view them with a Tele-  
" scope, do they appear to be any thing else than  
" a Collection of many small Stars.

Now I leave it to the Judgment of an impartial Person, whether one has not more Reason, from these Experiments, to believe that the starry Heavens do rather consist of a solid Matter than a Flood of Particles continually moving among each other; since the aforesaid enlighten'd Opening shews itself always circumscribed after the same manner; which in fluid Matters, that are so susceptible of Motion, can hardly be expected.

SECT. LIV. *The amazing Greatness and Distance of the Stars.*

Now to proceed: As this great visible Firmament is immensurable, on Account of the almost inconceivable Extent of the Distance thereof, so likewise must we look upon the Remoteness of the Stars, and the Magnitude of those Bodies, as things incapable of being determined by Men: The Reason is, because the Diameter of the Earth is to that of a fixed Star, as the horizontal *Parallax* is to the apparent Diameter of the same. Now it is plain by Experience, that the Earth, and even according to *Copernicus*, the Diameter of that whole Circuit which it makes about the Sun, must be consider'd only as a Point, with respect to the Distance of the Stars, and much too small to produce any *Parallax*. Besides, we likewise find, that the best Telescopes that are made, can only represent the said Stars as so many Points of Needles, and without Breadth, insomuch that we can't discover any Measure of the apparent Diameters thereof by the Help of those Instruments; so that from the Impossibility of observing the *Parallax*, and especially the apparent Diameter, we are entirely disabled from determining the Magnitude of those Stars.

Now

Now whether, with the modern Astronomers, we are to consider every one of those Stars, at least all those of the first Magnitude, such as the *Dog-Star*, and the like, as so many Suns, both in Splendor and Bigness, has not yet been proved by any one: This is certain, that they are immeasurably remote from us, and that in so unconceivable a Distance they derive a Native Light down to us; as also, that if the Sun were as far from us, it would not appear bigger than one of those Stars.

If therefore, without insisting upon a real Proof, we suppose those Stars to be so many Suns from the Strength of their Light, and from their great Distance (in which we do but follow, if not all, at least the greatest Astronomers) we shall have an Idea of the heavenly Bodies that includes it in an amazing Greatness.

According to this manner, the Conjectures of Mr. *Huygens* will not appear ill grounded, who, upon the Calculation laid down in his *Cosmotheoros*, p. 136, and 137. makes the Distance of the fix'd Stars from the Earth 27,664 times greater than that of the Sun. So that if, according to what we have said before, a Cannon Bullet will require 26 Years in passing from hence to the Sun, with the same Velocity wherewith it was discharged, it would require, in order to arrive at the fix'd Stars, 25 times 27,664, that is, 691,600, or almost Seven hundred thousand Years; and a Ship that can sail 50 Miles in a Day and a Night, will require 30.430,400 Years. And if we proceed further upon this same Foundation, and suppose with those Gentlemen, that each Star has a Space about it proportionable to that of the Sun, I leave every Man to judge, whether he be able, without a great deal of Pains, to form to himself a just Idea of this wonderful Ex-

tent of the Universe, and whether he be not in danger of losing himself in the Contemplation of so unconceivable a Greatness of so glorious a Structure, in which the Footsteps of the divine Builder do so manifestly appear. I have chose rather to make use of this Hypothesis of Mr. *Huygens*, preferable to others, because nothing else is maintain'd by him, than that one of those great Stars is like the Sun; and that the Splendor and Light of the Sun, when its Diameter is contracted according to the aforesaid Proportion, will be only equal to that of the *Dog-Star*; but whether this be true or no, yet it is beyond all Doubt that the fix'd Stars are very great, and that their Greatness and Distance is not to be determined, since the manner of inquiring into it can hardly be carried farther, according to the Opinion of great Mathematicians: See *Gregory Schol. Prop. 55. Lib. 3.*

SECT. LV. *Convictions from the foregoing Observations.*

I HAVE oftentimes most seriously reflected upon this Impossibility of determining the Magnitude and Distance of the Stars as an Effect of the adorable Wisdom of their Great Creator, who knowing, that if they were capable of being measured, how great soever the Extent thereof might be, yet from the Habitude and Custom of mentioning the same, the Wonderfulness thereof would be much diminished: He therefore thought it necessary to make them immensurable, and to put them out of the Reach of all human Endeavours, and likewise, to the end that those who despise him might be forced in spite of all their kicking against it, to confess a Power to which they could set no Bounds; and since all their Learning

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ing could never fathom it, to live in a continual Astonishment at it, as it happens most commonly in relation to Things that pass our Understanding.

SECT. LVI and LVII. *The Stars numberless, and Convictions from thence.*

AT least the divine Authority of the Holy Scriptures is evident from hence, by which, even from the first Ages of the World, the Magnitude of the Stars is determin'd to be absolutely inscrutable, and consequently shewn even then where the Efforts of Men in following Ages should find their Bounds, notwithstanding their utmost Endeavours to the contrary. The Places upon which we have our Eye on this Occasion, are the Words of *Job*, ch. ix. ver. 9, 10. where having first said of the fixed Stars in the 9th Verse, *which maketh Arcturus, Orion, and Pleiades, and the Chambers of the South*, he continues in the 10th Verse to say, *which doeth great things past finding out, yea, and Wonders without number.* From whence not only what has been said before, of the Inscrutability of the Stars Magnitude may be inferr'd, but likewise, in order to prove the infinite Knowledge of that Spirit, by whose Inspiration this Word is written, more plainly against all Unbelievers, we find it likewise literally expressed, that those Stars are not to be number'd; which could not have been irrefragably proved before our Times against any one that would have denied the same. Besides the above quoted Text, this Innumerability of the Stars has been likewise asserted in several other Places of Scripture: Thus God says to *Abraham*, in *Gen. xv. 5.* *Look now toward Heaven, and tell the Stars, if thou be able to number them: and he said unto him, so shall thy Seed be.* And the Almighty

does frequently make use of the same Comparison to express the infinite Number of the Children of *Israel*, viz. *Exod.* xxxii. 13. *Deut.* i. 10. —x. 22. —xxviii. 62. *Neb.* ix. 23. and several others; besides that these thousands of *Israelites* are oftentimes compared likewise with the Sand of the Sea, as in *Isaiab* x. 22. *Hosea* i. 10, &c. from whence it appears at the same time, that the Number of the Stars is not only made as great, but likewise as innumerable as the Sands of the Sea, in the said Holy Scriptures.

Now it is known to all Astronomers, that in order to pronounce such a great Number of Stars innumerable, or to compare the Number of *Abraham's* Children thereto, they could not be seen in the Heavens whilst they had no use of Telescopes.

*Hipparchus*, in his Catalogues of Stars, has transmitted to Posterity the Number of 1026; which, in our Age, has been increased to 1888, by the great Astronomer *Hevelius*; among which are to be reckon'd 950 that were known to the Ancients, 603 which he calls his, and 335 observed by Dr. *Halley* in the Southern Parts of the Heavens, of which Dr. *Gregory* treats more largely, *Lib.* 11. *Seet.* 29. but after that the Telescopes had discover'd that the great broad white Streak extending itself round the whole Heavens, and which, upon the account of its Whiteness, they call the *Milky-Way*, was formed of a Collection of numberless little Stars, which Dr. *Halley* likewise testifies of the *Southern Magellanic Little Clouds*: See *Gregory*, *Lib.* 11. *Seet.* 22. After that, as it appears from the afore-cited Place of Mr. *Huygens*, for one Star that we see with our naked Eyes, several others offer themselves to the Telescope; so that according to the Remarks of  
*Cherubin*

*Cherubin d'Orleans*, p. 270 and 312, by the Help of the same, only in the Constellation of *Orion*, more Stars, and according to the Observations of *Rbeita*, related by *Zhan*, *Fund.* III. p. 209, twice as many shew themselves, as are seen by the Eye only in the whole Heavens: I say, since these telescopical Observations, Astronomers have lost all Hopes of ever fixing the exact Number of the Stars, the rather, because the more those Telescopes are improved, the greater Number of Stars are seen; insomuch, that some, tho' without Foundation, have maintained, that the Number of the Stars is infinite, as *Mr. Huygens* witnesses of *Jordanus Brunus* in his *Cosmoteoros*, p. 138; but to say nothing more than what is true, this is certain, that the modern Observations made by the Help of these Instruments do sufficiently evince, that the Stars are not to be counted. See *Whiston. Praelect. Astron.* p. 23.

Now let an Infidel tell us how it is that *Moses* and *Job*, if they had not been divinely inspired, could in their Times have pronounced the Stars to be innumerable, since it was so many Ages after, that this excessive Multitude upon the Discovery of Telescopes, has been experimentally known to Mankind.

SECT. LVIII. *Whether the Stars differ in Magnitude.*

Now if we enquire into the Opinions of the greatest Mathematicians concerning the Difference of Stars from one another, we find the most able of 'em ingenuously confessing, that it is perfectly unknown to them, whether all the Stars are of equal Bigness; insomuch that it is doubtful whether some of 'em appear smaller only upon the account of their being farther distant from the Eye, or whether one Star is really bigger than another.

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THE Apostle *Paul* does positively determine the Matter in these Words, 1 *Cor.* xv. 41. *One Star differeth from another Star in Glory*; and if I may be allowed to add something by which that Saying of the Apostle seems to be verified in some manner from Nature, I desire the Reader to consider with himself, whether it be not more credible, that one Star is bigger than another, than that they should all be of the same Bigness, and at different Distances; since we find by the Observations of the greatest Astronomers, that it is certain enough that some Stars have plainly altered their Magnitude, and become smaller: (See an Account thereof in *Gregory*, *Lib.* II. *Seç.* 30.) for I cannot believe that any body will ascribe this only and entirely to their removing to a greater Distance. Yet if such a thing could happen, he may be pleased to pass this Reflection by, tho' otherwise the different Magnitude of the Planets seems in some manner to lead to such an Opinion.

### SECT. LIX. *Alterations in the Fixed Stars.*

BEFORE I proceed any farther, I cannot forbear, upon occasion of what we have already mentioned, to say something of what has been observed in the Heavens, with respect to the Stars about an Age ago, and which has astonished all the Astronomers. Mr. *Whiston* in his *Prælect. Astron.* p. 47. names it a *very great and astonishing Wonder, that must be transmitted or left to following Ages, without our being able to give any Solution thereof.*

That which is meant here, are those Alterations among the fixed Stars, that are still unintelligible to us, whereby we find that some new ones appear, and others that have been seen, do  
disap-

disappear; and a third sort shew themselves one time with more, and another time with a lesser Lustre. *Hipparchus* is said to have observed one; but in the Year 1572, we know that a new one appeared in the *Chair of Cassiopea*; in 1600, in the *Breast of the Swan*; in 1604, in the *right Heel of the Serpentarius*; and several others may be found in *Gregory, Lib. II. Sect. 30.* as also in *Mercator* and *Whiston*, that give us an Account of them and their Number. Some again, that had been seen before, are now invisible; and *Hevelius* says, in his *Præcursor*, that they sought in vain for five Stars, whose Places however *Tycho Brabé* had described full an Age before: Concerning which, the said *Gregory* gives us a farther Account in the *Act. Lipsf. 1691. p. 80.* as also how a Star belonging to the *Neck of the Whale* has often disappeared, and shewn itself again in the same Place at different times; See *Act. Lipsf. 1703. p. 213.* and how their Magnitude is remarkably changed in others, at least with respect to their Light. The Reader may likewise note what has been mention'd concerning *Kirchius* in the aforefaid *Transactions of Leipsick, 1687. p. 647.* since we cannot stand here to reckon up all those Particulars.

SECT. LX. *Concerning the Planets.*

LET us now proceed to the Planets, or Wandering Stars, so called, because they appear to us who live upon the Earth A, (*Tab. XXII. Fig. 1, and 2.*) to move sometimes quick, other-times slow; now forwards, then backwards, and another while to stand still for a time; which, to those that have not inquired into their Courses, looks like *Wandering*; tho' those that do understand it, know that with respect to the Sun they only proceed forwards, but yet occasion the same  
Appear-

Appearances, for which the Astronomers have accounted.

All the Planets, as we have said before, do move above the Sun S: But two, which are therefore stiled the lowest, *viz.* *Mercury D*, and *Venus C*, perform their Revolution in such a manner, that as they are seen from the Earth, they appear always on the same side with the Sun: Whereas the three other, *Mars E*, *Jupiter F*, *Saturn H*, are seen from the Earth A, sometimes on the same side, and sometimes on the opposite side of the Sun, as you may observe on the abovemention'd two Figures of this Table.

Now in order to form a right Notion of these Planets, we must again endeavour to divest our selves of those Prejudices which we have suck'd in as it were with our Mother's Milk, and by which we are taught to imagine, that these great Bodies are about the size of the Marbles we play'd with when we were Children, or somewhat less, and that they are but a very small Distance from us; and we are yet the more confirmed in the same, by the Figures that Astronomers are wont to give us of these Planets, which at the best do represent to us the Proportion of their Distances, but in a very small Compass, and do rarely or never shew us their Bodies in comparison of their real Magnitudes, which likewise considerably helps to hinder us from forming a right Conception of their true Magnitudes.

#### SECT. LXI. *The Magnitude of the Planets.*

THAT famous Astronomer Mr. *Huygens* in order to improve our Notions concerning the Planets, did at the latter end of his Life draw their Magnitudes in a particular Figure in proportion to that of the Sun, which we have therefore transferr'd

ferr'd from his *Autom. Planet.* to our *Tab. XXIII. Fig. 2.* where the Earth A, and the Moon by it at B, and so the rest of the Planets are represented in their proportionable Bignesses with respect to the Sun G D K. According to his Observations we find the Diameter of the Sun to be,

110 times greater than that of the *Earth* A.

308 ————— than that of *Mercury* D.

84 ————— than that of *Venus* C.

166 ————— than that of *Mars* E.

$5\frac{1}{2}$  ————— than that of *Jupiter* F.

$3\frac{4}{7}$  ————— than that of *Saturn's Ring* GI.

and that of the Ring  $2\frac{1}{4}$  times bigger than the Diameter of the Globe of *Saturn* H.

From whence it follows, if these Planets are compared with the Earth, which is best known to us,

I. That the *Earth* is not quite 3 times so thick, and consequently not quite 27 times as big as the Planet *Mercury* D.

II. That *Venus* C is about  $\frac{1}{3}$  as thick, and consequently as big as the Earth itself.

III. That *Mars* E, is smaller than the Earth, so that the Diameter of the latter will make  $1\frac{1}{2}$  of the former, and consequently contains  $3\frac{3}{8}$  as much Matter as the Globe of *Mars*.

IV. That *Jupiter* F, has 20 times as great a Diameter, and 8000 times as large a Bulk as that of the Earth.

It has likewise four Satellites or Moons about it, each of which does not seem lesser than the whole Earth: See *Huygens Cosin.* p. 101.

V. After these comes *Saturn* H, which, (what no Body could ever have thought or suspected) is surrounded with a Ring GI, that is flat and very thin in proportion to its Magnitude: There is a Space between that Ring and the Body of the Planet, which it encompasses without any Contiguity like a Vault or Ceiling; for which Reason

Reason this Disposition of *Saturn* with its Ring, being viewed from different Parts of the Earth, is wont to represent a very different Figure. The Diameter of this Ring *GI*, is, according to the foregoing Computation, about 30 times as large as the Diameter of the Earth; and therefore if it were a Globe, it would contain about 27,000 times the quantity of this Globe of the Earth.

The Diameter of *Saturn* itself is about 13 times as big as the Earth's, and consequently the Body of that Planet is 2197 times as large as the whole Earth; besides which there are five Moons that are observed to circulate about the said Planet and its Ring.

SECT. LXII. *The Times of the Planets Revolutions and Distances from the Sun.*

NOW the Times in which these Planets finish their respective Circulations about the Sun, have been observed as follows: That of *Mercury*, in three Months; of *Venus*, in about  $7\frac{1}{2}$  Months; of *Mars*, in almost two Years; of *Jupiter* in 12 Years; and that of *Saturn*, in about 30 Years, all of 'em computed as near as may be.

We shall here pass by the *Satellites*; they who desire to know the Time of their Revolutions about *Jupiter* and *Saturn*, may consult the Astronomers.

The Distances of these Planets from the Sun; are likewise reckoned in the following manner: Upon the Supposition that the Distance of the Earth from the Sun is 10, that of *Mercury* is hardly 4, *Venus* 7, *Mars* 15, *Jupiter* 51, and *Saturn* 95 of the same Parts: See *Gregory Astron. Lib. I. Sect. 1*. So that the Distance of our Earth from the Sun being, according to *Cassini* and *Flamsteed*, (for the more convenient Calculation) 10000 Diameters.



Diameters of the Earth; *Mercury* will be 4000; *Venus* 7000; *Mars* 15000; *Jupiter* 51000; and *Saturn* 95000; and proportionably so much greater, if with Mr. *Huygens* we account the Distance of the Sun to be 12000, or with Mr. *la Hire* 17000 of the said Diameters. We have here used the smallest Numbers, because we would proceed with the greater Certainty.

SECT. LXIII. *The Velocity of Venus and Jupiter.*

NOW let the Atheist consider, that notwithstanding the contemptible Notions he has of these Heavenly Bodies, which he looks upon as no bigger than they are represented in *Tab. XXII. Fig. 1* and *2*; and in *Tab. XXIII. Fig. 2.* yet *Venus*, the Evening and Morning Star, is a Globe not much smaller than that of the Earth; and, which is amazing, it moves about the Sun with a Swiftness, 146 times greater than that of a Bullet, shot out of a Cannon. To give likewise an Instance of one of the remotest Planets, let him contemplate that of *Jupiter*, which is a Globe 8000 times as big as this of the Earth; and let him consider, *First*, how great a Distance it must be from him, when so vast a Body shall appear as small as one of our Childrens Marbles: And *Secondly*, what a Force is necessary to move such a prodigious Globe along the Heavens, the Motion of which we find to be 54 times swifter than a Cannon-Bullet's.

SECT. LXIV. *The Calculation of the Revolutions of the aforesaid Planets.*

THIS may perhaps seem somewhat whimsical and incredible too to ignorant Persons; but those who understand Astronomy know that nothing

thing need be advanced by Conjecture or Guessing, when one compares the Magnitude and Distance of the Planets with that of the Sun; but that the same may be deduced by certain Consequences from the Observations that have been made concerning them, as every Mathematician knows, and as literally appears in the *Syst. Saturn.* p. 77 and 81, of Mr. *Huygens*; so that upon the whole Matter, it depends only on the Greatness and Distance of the Earth with respect to the Sun, not to know the Proportion only, but the true Measure thereof, of which Astronomers are in a manner so much Masters, that they can be sure that neither the Planets themselves nor their Distances are supposed too great.

If it be then known that there is no Mistake of any Importance made herein, the Swiftmess of their Motion may be easily computed from the time of their Revolution: As for Instance, a Cannon-Bullet runs, according to the Experiments of *Mersennus*, (quoted by *Huygens* in his *Cosmotheoros*, p. 125.) 100 *French Toises* of six Foot each, in the space of a Second; and according to the most accurate Measuring of the *French*, the Diameter of the Earth amounts to 6.538,594 of the said *Toises*, or Fathoms.

Accordingly then a Cannon-Bullet would run the length of the Earth's Diameter in about 65,386 Seconds, that is, full 18 Hours; from whence it follows, that it would run in one Year, consisting of 365 Days, 486 of the like Diameters, and 40 thereof in a Month of 30 Days.

Now it appears above, that (*Tab. XXII. Fig. 1 and 2.*) the length between the Sun and Earth, or the Line AS, being supposed to be 10,000 Diameters (which is less than what is allowed by Mess. *Huygens* and *la Hire*) the Distance of *Venus* from the Sun, or the Line SC, will amount  
to

to 7000 of the said Diameters; and if now we take the Revolution CIR for a Circle, of which CS is the half Diameter, the whole one CR will be 14000 of the Earth's Diameters; and supposing the *Ratio* of the whole Diameter to the Circumference of a Circle, according to what is known, as 113 to 355; the Circumference CIR of this Diameter CR, which *Venus* finishes in  $7\frac{1}{2}$  Months, will be 43,982 Diameters of the Earth.

But it is found before, That a Bullet runs 300 of the like Diameters in  $7\frac{1}{2}$  Months, or in the Time of *Venus's* Revolution. Thus it appears, that the Velocity of *Venus*, with respect to that of a Cannon-Bullet is, as 43,982 to 300, or that *Venus* moves 146 times faster than the said Bullet.

After the like manner, and with very little Trouble too, we may compute, that since *Jupiter's* Distance from the Sun, or the Semidiameter of its Way (supposing it likewise to be exactly circular) amounts to 51,000 Diameters of the Earth, and that the Time of its Revolution is 12 Years; it moves about 55 times, at least a good deal above 54, faster than a Cannon-Bullet, that shall run in one Year 486 of the like Diameters, as has been shewn above. We suppose here the Courses of the Planets to be uniform, tho' Astronomers find that they move one while faster, and another slower; but forasmuch as they perform their Revolutions in about the said time, this Calculation is certain enough.

SECT. LXV. *The Swiftnefs of one of Jupiter's Moons.*

IF we now suppose with Mr. *Cassini*, (See the *Cosmotheoros*, p. 101.) that the nearest of *Jupiter's* Moons is distant from it  $2\frac{1}{2}$  Diameters of that Planet, and that its Revolution is performed in

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one Day, eighteen Hours, twenty eight Minutes, and thirty six Seconds; the whole Diameter of the said Revolution will be  $5\frac{2}{3}$ , and the Circumference, supposing it to be exactly circular, will be  $17\frac{2}{3}\frac{2}{3}$  Diameters of *Jupiter*.

Now one Diameter of *Jupiter* is equal to 20 Diameters of the Earth; the Revolution therefore of this nearest Moon is 350 of the said Diameters; and according to the supposed Time of the Revolution, this runs in one Day in its Way about *Jupiter*, 201 Diameters of the Earth; and *Jupiter*, according to its before-supposed Distance and Time of its Revolution, runs 73 Diameters in its Orbit about the Sun in the said Space of a Day; so that this Moon runs in its Orbit about twice or thrice as fast as *Jupiter* itself, and consequently a great deal above 100 times faster than a Cannon-Bullet, tho' it be as big as the Earth itself. See *Huygens's Cosmotheoros*, p. 101.

### SECT. LXVI. *The amazing Force that is requisite to move Jupiter.*

Now if one would form an Idea of the amazing Greatness of that Power by which the said Planet is moved, it having been proved before, that the Diameter of *Jupiter* is 20 times greater than that of the Earth, it follows that the former Planet is 8000 times bigger than the latter.

Now those who understand Mechanicks know, that by multiplying the Mass of two Bodies, each of 'em by its own Velocity, the Proportion of the Powers that move them, may be learned from thence: Supposing then that the Earth's Magnitude to be as an Unit, and the Velocity of the Cannon-Bullet to be likewise as an Unit, the Force that must move the Earth with the same Swiftnes as a Cannon-Bullet is moved, must also  
be

be as an Unit, because an Unit multiplied by itself, produces only an Unit.

And in this Comparison the Globe of *Jupiter* must be supposed as 8000, and its Velocity as 54, because it moves in its Orbit 54 times swifter than a Bullet; which being multiplied with the other, gives 432,000 for the Force that moves *Jupiter*.

So that it is irrefragably proved hereby, that the Force which moves *Jupiter*, and consequently the Strength of the Planet itself, is at least 432,000 times as great as that which is capable of causing the Earth to move with the same Velocity as a Bullet is discharged from a Cannon.

We suppose here the Density of the Parts of which the Earth and *Jupiter* are composed to be equal; tho' some reckon that of the Earth to be greater than *Jupiter's*; yet this Difference will not hinder the said Number from remaining a great many Thousand Times more; but this is not the Place to make so nice an Enquiry in.

SECT. LXVII. *Convictions from the whole.*

Now they that hitherto doubt, whether there be a mighty Creator and Director of this Universe, let them sit down by themselves, and seriously consider, *First*, How these Planetary Globes so amazing in their Magnitudes, are whirl'd about the Sun with so dreadful a Velocity, so far surpassing the almost unconceivable Motion of a Cannon-Bullet.

*Secondly*, How other Planets, or Moons, each of which will hardly yield in Magnitude to the Earth, are carried with a yet greater Swiftnes about the aforesaid Planets.

*Thirdly*, That neither the Motion of *Jupiter* in his Orbit, nor of the rest of the Planets, can be performed but by a Force so many thousand

times greater than that mighty Strength by which a Globe as large as the whole Earth is driven with the same Velocity as a Bullet shot out of a Cannon.

And if this last Force, whereby the Earth can be so swiftly moved, surpasses all human Conception, what shall we say of that which moves the Planet *Jupiter* in the Heavens?

SECT. LXVIII. *The Evasions of Atheists, and their Pretences.*

I KNOW very well, that in order to elude the Proof of an All-ruling God, which is so terrible to Atheists, those miserable Wretches are wont to conceive the Motions of these vast heavenly Globes, as they were so many round little Balls, floating and circulating in a Vessel of Water, which happens when the Water is put into a Circular Motion; and they are not a little confirmed in such Fancies, by the Figures with which Astronomers are used to represent the Structure of the World, as may be seen in *Tab. XXII. Fig. 1, and 2*, where we find the Revolutions of the Planets represented like the forementioned Balls in Water, upon one and the same Plane; inso-much that there does not seem to be wanting any other Direction for their Motions, than only conceiving a circular Motion of the Matter in which they swim, and the rather, because if one moves the Water in a round Vessel swiftly about with a Stick, we may often observe some of the little Particles thereof whirling about their own Axes, and at the same time carried about the common Center; from whence they infer, That the Moons also of *Saturn* and *Jupiter* may be likewise carried about their respective Planets, as here at *F* and *H*, without any particular Direction.

And thus these deplorable Disputers are used to contemplate, and to account for the Wonders produced in the Heavens, without considering them otherwise than as very different Figures and Resemblances; and to make their Opinions pass with greater Appearance of Truth, they use those shallow Maxims of some Philosophers, That the most simple Hypothesis or Notions that People form of things, are always the truest, which being easily agreed to by the Ignorant, and those who endeavour to evade the Labour of a just Inquiry, satisfies them the better, and procures them the more Disciples.

But in case things happen'd after such a manner, yet from the Motion of this Matter that runs round, (if there be any such Matter) an overruling Power of the great Director may be clearly enough demonstrated; since Experience teaches (as shall be more fully proved by and by) that all simple Motions are perform'd in Right Lines, and that Bodies can by no means describe Circular ones without some particular Direction.

SECT. LXIX. *Those Evasions answer'd; First, By the Orbs in which the Planets move.*

BUT now when we turn away from this fictitious Heaven, which has no other Foundation but in the Fancy of those who only make use of it, that they may more conveniently (or according to them, more simply) form an Hypothesis for the Appearances that are most obvious to them; and if we further apply our Contemplations, without any Prejudices, to those Things which the true Inquirers have discover'd by their Observations, about the Motions of the Planets, it may be concluded, and not obscurely, by every one, that the former Evasions are groundless: For, *First.*

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all these great Globes are far from being moved in one and the same Plane, as they are represented in *Tab. XXII. Fig. 1.* and tho' this be the usual Figure by which Astronomers represent the System of the World; we are to suppose the Planes of the Orbit of the several Planets to cut thro' each other, like two Hoops placed obliquely in each other. For Instance, let the Plane of the Paper upon which is drawn the third Figure in *Tab. XXII.* be the Plane in which the Sun revolves about the Earth (or the Earth about the Sun, for we do not dispute that Matter here) and let the Oval Figure *E A F B*, be in this same Plane; then let us farther suppose the second Oval *A C B D* to be so placed, that the Part *A C B* be above, and the other Part *A D B* under the Plane of the first Oval; so that these two Planes, like the two abovesaid Hoops, have nothing common to each other, but one only Right Line *A S B*. If then we take this last *A C B D*, for the Way of any Planet, we shall perceive how it differs from the Plane of the *Ecliptick*, that is, from the Sun's or Earth's Way, and makes an Obliquity with the same, so that there remains, between both the Planes, a Width, or Breadth, on the one Side, as *C F*, and on the other of *D E*.

### SECT. LXX. *The Properties thereof.*

Now to form a fuller and truer Notion of the Planets Orbits, we must lay down some Conclusions which are known and agreed to by all Astronomers, namely, That,

*First*, The Way or Orbit of each Planet is in a particular Plane, and peculiar to itself, so that at one Time it is at *C* above, and another Time at *D*, under the Plane *A E F B* of the *Ecliptick*.

*Secondly*,



Secondly, That even the Moons of *Saturn* and *Jupiter* don't move in the same Plane in the which either the Orbit of their Planet, or the *Ecliptick* lies; but that they decline from both, and according to the most accurate Observation, compleat their Course in a particular Plane. See *Whiston's Prælect. Astron.* p. 201. where he reckons up their Appearances.

Thirdly, That each of these particular Planes, in which the Planets move, do never intersect the Plane of the Sun's Way in the same, but all in different Lines: So that, for Instance, if *Mars* does it in the Line AB, *Jupiter* will do it in the Line RT, &c. See *Whiston's Prælect. Astron.* p. 191.

Fourthly, That even the Obliquities or Angles which the Planes of the Planets Orbits make with the *Ecliptick*, do not agree in any two, so as to be the same, but are different in all of them: They who desire to know the Occasion and Measure of these several Intersections and Obliquities of the Planes (called by the Astronomers the *Inclinations*, *Latitudes of Planets*, and *Lines of Nodes*) such as AB, TR, and CF, ED, may meet with 'em in the *Automaton*. of Mr. *Huygens*, p. 447, and elsewhere.

Fifthly and Lastly, We are to know, That all these intersecting Lines AB, TR, &c. tho' they all of 'em differ, yet each of 'em pass through the Sun S; so that that Luminary shines upon the Intersections of all the Planes of the Planets Ways.

SECT. LXXI. *Convictions from thence.*

IT is needless now to observe, how much this differs from Globes or Balls floating in Water on the same Plane or Superficies. And I leave the most obstinate Atheist himself to judge, whether

it be by mere Chance, or ignorant Laws of Nature, and without any directive Power, that such vast Globes (some of which are likewise attended with their particular *Satellites*) should each of them move about the Sun in a different Plane; and that every one should have continued his Course for so many Thousand Years, without ever failing, and unvariably preserv'd the same Obliquity, tho' the Swiftneſs of their Motion is ſuch as far to ſurpaſs that of a Cannon-Bullet.

And in order to be convinced of the contrary, let an Atheiſt fancy to himſelf a Machine, repreſenting to his View in little, the Motions of ſo many Globes about another Globe, each of them in an oblique Courſe one to the other, and every one of them moving with the ſame Velocity as a Man can throw a Stone, and at the ſame Time let him not know how theſe Globes are moved or projected. Now, if he diſcovered, or was told that every one of theſe Globes had continued in ſuch a Motion but a few Years, without any Confuſion, and did continue ſo daily, would he not think ſuch a Machine to be the Workmanſhip of the greateſt Artiſt in the World? How dares he then ſay otherwiſe of ſuch an unconceivably glorious Machine as this ſtarry Heaven?

SECT. LXXII. *The Atheiſts Eviſions Answer'd;*  
 Secondly, *By the Planets continual Approach to the Sun.*

Now if what has been already ſaid, concerning the wiſe and wonderful Direction of the Planets Motion, be not ſufficient to convince the moſt obdurate Atheiſt; a gracious God has vouchſafed yet farther to repreſent and manifeſt to the Sight of every one, ſomething in the Courſe of theſe heavenly Bodies that ſeems to  
 put

put beyond all Dispute the Greatness of that Power which rules and directs them, and to reduce the Matter to an entire Degree of Certainty. In order to prove this, we affirm, and no body can deny it, that it is experimentally true, That all Bodies when put into Motion, do go on in a Right Line, unless some other Cause or Power obliges them to recede from it ; and it is known, that a Stone A moved circularly in a Sling about a Point S (*Tab. XXII. Fig. 4.*) in the Circle AHDE, with such a Swiftness, that it cannot be brought down by the Force of its Gravity when it is at A, will not continue to move in the same Circle towards H, as soon as the said Sling is loose, and the Stone left to itself, but pursue its way according to the Right Line AF, which touches the Circle at A ; and this happens not only in a Circle, but in all other Curve Lines, as Experience teacheth us.

Now let the best Philosopher tell us, how it comes to pass, that such great Bodies as these Planets are, moving about the Sun with a Swift-ness so much greater than that of a Cannon-Bullet, and with so prodigious a Force as has been shewn above, do not likewise obey this Law, and run always in a strait Line, but describe incessantly a Curve Line, and always return to the Point from whence they began ; and how these moved Bodies are compelled every Minute to depart from their Right Line, and describe by their Course, the Orbit which they do.

For that the Planet A (*Tab. XXII. Fig. 5.*) being moved about the Sun in the Curve Line AEDZ, when it is at A endeavours to go to F, along the Tangent AP, and when at G tends to I, along another Tangent GQ, is disputed by no body. Tell us then the Reason why such a great and swift Globe, certainly tending from A to F, and  
from

from G to I, is continually protruded or attracted to the Sun, or at least is brought nearer to it; so that AF and GI, being the Lengths which the said Planet is to run at each Place in the following Minute, in the Tangent Lines AP and GQ, it is forced to forsake them, and, in the very same Instant, to approach so much nearer to the Sun, as the Lines FG and IH are in Length; without which it would not be possible that this Planet could continue in its Curve Way AEDC about the Sun?

This is not to be answer'd by the Hypothesis which some Philosophers have hitherto maintain'd, That the Sun has a Vortex of a subtile Matter about it, which running round, drags the Bodies of these Planets along its Stream; forasmuch as the Gravity thereof remains the same; therefore they are bound to shew why that Matter itself describes a Curve Line, and does not, like other Things, move directly, according to Tangents; so that here likewise we must have recourse to a Power that governs the Motion of this Matter: But the famous Mathematician Sir *Isaac Newton*, and others, have shewn, that we seek in vain the Properties of this circular Motion in the Matter of the Vortices.

SECT. LXXIII. Thirdly, *By the Course of the Planets in an Ellipsis.*

BUT to cut off all Cavilling about this Difference, it may be sufficiently proved from the Property of the Curve Line, according to which each of these Planets are moved, that there must be an incessantly directing Power that regulates their Courses, and that they cannot alone be carried forwards by any circularly moving Matter.

For the continual Experience of all Astronomers that have succeeded the Great *Kepler*, and Observations so frequently repeated, have put it sufficiently out of all doubt, that the Planets are not moved in exact Circular Figures; in which Case it might be supposed, with some Appearance of Truth, that there is such a whirling Matter; but they are Curve Lines of quite another Property than Circles, and appear by manifold Observations to be *Ellipses*, or oval Figures, as you see in *Tab. XXII. Fig. 5.* A E D Z.

In these *Ellipses*, as is well known to the Mathematicians, there are two Points K and S, each of which they call a *Focus*, or *Point of Burning*, from whence the same may be described by a String K E S, fasten'd at K and S, and by a Nail at E, which being directed by the String, describes the Circumference E D S A, as is known to Carpenters, Joiners, and other Mechanicks.

In one of these *Foci* is plac'd the Sun S, about which the Planet is continually moving; A is the remotest, and D the nearest Point of the Orbit in respect of the Sun; for which Reason likewise, A the farthest, and D the nearest Point to the Sun, are termed by Astronomers, the *Aphelium* and *Perihelium*.

SECT. LXXIV. Fourthly, *Because their remotest Points extend to different Parts of the Heavens.*

AND that no body may imagine neither, that any ignorant Laws of Nature have any Place here in a Stream of *Vortices*, or whirling Matter; the adorable Creator, who alone will be acknowledged and glorified herein, has shewn, with irrefragable Proofs, his absolute Empire over these great Bodies, and likewise his wonderful Power in those vast and remote Spaces; for which Purpose

pose he has not thought fit that the *Elliptical* Orbits of the Planets, as AEDZ, and LR, MT, (which very much differ in Magnitude and Distance from the Sun) should have their *Aphelia* A and L extended from the Sun S towards one and the same Place of the Heavens, as B; which would have appeared more convenient to our Conceptions, and might have been used as a Principle to discover, after this manner, a general Law of Nature, whereby we could have accounted for these Motions and Dispositions in the Heavens.

But on the contrary, to the End that every one who contemplates these great Works, might be certain, that it is only the irresistible Will of a supreme Director of all things that has place in this Matter, he has so order'd the Orbits of the Planets A and Y, namely, AEDZ and YVNW, for so many Ages, that the one seems to be entirely independant of the other; placing not only each of them in a different Plane obliquely upon the other, as we have shewn above, but likewise causing all the Lines proceeding from the Sun S, thro' the *Aphelia* or remotest Points A and Y, to tend to different Parts of the Heavens, as B and C, altho' the said Sun S, with respect to which only he has made them, does sufficiently appear in common to one Focus in all these *Ellipses*: The Truth of this may be seen in all the Books of the Astronomers, and particularly the Places of the *Aphelia* of each in the *Automaton* of Mr. Huygens, p. 441.

SECT. LXXV. *Convictions from thence.*

Now after having well conceived all this, those who think it concerns them to learn God from his wonderful Works, will be pleased to use  
their

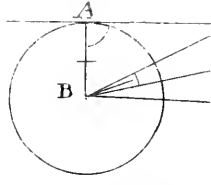


Fig. 2.

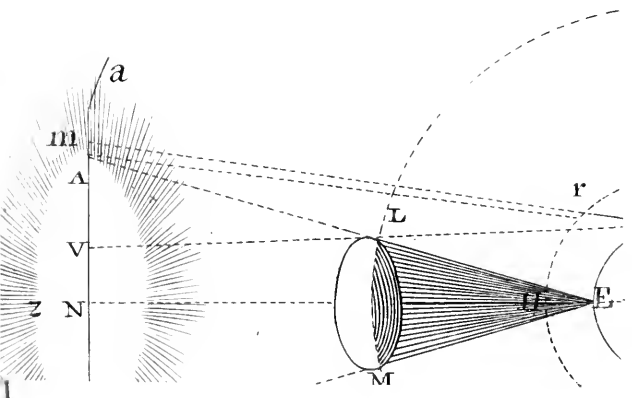
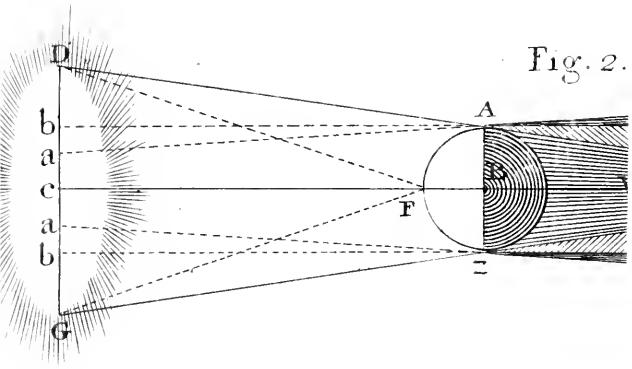




Fig. 2.

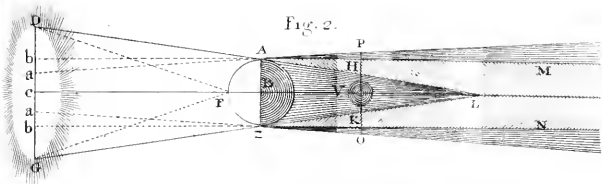
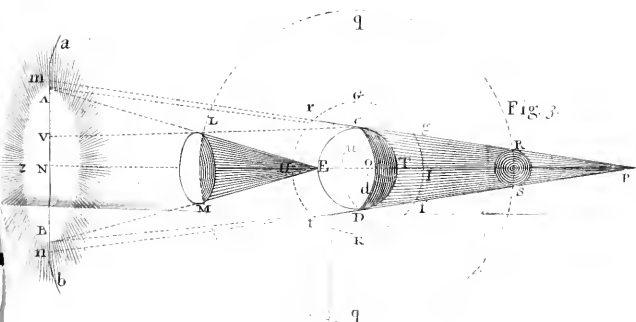


Fig. 3.





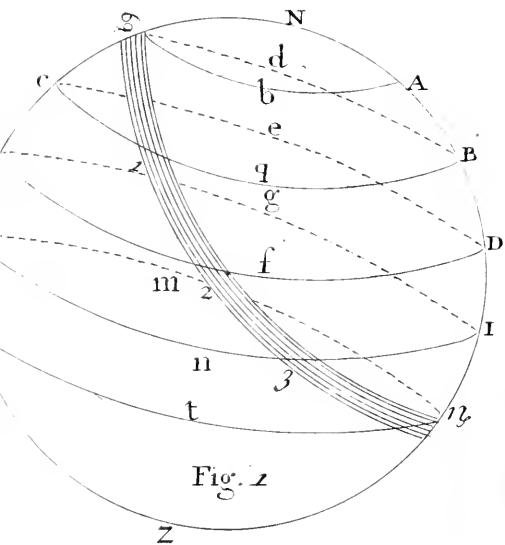


Fig. 2

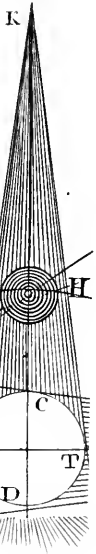
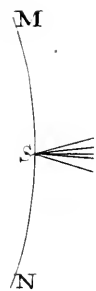
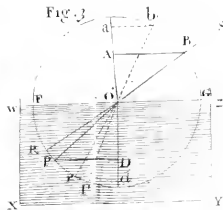
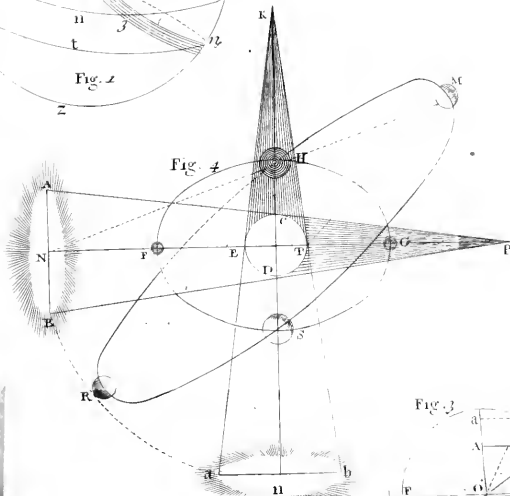
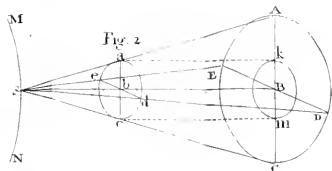
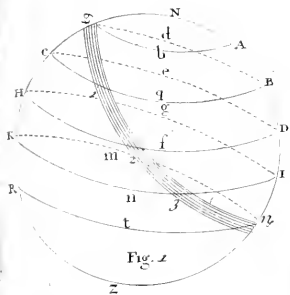


Fig. 4



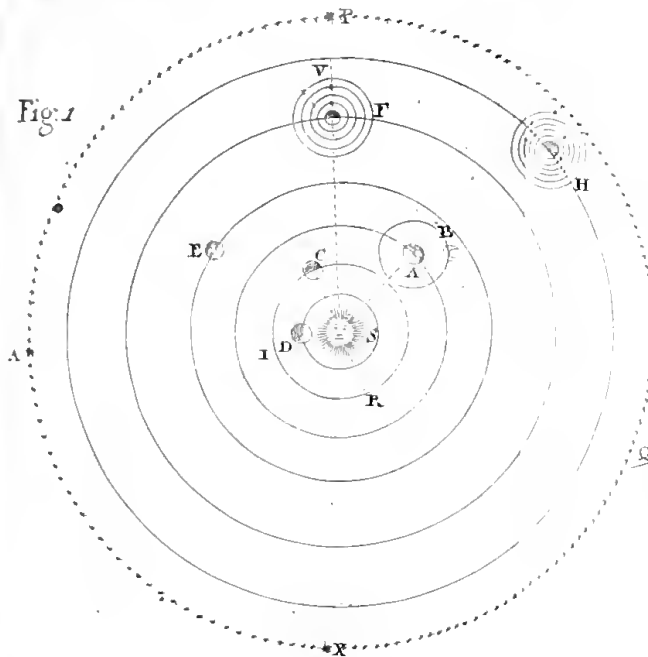


Fig. 1

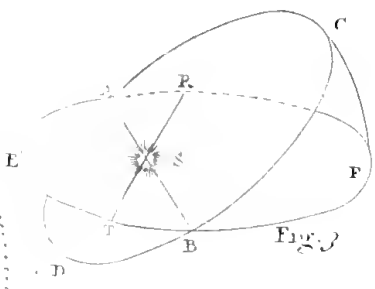


Fig. 3

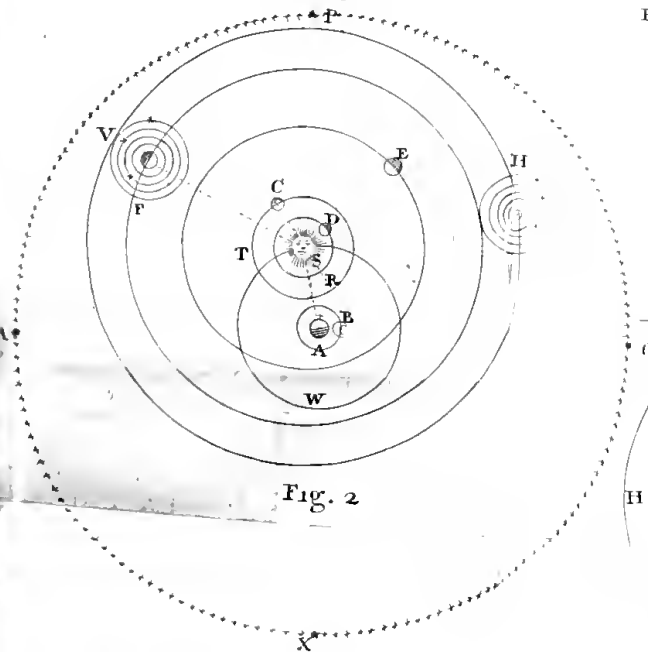


Fig. 2

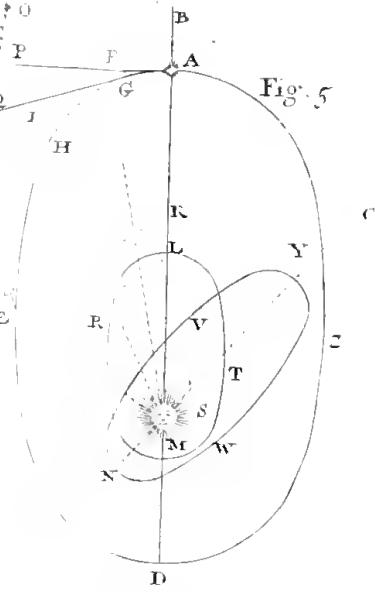


Fig. 5

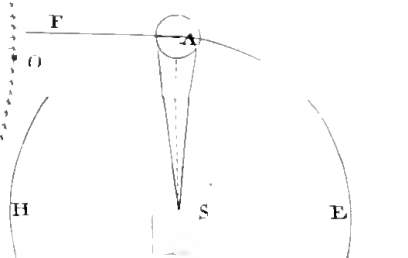


Fig. 4

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their Endeavours, first, by what has been said, to gain a true Notion of the Planetary Heavens familiar to them, and comparing one thing with another, to consider whether a Man argues without Foundation, who maintains, that the Power and Wisdom of the Great Creator shines out more brightly here than the Skill and Contrivance of the Workman in the most curious Clock, or any other Machine whatsoever.

For, *First*, considering the almost unconceivable Magnitude of these wandering Globes, and their Distances from the Sun, which may only and easily be determined by the Diameters of the Earth. And, *Secondly*, seeing that *Saturn*, tho' it be distant from the Sun at least 100,000 of the said Diameters, according to the latest Observations, between every two following Points of its Orbit, is always attracted towards the Sun, notwithstanding there is not the least Band or Connexion between the one Body and the other. *Thirdly*, Finding that these Approaches to the Sun have place in all the Planets, tho' there is likewise no Union between any of them. *Fourthly*, Knowing that each of them performs its Course in a particular Plane. *Fifthly*, That they describe no Circles which we see generated in natural Motions, after different manners, but to shew that a particular Direction obtains here, they move in *Ellipses*, or oval Figures, every where preserving their Geometrical Properties. *Sixthly*, That these oval Figures are each of 'em extended lengthwise to a different Place in the starry Heavens. *Seventhly*, That their Motions have continued for many Ages in this Order, without any Confusion among each other. And, *Finally*, since no body who understands it right, can, without Amazement, observe, That these Globes of such an amazing Magnitude (that *Jupiter* is at least

8000

8000 times bigger than the Earth; and the rest, excepting *Mercury* and *Mars*, which are somewhat smaller) are either as big or bigger than the Earth, itself, and yet all of 'em move about the Sun with so prodigious a Swiftneſs, as far exceeds that of a Cannon-Bullet.

SECT. LXXVI. *The Motion of the Planets about the Sun.*

NOW if we reflect upon the Experiments, which, besides the foregoing, have been made by the modern Astronomers, and would be too tedious to be related here, new Wonders will occur to us at every Turn, and always administer fresh Occasion of acknowledging a tremendous Power, and a Direction continually exerting itself.

To say nothing therefore of the Comets and their Courses from and to so many different Places of this immensurable Space, since neither their Causes, nor the Ends for which they have been made, do yet fully appear to us: Let us once again bring before our Imagination those great Celestial Globes, the Planets, and consider, that in that incomprehensible Motion with which they circulate about the Sun in their Orbits, they likewise revolve or turn upon their own Axes from West to East, at least it has been visibly observed already in *Jupiter*, *Mars*, and *Venus*, and even in the Sun itself.

Thus we find (to say nothing of the Earth, since all Astronomers do not agree therein) that that dreadful Globe of Fire, the Sun, turns round upon its own Axis in 25 Days; *Venus* in 23; *Mars* in  $24\frac{2}{7}$ ; and the great Globe of *Jupiter* in 10 Hours. See *Gregory's Astron.* p. 36. As for the rest, we have not yet been able to discover any thing certain about them.

And

And in order to convince every one of the Dreadfulness of the Powers which exert themselves in this Matter, we need only investigate the Swiftneſs wherewith theſe great Globes are carried about their reſpective Axes after the following ſimple Manner.

For ſuppoſing the Earth's Diameter to be 6.538,594 *French Toiſes* or Fathoms long, the Circumference thereof will contain 23.541,600 of the ſame, ſince the Diameter of a Circle is to its Circumference, as 7 to 22, or yet nearer, as 113 to 355.

Now each Point that is upon the Surface of the Earth at the Equator would run ſo many Fathoms in 24 Hours, and conſequently  $237\frac{3}{4}$  in one Second of an Hour.

But a Cannon Bullet (as has been ſhewn above) runs 100 of the like Fathoms in a Second.

Conſequently every Point upon the Equator of the Earth revolves with much more than twice the Swiftneſs of a Cannon-Bullet.

If then, according to this Proportion, the Velocity in the Revolutions of the other Planets be meaſured, and if it be ſuppoſed (to ſpeak within compaſs) that the Diameter, and for the ſame Reaſon the Circumference of the Sun, is but 100 times bigger than that of the Earth, we ſhall find, that ſince it employs 25 Days in one Revolution about its own Axis, it turns four times as ſwift as the Earth, and each Point in its Equator conſequently is moved 8 or 9 times as faſt as a Cannon-Bullet.

So likewise *Jupiter*, which is 20 times as big as the Earth, and revolves in the Space of ten Hours, would carry every Point in its Equator 20 times as faſt about its Axis, as thoſe of the Earth; ſuppoſing that this Planet ſhould likewise require 24 Hours for that Purpoſe; but as it performs

forms the same in 10 Hours, its Velocity will be yet  $2\frac{2}{7}$  times greater, or *Jupiter* will revolve 48 times swifter than the Earth, and each of the aforesaid Points move above 100 times faster than a Cannon-Bullet.

SECT. LXXVII. *The Velocity of Saturn, and of his Ring.*

LET us moreover cast our Eyes upon *Tab. XXIII. Fig. 2.* or the Representation of *Saturn A*, and its Ring *GI*, and consider, that this Globe *H* is about 2000 times bigger than the Earth, and that the Ring *GI* is full 4 times as broad as the Globe of the Earth is thick, and that the Space likewise between the said Ring and the Body of that Planet, is not less in its Breadth. Again, that this Ring is thin and flat, and no way adheres to *Saturn*, but is quite loose round about, as has been hinted above; yet that this Ring never forsakes nor stays behind *Saturn* in its Motion but always accompanies it with equal Velocity, and has done so for many thousand Years, notwithstanding that that Globe moves about 20 times as fast as a Cannon-Bullet, as may be easily computed after the above-mention'd manner.





## CONTEMPLATION XXV.

*Of the Unspeakable Number, and Unconceivable Smallness of the Particles of which the UNIVERSE consists.*

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### SECT. I. *Transition to the Smallness of Parts.*

**I**F now, after having contemplated the visible World in some of its Parts, we turn our Thoughts farther, to those so wonderfully small and numerous Particles of which it consists; and then consider the Laws which they continually obey, though ignorant of the whole, and even of themselves too; and which Laws the Great Creator has been pleased to render subservient to the Execution of his marvellous Purposes; that Man must be quite blind and inexcusable, who cannot discover therein, the Power, Wisdom and Goodness of an adorable Ruler of the Universe.

The Reader must not expect to meet here with an exact Description of the Figures thereof, forasmuch as without ever being thoroughly fathomed or comprehended, they will always furnish new Matter of Inquiry to learned Men, as long as this Universe shall be preserved in its present State and Condition. We shall therefore only consider some Matters and Bodies with respect to their Smallness, not perhaps so thoroughly as the accurate Truth of the Thing may require, but only so far as Experience may lead us therein.



SECT. II. *All Bodies consist of small Parts.*

NOW that all visible Bodies do consist of an unconceivable Number of such little Parts, is already admitted by all Philosophers, and demonstrated too by so many Experiments and Proofs, that no Body who has taken the least Trouble of examining the Nature of Creatures, can entertain any kind of Doubt thereof. Concerning which, *Robault's Physics*, *Boyle's Subtil. Effluvia*, *Keill's Introduction*, and other Books may be consulted.

SECT. III. *Our Conceptions must be Rectified.*

BUT as our Imagination is incapable to represent to us the amazing Magnitudes of the Heavenly Bodies, so likewise we find it as little able to give us just Ideas of the Smallness of the Parts whereof all visible Things are composed; for which Reason as the former, so likewise the latter is by many thought incredible, especially by some of those, who, when they conceive Things according to Truth, are afraid they shall discover in them a great and terrible God.

SECT. IV. *A Cubical Inch contains a Million of visible Particles.*

ALL kinds of visible Bodies may be divided into *Fluid* and *Solid*; we will begin with the First:

And before-hand advance what *Mr. Boyle* in the beginning of the second Chapter *de Subtil. Effluv.* affirms to appear by Experience; namely, that the Length of an Half-Inch, can be divided into 100 Parts, which shall all of 'em be big enough

enough to distinguish themselves for Use; but we, to prevent all Cavilling, will only maintain the same of an entire *Rynland-Inch*; from whence it follows, that a Cubical Inch, or a square Stone, which is an Inch long on all Sides, contains a Million of such little Cubes, each of which in all their Dimensions, or in their Length, Breadth, and Thickness, are no more than the  $\frac{1}{1000000}$  of an Inch long, which is known to every one that is a little versed in the Principles of Geometry.

So that we may safely lay it down for a Truth; (since if the Length of such a small Cube is visible, the whole little Cube will be much more visible) *That a Cubical Inch contains a Million of visible Parts.*

SECT. V. *A Cubical Inch of Water contains the like Number of Parts.*

Now if the Point of a Needle can be ground so sharp, that the Bigness of it may be equal to the Bigness of such a small visible Particle; and that this Point were to be just dipt in Water, and being drawn out again, should appear wet, or that some Water cleave to it, all which may be allowed without any Difficulty: If then it should be farther supposed, that there was but one only Particle of Water that stuck to it, and (for the more convenient Computation) that it was as thick as the little Superficies of the Point of the said Needle; and moreover, of a Cubical Figure, it is plain from the Premises, that it is no bigger than  $\frac{1}{1000000}$  Part of a Cubical Inch of Water, and consequently that such an Inch contains a Million of Water-Particles, which if they were separated, would each of 'em be so big as to be visible. From whence it follows, that such a vast Quantity of Cubical Inches of Water as are in the Uni-

verse, in Air, Earth and Water, and are moved, must certainly contain so many Millions of Parts, and be as certainly moved.

SECT. VI. *A Cubical Inch of Water Rarefied in an Æolipile, will yield above 13300 Millions of Parts.*

BUT to proceed a little farther; Mr. Boyle, in the Third Book of the above-mentioned Treatise, says, that (See *Tab. XXIII. Fig. 3.*) an Ounce of Water EFG, being put into a Copper Globe A, in which there was a little Hole at B; the said Globe, commonly called by the Learned an *Æolipile*, was put upon the Fire; whereupon the Vapours of the Water begun to be protruded thro' the said little Hole B, which produced a Pyramid of Vapours DBC, for the Space of 18 or 20 Minutes; the Length of which BR, was twenty Inches, and the greatest Breadth at CD, was of one Inch: Yet so, that at the Distance BM, (being five or six Inches farther than BR) they could perceive vapoury Clouds still hanging together, which extended themselves to the Breadth of four or five Inches at KL.

If now for the more easy Reckoning, we consider the long Pyramid BDC, joined to the short one DCKL, as one only Pyramid; the Length of which from B to R, is of 21 Inches, and the Diameter from C to D of  $1\frac{1}{2}$  Inch, the Superficies of the Circle CNDG will be  $\frac{22}{7}$  Superficial Inches, which Multiplied by 7, (being the  $\frac{1}{7}$  of BR or 21) will amount to the Magnitude of  $\frac{22}{7}$ , or  $12\frac{2}{3}$  Cubical Inches for the whole Vapour-Pyramid.

If this had been computed nicely according to Mr. Boyle's Measure, the long Vapour-Pyramid BCD, together with the short Cloud-Pyramid

CDLK, would amount to above 32 Cubical Inches, tho' we should reckon BR to be but 18, CD, 1, RM, 5, and KL, 4 Inches; but for the greater Conviction, and to prevent all Cavilling, we have reckoned it all to be but 13 Inches.

Let us now suppose, that one of the Particles of the Vapours rushing out of the aforesaid *Æoli-pile*, runs the Length from B to R in the Second of a Minute; so that in every Second there is a new Vapour-Pyramid formed: There would then in 18 Minutes, or in 180 Seconds, be produced so many different Pyramids.

Now each Vapour-Pyramid makes  $12\frac{7}{8}$  Cubical Inches, and consequently all the Pyramids that are formed from one Ounce of Water, will produce  $12\frac{7}{8}$  times 1080, or 13,365 of the like Inches. If now in each visible Particle of all these Pyramids there is but one Particle of Water (since there are a Million of them in one Inch) there will be in the whole 13,365,000,000, and consequently one Ounce of Water may be really divided into 13,365 Millions of Parts at least.

But since it is desired to know farther, into how many Parts an Inch of Water may be likewise divided after the said manner; let us suppose, that a Cubic Foot of Water weighs 64 Pounds, and that there are 10 Inches to a Foot; accordingly a solid Foot will contain 1000 of such Inches, and at the rate of 16 Ounces to a Pound, there will be 1024 Ounces in 64 Pounds. From whence it is easie to prove, that a Weight of one Ounce makes  $\frac{1}{1024}$  or  $\frac{1}{256}$  of (or rather almost so many Parts of) an Inch; so that we may safely enough affirm, that a Cubical Inch of Water is according to this way divisible into 13,000 Millions of Parts.

SECT. VII. *There may hang about 13,000 Particles of Water to the sharp Point of a Needle.*

Now it appears from *Section the 5th*, that the Water which may stick to the extreme Point of a Needle, which is so sharp as to be just visible, and the Breadth of which is  $\frac{1}{1000}$  part of an Inch, may safely be allowed to amount to the thousand thousandth part of an Inch.

Therefore it is sufficiently certain, that this little Water that sticks to such a fine Point, does consist of no less than 13,000 Particles, if it be only a little Cube of Water that has the same Breadth.

SECT. VIII. *That a Drop of Water is divisible into above 26.000,000 Parts.*

BUT now let us compute with Amazement, how many Parts are to be found in one Drop of Water, upon the Supposition which has been just now proved, that as oft as one dips the Point of a Needle or fine Pin, and something adheres thereto, so often there are 13,000 Particles of Water requisite to compose the said Drop.

Now to form a rough Conception of this Matter from another Method; let a Drop of Water be supposed to be of the Weight of a Grain, of which 480 go to an Ounce Troy-Weight, and compute according to the Rule of Three, that if 480 Grains gives  $\frac{2 \frac{1}{2}}{1000}$  Parts of an Inch, what gives one Grain; and we shall find it to be full  $\frac{1}{480}$  Part of an Inch.

Now to lose nothing, and to allow enough, let us make the Calculation with a smaller part of an Inch, namely, with the  $\frac{1}{1000}$  thereof; and suppose that a single Drop, tho' it be greater, does  
not

fronting p 352.

Fig. 2

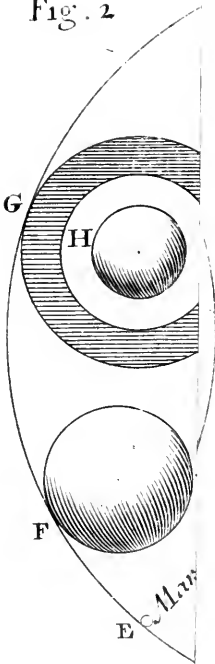
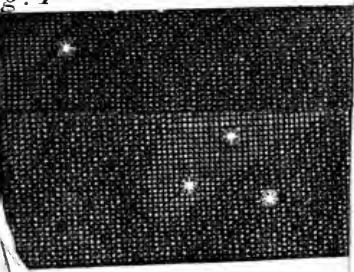
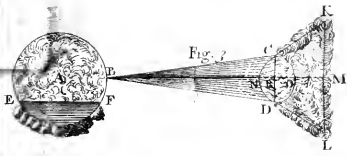
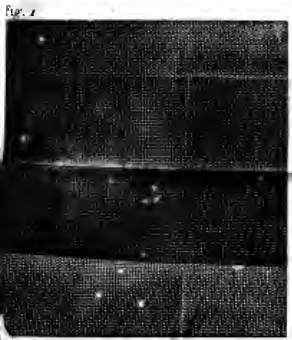
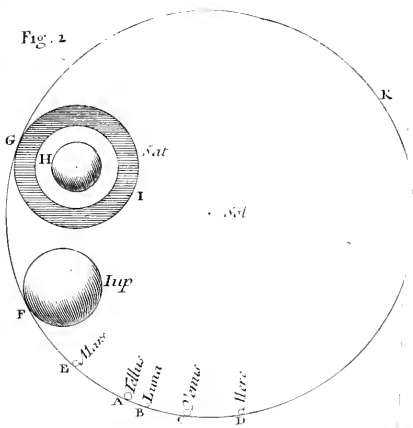


Fig. 1





not contain more Water Particles than the said  $\frac{1}{1000}$  Part.

Now a cubical Inch of Water contains 13,000 Millions, or a Million of times 13,000 Particles, consequently  $\frac{1}{1000}$  of an Inch, or one Drop contains 2000 times 13,000 Water Particles, or in one Sum 26.000,000, that is, six and twenty Millions thereof; of which if we again cast away six Millions, because we don't desire to have too much granted to us, it seems plain beyond Contradiction, that *in one Drop of Water* no bigger than  $\frac{1}{1000}$  of an Inch, there are at least not fewer than *twenty Millions of Water Particles.*

SECT. IX. *Convictions from the foregoing.*

BEFORE we proceed any farther, let an Atheist stop a little here, and consider with us, how great and how penetrating that Providence and Direction must be, which before a Drop of Rain Water of the Quantity and Weight only of one Grain shall fall down upon the Earth, has thought fit to compound it of so many Millions of Parts.

And if he should refuse, as he has hitherto done, to own a Providence herein, let him tell us, whether he can persuade himself, that such an innumerable Multitude of Millions of Water-Particles could by mere Chance, or without any Wisdom and Direction for so many thousands of Years continually and incessantly proceed from Seas, Rivers, and other moist Places, rise up into the Air, divide themselves into Clouds, as it were into so many Armies; where floating in that thin Matter, they are carried by the Winds towards so many different Parts, in order to compose whole Streams and Rivers; to descend in Rains upon the dry Ground; to cause the Fruits



of the Earth to grow; to furnish Drink to all kinds of Animals; in a Word, to perform all those Functions and Services which we have before ascribed to Water, and to preserve the whole Globe of the Earth with almost all that is upon it, or proceeds out of it, alive and in good Condition. Certainly, if this Atheist be any ways reasonable, he must stand amazed: *First*, At that Power which has made so many Thousand Millions of Water-Particles, as are to be found in Brooks, Rivers and Seas, and preserved them in their Motion, Figure, and Quantity. *Secondly*, He can never sufficiently praise that most adorable Wisdom that has separated, and as we may say, rent all these Particles, and set each of them, how little soever they be, loose and free from the rest; without which Division they could not have ascended by reason of their Weight, nor hardly been of any Use. And *Lastly*, That he is bound to return Thanks to this so gracious Benefactor, who has made such an unspeakable Number of Beings subservient to his, and all other Men's Advantages, after so multifarious a manner.

SECT. X, XI, and XII. *This Hypothesis founded upon the Observations of Mr. Leuwenhoek, namely, That a Drop of Water contains many more than one Million Millions of Parts; the same applicable to all kinds of Liquids.*

I HAVE been willing to prove here by degrees, that the Particles of Water are exceeding small, to the end, that I might not at first deter our Imagination from contemplating the same, by reason of such a Smallness of which it can scarce possibly frame any *Idea* to itself; and therefore the Reader will be pleased to judge from what follows, whether he must not agree, that altho' the

the now computed Smallness does seem already to escape our Imagination, yet that it is far different from that which we must necessarily allow to be found in the Particles of Water.

Now to shew this, we will lay down for a Foundation, the Experiments of Mr. *Leuwenhoek*, as they are described by him in his Letter of the 12th of Nov. 1680, p. 29; where he relates, that he distinguished in Pepper-Water, in the Sperm of Animals, &c. three sorts of *Animalcula* of different Sizes, of which if we take the Diameter of the smallest for the Measure of the others, and call it an Unit, that of the Second or next biggest *Animalculum* or Insect will be 10, and that of the Third or biggest 100 times as long as the Diameter of the Second; so that the Diameter of this last, is  $1 \times 10 \times 100$ , or 1000 times as long as that of the First.

If now for the more convenient Calculation, this last *Animalculum* and a Grain of Sand be supposed to be of the same Figure, for Instance, that each of 'em be either globular or cubical, the Grain of Sand will be so much bigger than the Body of this *Animalculum* as the Cube 1,000.000,000 of the Diameter 1000 of the last is bigger than the Cube 1 of the Diameter 1 of the first, and consequently we see that *such a Grain of Sand is equal to 1000 Millions of these Animalcula, each of which are visible thro' a Microscope.*

Now Mr. *Leuwenhoek* (in his Discoveries the 26th of April, 1679, p. 14.) supposes that 100 Grains of Sand are equal to an Inch in Length; so that 1,000,000 of such Grains compose a Cubical Inch.

If then we argue after this manner :

Since 1,000.000,000 *Animalcula* go to one Grain of Sand, and 1,000,000 Grains of Sand to an Inch, which we here reckon at  $\frac{1}{12}$ , and not  $\frac{1}{25}$  part

part of a Foot) there will be contained in such a Cubical Inch, 1,000.000,000.000,000 of those *Animalcula*.

But according to *Seet. VIII.* it appears, that one Drop of Water is  $\frac{1}{3000}$  of an Inch; so then according to that Calculation, 2,000,000.000,000 *Animalcula* are but equal to such a Drop of Water.

But to prevent any Objections against the said Calculation, we will abate the half of it, according to which there will be then a *thousand times a thousand Millions of these Animalcula capable of being contained in one Drop of Water.*

Let us stop here again, and reflect with Amazement at that dread Wisdom and Power, which before he causes one large Drop of Water to fall from the Air, makes use every time of such a prodigious number of watry Particles for that Purpose.

This last being now proved about Water, we may easily see that it is applicable to many other fluid Matters; especially to such as are wet, and which by sticking to solid Bodies, do moisten the same; for which reason we need not say any thing of Oil, Spirits and the like; but we will add a few Words about other Fluids that are not moist.

S E C T. XIII, XIV, and XV. *The Smallness of the Particles of Air, Fire and Light.*

THE abovemention'd Mr. *Leuwenhoek* in his 7th Continuation, p. 424. says, that having pressed the Air and Blood out of the little piece of the Lungs of a Sheep, he found that many of the Air-bubbles were so small, that they were hardly visible, even with a Microscope; insomuch that they must be smaller therefore than those *Animalcula*

*cula* which we have lately spoken of from him, and which could be seen: And consequently a Grain of Sand is more than equal to 1,000 Millions of the same, or a Cubical Inch will contain above 1,000.000,000.000,000 Particles of Air.

Now tho' some think they have reason to believe, that the Particles of Air are bigger than those of Water, because the latter can pass thro' Orifices or Holes, which seem impervious to Air; yet we see that the Particles of this latter are exceeding small, since it might be demonstrated here, That by reason of their Invisibilty, they far surpass in Smallness the aforementioned *Animalcula*.

Certainly that they do likewise penetrate thro' very narrow Passages, is not only plain from Plants, into all which they insinuate themselves, tho' we cannot discover any Pores or Cavities in some of them; but it is likewise well known to those that use Air-Pumps, who find how much Pains it costs them before they can exhaust the Air; at least if it may be proved, as perhaps it can, that the Particles of Water are smaller than those of Air; this is still sufficient to convince us particularly, that we are far from having as yet investigated the real Smallness of the Particles of Water.

Now how much more minute Parts Fire consists of, than all these above-mention'd Fluids, may appear from hence, that Air, Water, Oyl, and the like, are found to consist of such gross Parts, that they cannot pass thro' the Pores of Glais and other hard Bodies, as Iron, Steel, &c. and can therefore be excluded or kept out from Vessels made of those Materials; whereas there are no Passages, tho' ever so small, in any Bodies thro' which the Particles of Fire cannot penetrate; which appears by their rendring all Bodies either glowing, that is to say, full of Fire-Particles, or putting them into Fusion, or causing them

them to evaporate; of all which nothing could come to pass, if the Fire were not able to insinuate itself into the innermost Parts of those Bodies.

We should now pass on from the Fire in the last Place, to its Effluvia or Matter of Light, and give the Reader here a rough Sketch of the Fineness of the Parts thereof, since we are far from being able to trace the Multitude and Smallness of them, and particularly have given a certain Demonstration how many Particles of Light may be safely affirmed to fly out of a burning Candle in the Second of a Minute.

They that have not a mind to read the following Demonstration, may pass on to *Sett.* XVI, and XVII.

*A Calculation of the Number and Smallness of the Particles of LIGHT.*

I. IT is supposed, That the Flame of a Candle of Six to the Pound, may be seen at the Distance of 2000 Paces, or 10,000 Foot, each Pace being computed at 5 Foot; that is, from O to E. *Tab.* XXIV. *Fig.* 1.

II. It is plain then, Since the said Flame may be seen at the same Distance all round, that it fills the whole Globe or Circle R Q E S.

III. Now to find the Bigness of this Globe RE, we must first observe, that the whole Diameter is equal to twice O E, that is, 20,000 Foot.

And forasmuch as 100 is to 314 as the Diameter RE to the Circumference R Q E S, we shall find, by the *Rule of Three*, that this Circumference includes 62,800 Feet.

IV. Now

IV. Now if we multiply the whole Diameter by the Circumference, and that Product by the sixth Part of the Diameter, it will produce the solid Contents of the Globe R Q E S, being 41.866,000.000,000 Cubical Feet, as is known to all Geometricians.

V. If now we divide a Foot into ten Parts, and call each of them an Inch, 1 Cubical Foot will contain 1000 Cubical Inches; as the aforementioned Globe will contain 41,866.000,000.000,000 Cubical Inches, which for Shortness, and that we be not every time obliged to write the said Sum at length, we will express by placing the Number of the Cyphers omitted over the first Cypher: So that according thereto, such a Globe contains 41,8660<sup>11</sup> of such Inches.

VI. Again, Since a Candle of 6 to the Pound, will burn five Hours, it may be easily computed how much thereof will be spent in a Second; for allowing 3600 Seconds to one Hour, and to every Ounce (16 of which make a Pound) 480 Grains, Apothecaries Weight, we shall find by the said *Rule of Three*, there is burnt in one Second  $\frac{1}{325}$ , that is, full  $\frac{1}{17}$  Part of a Grain of Tallow.

VII. Now to know how many of these Grains of Tallow, or Wax, go to one Foot:

Let us suppose, *First*, That a Cubical Foot of Water weighs 64 Pounds, to which the Weight of most Waters will amount.

And, *Secondly*, That 5 Feet of Water are as heavy as  $5\frac{1}{5}$  Cubical Feet of Wax. Vid. *De Stair, Senguerdius*, &c.

Supposing then Wax and Tallow to be of equal Weight, since the Experiment of burning 5 Hours has been made with a Tallow-Candle, 5 Feet of Water will amount to 320 Pounds Weight, and so will  $5\frac{1}{5}$  or  $\frac{26}{5}$  Feet of Wax or Tallow.

So

So then a Cubical Foot of Wax weighs 60 Pounds, that is, 460,800 Grains, and consequently 1 Grain the  $\frac{1}{460800}$  Part of a Cubical Foot of 1000 Inches, which being reduced to single Inches, amounts to  $\frac{1}{4608}$  or  $\frac{1}{4608}$  of a Cubical Inch.

VIII. Now if we consider here likewise the aforementioned Velocity of Light, and suppose O E the Distance of the Candle O to the End of the enlighten'd Globe Q E R S, to be 10,000 Feet; and whereas it has been already proved, that the Light of *Jupiter's* Moons passes thro' the whole Space which is between the Sun and Earth, or 12,000 Diameters of the Earth, in the  $\frac{1}{8}$  Part of an Hour, or 450 Seconds, that is, in one Second  $26\frac{2}{3}$  of the said Diameters; it will follow then, that every one of these Diameters being computed at 39.231,564 *Paris* Feet (See *Whiston. Prælect. Astron.* p. 13.) according to the most accurate Measure of the *French*, the said Light will run 1,046.175,040 of the said Feet; since so many of them go to the said  $26\frac{2}{3}$  Diameters of the Earth.

But in case any one should affirm, that this Calculation is too large, forasmuch as it supposes that the Light of a Candle runs as swift as that of the Sun, he must be pleased to Observe, *First*, That it has not been yet demonstrated, that one kind of Light moves faster than another. For if a Man were placed in a great dark Room, and a Hole were made in the same, for the Day-Light to pass thro', or before which Hole a Candle were held, I don't think that the Light of the Sun would reach him sooner than that of a Candle, at the same Distance. But it is hardly possible to make such an Experiment, because the Difference between such great Velocities of both these Lights is not to be observed. *Secondly*, Because Light does probably not vary its Swiftnes at all; since the surprizing Emanation of Light,

of

of which mention has been made before, and is now here repeated, is not observ'd with respect to those Rays that proceed immediately from the Sun, but only as they be reflected from *Jupiter's* Moons. So that it retains still this Velocity after having run above five times the Length of that Space between the Sun and Earth; for so have we shewn above, in *Contemplation XXIV.* that *Jupiter* is at such a Distance from the Sun. *Thirdly,* Besides several other ways by which we might prove the unconceivable Velocity of the Particles that proceed from a burning Candle, the same does appear by the Effects it has in melting Glass, Enamels, Metals, and other very hard Bodies; which Force, since it can't be ascribed to the Magnitude of the Particles, they being exceeding small, must needs result from their Velocity; it being a known Rule in Mechanicks, that all the Force of Bodies is in Proportion to their Mass multiply'd by their Velocity.

But that we may here likewise concede enough, let us suppose, That instead of so many more than 100,000 times, in which the Light would fill this Globe in one Second, it be only 1000 times, whereby the Motion of the said Light is granted to be above 100 times slower, as it must be, if we compare its Velocity with that of the Light which comes down to us from *Jupiter's* Moons.

IX. We suppose farther, that the smallest *Animalcula* that can be render'd visible by the best Microscope, is much bigger than any Particle of Light. *First,* Because many more Particles of Light than one are requisite to render it visible. *Secondly,* Because these *Animalcula* are visible, whereas the Particles of Light are invisible. *Thirdly,* Because Light can pass thro' the imperceptible Pores of Glass, which the smallest Insect in  
the



the World can't do. And, *Fourthly*, This appears very plainly to such as know that these *Animalcula* being view'd against the Sun with a good Microscope, it is observ'd not only that they are transparent, but also that the Rays which pass thro' them, represent all the Colours of the Rainbow; to produce which, many and different Rays are necessary. The *Phænomenon* is familiar to those that deal in Microscopes, and we find it confirm'd in the *seventh Continuation of Leuwenboek*, p. 100. We premise this, for the sake of what follows, namely, That an inexpressible Number, or  $10^{20}$  (a Unit with 20 Cyphers) of Light-Particles is really contain'd within the Space of one of these so small Insects; as also to assist the Weakness of our Imagination.

X. It is likewise known, That when a burning Candle placed at O, (*Tab. XXIV. Fig. 1.*) and diffusing its Light as far as E, and filling the whole Globe E Q R S, communicates the same to the Point A, which is near the Candle, the said Point A, will be as much more enlighten'd than another Point E, which is at an equal or greater Distance from thence, as the Square of the greatest Distance (for instance, of OE) is greater than the Square of the small one OA.

In the Language of the Mathematicians, what we have laid down above, is express'd in the following Manner:

*The Number of the Particles of Light in two equally great, but unequally distant, Places from the Flame, are to each other in an inverted Ratio of the Squares of their Distances.* This has been shewn more circumstantially above in *Contemplation XXIV.* and is well known to all Mathematicians.

XI. To proceed a little farther :

Suppose then that OE, or the utmost Extent of the Light in the illuminated Circle Q R S E, be

be of the Length of 10,000,000,000 or  $10^{10}$  of such *Animalcula* as Mr. *Leuwenhoek* view'd with his Microscope (why we restrain it to just this Number, shall be shown hereafter in *Num. XXIII.*) and let the Length of the Ray OE be divided into the smallest Parts OA, AB, BC, CD; allowing to each of them the Length of one of the said *Animalcula*.

If now it be farther supposed, That in the Space of that *Animalculum*, which is the last and most remote from the Candle O, as here at VE, there be but one single Particle of Light; and that the nearer these Points come to the Candle in every following Space, as DO, CB, BA and AO, the Light-Particles always and continually increase in the *Animalcula*, according to the afore-said Rule, *Num. X.* It may be accordingly known, how many Particles of Light are contain'd in the Space of an *Animalculum*, the Distance of which from the Candle O, is likewise known, as here at OA, AB, BC, &c.

XII. For this Purpose, and for the sake of Order and Conveniency, Let there be perpendicular Lines of an indefinite Length drawn upon the Points A, B, C, D, and all the Partitions of these Lengths of the *Animalcula*, such as Ag, B b, C i, D k, E q, &c. in order to describe thereby the Number of Light-Particles which are to be found in the Space of each particular *Animalculum*.

And having taken at E q the Length EF, equal to an Unit, forasmuch as in the last Space VE, there is supposed to be contain'd but one single Particle of Light; and OE being found as above, to be equal to  $10^{10}$ , say, according to the foregoing Rule:

I. As the Square of OA, or 1, Is to the Square OE, or  $10^{20}$ : So is FE (a Light-Particle

ticle in VE) To  $Aa$ ,  $10^{20}$ ; or the Number of Light-Particles in OA.

Take then in the indefinite Line  $Ag$ , the Length  $Aa$  equal to  $10^{20}$ , so will this Line  $Aa$  represent the Number of the Particles of Light at  $A$ , or in the *Animalculum's* Space OA.

2. As 4, or the Square of OB, which contains two *Animalcula*, Is to the Square of OE, or  $10^{20}$ , which contains the Length of  $10^{20}$  *Animalcula*: So is 1 or FE To  $10^{\frac{20}{4}}$  or  $250^{10}$  Bb.

3. So likewise then OD contains 10 *Animalcula* in Length, to find Dd, or the Light-Particles that are in D.

As 100, the Square of OD,  $10 =$  To  $10^{20}$ , the Square of OE: So is 1, or FE, to  $10^{\frac{20}{100}}$  or  $10^{\frac{2}{10}}$ , or Dd, and so of all the rest.

XIII. From hence then it appears, that if Perpendicular Lines, such as  $Aa$ ,  $Bb$ ,  $Cc$ ,  $Dd$ , &c. be let fall upon all the Partitions A, B, C, D, &c. as the Line OE is divided into  $10^{20}$  Parts, and each of them amount to the Number of the Light-Particles contain'd in the Spaces of the *Animalcula* OA, BC, AB, DD, &c. there would be nothing requisite more than to add up the Numbers of all the said Perpendicular Lines together, in order to know how many Particles of Light are contain'd in all the *Animalcula-Spaces* of OE, as they increase after the said manner from E to A, in which there is no Difficulty.

XIV. As likewise by drawing GF parallel to OE, so that AG, Br, Cs, Dt, &c. be each of 'em equal to FE, or an Unit; that the Sum of all those Units will produce the Number of all the Light-Particles that are contain'd in OE; if in each *Animalcula's* Space, OA, AB, BC, CD, &c. there be found but one Light-Particle.

Now

Now since OE is supposed to consist of  $10^{10}$  *Animalcula*-Spaces, the Number of Light-Particles in the same will likewise be  $10^{10}$ .

XV. From whence it therefore follows, that the Number of Light-Particles in the Length OE, supposing there be one in each *Animalcula*-Space, Is to the Number of the same, supposing likewise, that they increase according to the Rule *Num. X.* As  $10^{10}$ , or so many Units as are contain'd in the Lines *AG, Br, Cs, Dt, &c.* Are to the Produce of all the Numbers that compose the Perpendicular Lines *Aa, Bb, Cc, Dd, &c.*

XVI. It is not necessary to prove that the Numbers of all these Perpendiculars *Aa, Bb, Cc, Dd, &c.* do contain so great a Quantity.

Since the first and greatest *Aa* being  $10^{10}$ .

The Second *Bb* will amount to  $10^{\frac{10}{4}}$ , or 250.

The Third *Cc*  $10^{\frac{10}{9}}$ .

The Fourth *Dd*  $10^{\frac{10}{16}}$ .

And so forth; each of these Lines equal to the Line *Aa* or  $10^{10}$  divided by the Squares of their Distances from O; all which amounting to the Number of  $10^{10}$ ; so as the last *FE*, by an Unit, will produce a great Sum, which to compute here would be a very great Trouble, and require too much Time and Room.

XVII. That we may not therefore be deceiv'd in our Calculation, we shall make choice of a much smaller Sum than we need do, and therefore only retain the Number  $10^{10}$ , that alone being the greatest Quantity of Light-Particles in the Space of one of the *Animalcula*, or the Line *Aa*; and we will throw away the rest *Bb, Cc, Dd, &c.* which would likewise amount to a vast Sum.

And having done so, it will easily follow; that the increased Light-Particles  $10^{10}$ , or *Aa* (*Num. XVI.*) Are to the Number of Light-Particles in OE, As one in the Space of each *Animalculum*, or

to  $10^{12}$  (*Num. XIV.*) As  $10^{12}$  to 1. Or that (if we admit the Increase *Num. X.*) the *Animalcula* in OE are  $10^{12}$  times more, than if we were to suppose but one in each of the Spaces between O and E, QRSE. This is applicable to all the Rays like OE thro' the enlighten'd Globe, and consequently to the said whole Globe.

XVIII. Before I proceed, I beg Leave to obviate the Opinions that some People may entertain of these Matters :

Namely, That since the Curve-Line  $a, b, c, \&c.$  F which connects all the Tops,  $a, b, c, \&c.$  of the Perpendicular Lines  $Aa, Bb, Cc, \&c.$  which are here drawn so close to each other, is of a known Property; which, if we call each of the Lines or Distances OA, OB, OC,  $\&c.$   $x$ , and the respective Perpendiculars  $Aa, Bb, Cc, \&c.$  each  $y$ , and the Line OE,  $a$ , and EF,  $b$ , and expresses the same by the following Algebraic Equation,  $xx y = a b$ . A Mathematician will wonder, perhaps, why I did not find the *Area* of the Magnitude of the *Mixtilineum*  $AaFE$  by Approximation, or even after the Method of *Mercator, Wallis*, and other great Mathematicians; to the end, that after having compared the same with the Greatness of the Rectangle  $AGFE$ , to find the Proportion from thence of the increas'd Number of Particles of Light in OE to the Number of the same OE, if there were but one Particle in the Space of each *Animalculum*: which has been done, it may be, by others on the like Occasion.

But they must be pleas'd to observe; *First*, That I have omitted these Methods, because all of 'em suppose, that the Line OE is to be divided into infinite small Parts, as OA, AB, BC,  $\&c.$  whereas we have only adapted our Divisions to such Parts as are equal to the Space fill'd by each of those *Animalcula* that are visible thro' a Microscope,

scope, which is yet bigger an infinite Number of times than one of those infinite Parts.

*Secondly*, We have given one Reason in *Numb. XVII.* which will make our Conclusions much more acceptable, because we choose so much smaller a Number.

*Thirdly*, What we here write is not so much for great Mathematicians, as for others that are of a good natural Understanding, tho' not thoroughly vers'd in Lines and Figures; wherefore, when we can use other Methods of Proving, we avoid as much as possible those of the Mathematicians; my chief End being to render myself intelligible even to the meanest Capacity, rather than to please the Learned, provided I can make the Truth appear in such a manner.

XIX. To draw therefore those Conclusions which we have in View from these and the foregoing Principles; let us suppose, (1.) with *Leuwenboek*, that 1,000,000,000 of those *Animalcula* which are visible thro' a Microscope, do make up one Grain of Sand, *See. X.* (2.) That 1,000,000 of Sands are equal to a Cubical Inch, *See. X.* according to which  $10^{12}$  of these *Animalcula* are equal to a Cubical Inch, allowing but 10 Inches to a Foot in length.

Now according to *Num. V.* the Globe QRSE contains  $418660^{12}$  of such Inches, and consequently  $418660^{26}$  of the said *Animalcula*.

XX. Let us suppose further, that in every one of the Spaces fill'd by each *Animalculum*, there is but one Light-Particle thro' the whole Globe.

XXI. If now the Velocity of Light be so great as to enlighten this Globe in one Second, (See *Num. VI.* and *VIII.*) and a Candle of Six to the Pound will burn 5 Hours, there will be  $\frac{1}{7200}$  part of a Grain of Tallow spent in each Second. Consequently there will proceed from  $\frac{1}{7200}$  of a Grain

of Tallow 418660<sup>26</sup> Particles of Light, and 14 times so many, or 5161240<sup>26</sup> from a whole Grain.

XXII. But one Grain is  $\frac{1}{480}$  Part of an Inch of 10 to the Foot, *Num.* VII. there proceeds therefore from one Inch of Candle-Tallow 460 times 5361240<sup>26</sup>; or in one Number 269617040<sup>22</sup> Particles of Light.

XXIII. But supposing with Mr. *Leuwenhoek*, 1000 Diameters or Lengths of one of these *Animalcula* equal to one Grain of Sand; and 100 Diameters of one Sand, to be the Length of an Inch, and 10 Inches the Length of one Foot.

Then 10<sup>6</sup> Diameters of the *Animalcula* make the Length of one Foot, and 10<sup>12</sup> of the same, the Length of OE, or 10,000 Feet.

XXIV. Now we have shown, *Num.* XVII. that altho' we throw away many Thousands of Millions of Light-Particles in the Globe QRSE, there be really 10<sup>12</sup> more Light-Particles, than when as above in *Num.* XX, we suppose but one single Particle in the space of each *Animalculum*. So that there proceeds from  $\frac{1}{4}$  of a Grain of Tallow, 10<sup>12</sup> times more Particles than are supposed *Num.* XXI; and consequently from one Inch of Tallow, 10<sup>12</sup> more than in *Num.* XXII; that is, from one Inch of Tallow there will proceed 269617040<sup>22</sup> such Particles.

XXV. And all this is true: *First*, Altho' we should suppose that there is but one Light-Particle in the Space of one *Animalculum*, at the extreme Part of the illuminated Globe, or at VE, which every Body sees is too little, considering the gradual Increase of Light, as we come nearer to the Candle O. And *Secondly*, although the said Globe should be enlighten'd but once in one Second, or that the Light passes from O to E in that Time.

But

But forasmuch as according to *Num.* VIII, the Light runs 1000 times swifter, and does not only run once, but 1000 times the Length of OE on all Sides, there being 1000 of such Globes fill'd with Light by  $\frac{1}{7}$  Part of a Grain of Tallow in one Second.

It plainly follows, that the Number found by *Num.* XXIV, must be multiply'd by 1000; and that one Inch of the Tallow burning in such a Candle does emit 269617040<sup>42</sup> Particles of Light, whereby the most astonishing Smallness and Number thereof is plainly *Demonstrated*.

SECT. XVI. *How many Particles of Light fly out of a burning Candle in a Second.*

To know then how many Particles of Light fly from a burning Candle in the Second of a Minute; it has been demonstrated from the foregoing Considerations, that  $\frac{1}{7}$  of a Grain of Tallow is consumed in the Second of a Minute, or, which is the same thing one whole Grain in 14 Seconds. Now an Inch of Tallow contains 460 Grains, so that an Inch of Wax or Candle-Tallow is burnt in 460 times 14, that is, in 6440 Seconds; in which time if there proceed 269617040<sup>42</sup> Particles of Light from an Inch of Tallow, there will fly out of a burning Candle in the Second of a Minute, the Number of 418660<sup>32</sup> Particles.

SECT. XVII. *The Particles of Light compared with the Sand of the whole Earth.*

AND since according to the most exact Measure of the *French Astronomers*, the Diameter of the Earth amounts to 39.231,564 *Paris Feet*, reckoning 10 Inches to one Foot, and that 100 Sands are equal to one Inch; the Number to be taken



for all the Sands that could be contained in the Earth, will require a Sum of not less than 32 Figures, the first of which is a (3,) and the whole too long to be expressed here.

Now in *Seç. XVI*, the Number there found was 44 Figures, of which the first was a (4.)

Now let us for Conveniency and to prevent any Disputes, suppose that both the first Figures were a (1,) and the rest Cyphers or Noughts, by which we lose an unconceivable Number of Parts; Accordingly the Sands of the whole Earth will be  $10^{11}$ .

And the Particles of Light flying out of a Candle in a Second  $10^{43}$ .

The Proportion of the one to the other, will be As 1 To  $10^{12}$ , or as one To a thousand times a thousand Millions.

From whence it may be concluded, that *in one Second* (which is commonly equal to one Pulse of a healthy Man) *there fly out of a burning Candle of Six to the Pound, many more Particles of Light than a thousand times a thousand Millions of that Sand the Number the Earth can contain, or be equal to.*

I leave every one to consider, whether this does not appear most amazing to him, and whether he is not bewilder'd, and loses himself in the Number and Smallness of these Particles of Light, tho' there were no more of 'em; whereas every one may perceive from what has been said, that if we had kept to a strict Calculation, the Number thereof would very far, yea unconceivably, surpass what we have here set down.

SECT. XVIII. *The Smallness of Parts in solid Bodies, such as Copper or Brass, &c.*

LET us now pass on to solid Bodies (tho' the Division of this Tallow may likewise be serviceable to the same Purpose) and endeavour to shew, *First*, That they consist of a vast Number of different Particles. Some of the most intelligible Methods seem among others to be the following.

1. Mr. *Boyle* (*de Subtil. Effluv.*) says, that a Grain of Copper having been dissolved by him in Spirit of *Sal Armoniac*, did thereby communicate a visible blew Colour to 28,434 Grains of Water.

Now if we suppose that each Grain of Water was impregnated with one Particle of Copper, it will follow from thence, that one Grain of Copper was divided at least into so many Parts as there were Grains of Water.

But supposing with Mr. *Boyle*, that  $\frac{1}{1000}$  of an Inch in Length is visible,  $\frac{1}{1000000000}$  of a Cubical Inch will be likewise visible.

And since one Foot of Water of 64 Pounds (allowing 12 Inches to the Length of one Foot) contains 1728 Cubical Inches; the aforesaid 28,534 Grains will amount to above 100 of the said Inches; and consequently in all those Inches there will be more than 100,000,000, or one hundred Millions of visible Parts; wherefore if there be but one Particle of Copper in every visible Particle of Water, a Grain of Copper will be thereby really divided into so many Parts.

SECT. XIX. *The Smallness of Parts in solid and fluid Matters in general.*

Now how far the Parts of Gold may be really extended by human Instruments, has been shewn by *Robault*, *Boyle* and others.

One Proof which is as applicable to all solid Bodies as well as fluid, may be briefly shewn in the already-mention'd Experiments of the Microscopes of Mr. *Leuwenhoek*; by which it appears, that of those smallest *Animalcula* which he could see through them  $10^{15}$ , or 1,000,000,000,000,000 go to the making up of one Cubical Inch. Now it is certain, that if the Particles of which a Body is composed are so small, that each of 'em are invisible to the Microscope, every Inch at least of the said body must consist of more than  $10^{15}$  of such Particles.

From whence then the same may be truly affirmed of all Metals, Minerals, Animals and Plants, in a Word, of every thing that is visible.

And no Body ought to be surpriz'd, if we should add, that this Number of Parts is much too small to express properly the Multitude thereof; and this may certainly be proved in many Cases, if it be consider'd;

*First*, That these small *Animalcula* which are only visible through the Microscope, must be furnished likewise with the proper Instruments for Life, Motion and Procreation, as also with their Juices by which they are nourished; to the smallness of which, no Power of human Imagination seems capable of being extended.

*Secondly*, That almost all Animals and Plants are combustible, and may be put into a perfect Flame; for which Reason, if we only make a rough Estimate (according to what has been said above,

above, *Sett.* XVI and XVII, of the Smallness of the Particles of Light) how much greater the Flame proceeding from them is, than that of a Candle; and consequently, how many more Parts do every Moment fly out of them under the Figure of Light, all which did contribute before to the Structure of such a Plant or Animal, such a Multitude, and such a Smallness of Parts will result from thence, as (to those who do not see the Force of these Consequences) must seem incredible, and unconceivable even to those that can see them.

SECT. XX. *Experiments shewing the determinate Properties of these small Parts.*

NOW that these numerous Particles which flow from Bodies, are not only very small, but have likewise a determinate Nature and Essence, has been shewn by the Learned Mr. *Boyle* in a particular Treatise, to which we refer the Reader.

But to say something of the Matter; *Glass of Antimony*, as is well known to those that understand the Virtue of it, being infused in Wine, will make a Vomit, though the *Antimony* loses nothing sensibly of its Weight; and the Parts of it are so exceeding small and fine, that an Ounce or less would furnish Vomits for more People than are in the whole City of *Amsterdam*.

From whence appears, not only the Smallness of those Parts which it communicates to the Wine, but also that the Nature thereof is determinate.

*Gold, Silver, Mercury*, it may be other Metals too, being dissolved in their respective Menstruums, are divided into an infinite Number of invisible Particles; and they may be all precipitated, as the Chymists phrase it, or caused to subside

side in those Liquors, and be returned again into their several Metals.

How small the Effluvia are that come out of a *Loadstone*, and which will even pass thro' Glass to move Iron, is plain enough from such an Effect; and wicah, that they have their determinate Properties.

SECT. XXI. *Of the Smoak of Benjoin.*

THEY who desire to see a Calculation of the Smallness of the Particles that exhale from sweet or stinking Matters, such as Musk, Civet, Ambergrease, *Affa Fœtida*, and the like may meet with them in *Dr. Keil's Introduction*, and yet they all retain their particular and determinate Scent: To say nothing of the Particles which a Hare or other hunted Beasts leave upon their Foot-steps, since *Mr. Boyle* has expressly treated of the same, it may be proved from the following Experiment, without any Trouble or Charge, of how many Particles a solid Body consists.

In a Chamber that was 24 Foot long and broad, and about 16 Foot high, I placed little Pans of Fire in 4 several Places, and strewed upon each of them about  $\frac{1}{4}$  of a Drachm of *Benjoin*; whereupon, the Chamber, after some time, was full from one end to the other, of a thin visible Smoak.

Now the Contents of this Chamber were 9216 Cubical Feet, which being multiply'd by 1000, or the Number of Inches in a Foot (supposing it be divided into 10 Parts in Length) amounted to 9.216,000 Inches.

Now  $\frac{1}{1000}$  of an Inch in Length is visible to the naked Eye, (*See* IV.) consequently then  $\frac{1}{1,000,000}$  of a Cubical Inch; so that there being 1,000,000 visible Particles in an Inch, there were

9.216,

9.216,000.000,000 of the same in this Chamber; and in case there were but one Particle of *Benjoin* in each, the 8<sup>th</sup> part of an Ounce of the said Perfume, would be thereby divided into more than nine thousand thousand Millions of Particles, tho' the same be much smaller in quantity than an Inch.

If now we add here, not only that this Smoak diffused the Scent of the *Benjoin* in all Parts of the Room, but likewise, as the Chymists know, that the said Smoak being collected, does yield a purified *Benjoin*, called the *Flower of Benjoin*; besides the Smallness of its Parts, the settled and determinate Property thereof may be proved from thence; and that as well these small exhaled Particles do retain the Nature of the *Benjoin* itself, as the Vapours do of the Water out of which they proceed, and into which, being collected, they are turned again.

SECT. XXII and XXIII. *Convictions from the Smallness of Parts in General, and in Particular.*

NOW let an unhappy Atheist, who has not only understood all that has been here said of the Smallness and Multitude of these Particles, but who by Reading and Reflecting has made the Contemplation thereof habitual to him; let such an one I say, set before his Eyes the great Structure of the visible World, and all its Parts; and let him consider not only of what an innumerable, unexpressible, yea, and unconceivable Multitude of Atoms the same consists, but particularly, that none of them all have the least Knowledge or Skill to create or move themselves; and let him judge farther, that if no Wisdom had intervened in this Matter, and that all their Motions had been produced without any Order, and  
by

by mere Chance; whether it would not be certain, that this noble Frame of Heaven and Earth would have been quickly turned into a Chaos, in which Fire, Water, Air, and all things besides, would have been confusedly jumbled among each other; and so much the more, if there had not been a Power so unconceivably great, as to extend itself to every Individual of all those thousand thousands of unexpressibly many Millions of Millions, and which could have directed and governed each of them in Particular; which Direction is therefore necessary, because each of 'em have their determinate Properties; and therefore one kind of them is not adapted for executing such a Purpose as may be performed by the other.

Or if this Proof be too general for these miserable Philosophers, so that they will fancy to themselves, that perhaps they may find out here or there some Subterfuge among this great Number of Objects, let them cast their Eyes upon Particulars: let them read all the modern Discoveries by the Help of Microscopes; let them apply themselves to see with their own Eyes what they had heard before thereof; and that travelling thro' this new World, which for so many Ages has been invisible, they may contemplate those numberless strange Things, which would have been incredible, if Experience had not render'd them certain: And when they have been assured by their own Sight, that for Instance, such a little contemptible Creature as a Mite in Cheese appears to the naked Eye, is a compleat Animal, having all those Limbs and Joints that are proper for its Motion, and its Body cover'd with Hair: that such Insects couple with each other, lay Eggs, from which their young ones are hatch'd; that farther, on the contrary, the little Eels that may be discover'd in  
Vinegar,

Vinegar, lay no Eggs, but bring forth their young ones alive. This last we are told by Mr. *Huygens* in his *Dioptrics*, p. 227; where he says, that he saw in such an Eel four young Eels (for they are entirely transparent) and that after having kept the old Eel a little longer in the Glass Tube, the four young ones were observed swimming by their Dam.

And if this Contemplation alone may have so much Power over them, as to force them to confess, that an over-ruling Wisdom prevails in all these Matters; the Smallness and innumerable Multitude of these Objects in which its wonderful Operations appear, will easily convince them, that there must be something Divine therein; and it may serve at the same time to illustrate that great Article of Christianity, namely, *That even the most minute Things cannot by their Smallness escape the Direction and Providence of the great Creator.*

SECT. XXIV. and XXV. *The Hand of God particularly manifested in the Use of these small Parts.*

LET not then any Infidel who only reads the Bible to form Objections against it, imagine any longer that it was almost an incredible Hyperbole used by the Saviour of the World, when he was pleased to say, *Matth. x. 30.* That *the Hairs of our Heads are all number'd*: Since we have shewn a Providence, exerting itself with respect to those *Animalcula*, that can by no means be compared with one single Hair for Greatness; and since in one Second of a Minute there are more Particles of Light diffused from a burning Candle on every Side (all which, as the Mathematicians know, are most exactly governed and directed by the Laws of *Opticks*) than there are Hairs upon

on



on the Head of any one Man living, tho' that Person had as many Hairs upon his Head as there are People in all the World.

To set this Matter in a true Light, tho' it may be very easily deduced from the foregoing: It has been shewn in Sect XVII, that the Number of Particles of Light that proceed from the Flame of a Candle in one Second, is much greater than a certain Number, the first Figure whereof is 4, followed by 43 Noughts, or  $40^{43}$ .

Now Mr. *Leuwenboeck* in his *First Letter*, p. 14. finds that the Number of Men upon the whole Earth, according to his Calculation, amounts to 13,385,000,000 or  $133850^6$ . Now let us compute this Number at above much more than 10 times the same, and suppose it to be  $20^{11}$ .

Now if every Man had so many Hairs upon his Head as  $20^{11}$  (which is much too many) the Number of the Hairs of all Men would be  $40^{22}$ , which as appears, would be no more than a  $10^{11}$  part of the Particles of Light that proceed from a burning Candle; so that from hence we may conclude with the utmost Certainty, that the Son of God far from using an Hyperbolical Way of Speaking, falls much short of the ordinary Operation and Direction of his Providence, how figurative soever this Expression may appear to weak Men.

Besides all this, it may perhaps be an Inducement to an Atheist to acknowledge a God, if he considers, that this adorable Creator and Governour of all Things has thought fit to shew particularly thereby his Godhead and Sovereignty over all his Creatures; that in order to produce the greatest and most surprizing Events and Things, he oftentimes makes use of no other but these small Particles, these contemptible Atoms or  
Points,

Points, making infinite Numbers of the same subservient to his wise Ends and Purposes.

To prove this Experimentally, the whole World may in a manner serve for an Example: for to say nothing of the smallness of those Particles which cause Pestilences and contagious Distempers, whereby so many thousand Men are often snatched away in a little time (in which therefore King *David* acknowledged the Hand of God appearing after an eminent manner; 2 *Sam.* xxiv. 14. and which even at this time are called by many *the Gift of God*;) how small and numerous are the Parts of Water, of which above a thousand times a thousand Millions are necessary to make up one Drop, or one single Hail-Stone equal to the Weight of one Grain? And to how great Purposes are they used, for which Water would be entirely unfit, if it were not capable of being separated and divided into Particles of *an innumerable Multitude, and of an unconceivable Smallness*? How many thousand Millions thereof ascend daily out of the Seas and other Streams? How many of 'em float in the Air, and that we may not repeat what we have said before in the *Contemplation of Water*, how many fall down in Rain, how many in Snow, how many in Hail, how many in Dews and Mists; how many are employed in the Nourishment and Increase of Plants, and in Drink for Animals; how many in barren Wilderesses, and for the Support of the wild Beasts therein? And must it not be confessed, that all this depends upon the Divisibility, and upon the actual Division of Matter into an infinite Number of small Particles?

SECT. XXVI. *Convictions from several Texts of Scripture.*

NOW he that can still deny a God, let him sit down, and seriously reflect on this great Truth, and then let him judge how vast that Power must be, who, to demonstrate beyond denial his infinite Existence to the confusion of those that blaspheme his Holy Name, brings about such great Events, by such small Atoms: and who has not only created such an extended quantity of Water as that is, which can contain all the Water of this Globe, but who has likewise separated and divided it into such small Particles; and how far that Wisdom and Direction can go, which extends itself to every one of these numberless little Parts, and makes them all continually subservient to such important uses as these are. And if he says he can't discover a God in all this, let him show us the Creatures, or, to speak in his own Language, the Natural Causes, to which so much Power and Direction over these and thousand other small Particles besides, may justly be ascribed. If he deduces all this from meer Chance, how then can he derive so steady an Order and Regularity, which has prevailed so many Ages among such numberless Millions, from Chance, whose very Essence consists in operating without Order? If he says, it is owing to unalterable and necessary Laws of Nature; who has then given Forms and Bodies to all these different Beings that know nothing of their own Existence? And who has bound them to obey certain Laws? If therefore a Wisdom is to be seen in all this, yet is it not to be found in a Matter that is ignorant of every thing: And where must a reasonable Man look for a Cause of all, and such a Cause as can  
 quiet

quiet his own Mind, if he does not acknowledge a God therein?

In case now this Proof, which is only deduced from the Particles of Water, seems to be of any Weight to an Unbeliever, (who nevertheless acknowledges a God) the Wisdom of the Divine Word, and the Truth which shines out of it, will not seem obscure to him, forasmuch as they demonstrate a God from the *Rains and Floods of Waters*, and that the true God is thereby distinguish'd from the Idols. See *Jer. xiv. 22.* *Are there any among the Vanities of the Gentiles that can cause Rain? Or can the Heavens give Showers? Art not thou he, O Lord our God? Therefore we will wait upon thee, for thou hast made all these things.* We likewise see that his Saints deduce a particular Argument from thence to praise God. *Pf. cxlviii. v 7, 8, 9.* *Sing unto the Lord a Thanksgiving; sing praise upon the Harp unto our God: Who covereth the Heaven with Clouds, who prepareth Rain for the Earth, who maketh Grass to grow upon the Mountains. He giveth to the Beast his Food, and to the young Ravens, which cry.* We likewise find the Almighty himself enumerating this among his Glorious Wonders, *Job xxxviii. 25, 26, &c.* *Who hath divided a Water-course for the overflowing of Waters? Or a way for the Lightning of Thunder, to cause it to rain on the Earth, where no Man is; on the Wildernets wherein there is no Man? To satisfy the desolate and wast Ground, and to cause the bud of the tender Herb to spring forth? And he asks further in the 28th verse, hath the Rain a Father? Or who hath begotten the Drops of the Dew? By which he shows that the Rain has no Father or Mother, that is to say, no other Origin but from him.*

'Tis true, that the Greatness of God is mostly proved here by the Benefit which the Earth and the Inhabitants thereof do reap from Water itself;

but that the same Spirit which dictated those Expressions, proves the same from the Smallness, and consequently the Number of the watry Particles, may be inferr'd from the before-quoted Texts of *Job xxxvi. § 26, 27 and 28*, in the XIXth *Contempl.* where after having said, *Behold God is great, and we know him not, neither can the Number of his Years be searched out.* He presently after subjoins the Reason, in § 27. *For he maketh small the Drops of Water; they pour down Rain according to the Vapour thereof,* And pressing further to show that Rain consists of the great Number of these watry Atoms, he says in the 28th Verse: *Which the Clouds do drop, and distil upon Man abundantly.* From which Text it therefore plainly appears, that not only the Smallness, but the Numbers of watry Particles are meant.

As likewise in the Prophecy of *Nabum i. 3.* *The Lord bath his Way in the Whirlwind, and in the Storm, and the Clouds are the Dust of his Feet.* By which last Words is plainly shown, that the *Clouds* are compos'd of exceeding small and numerous Particles, compared therefore to *Dust*, and that the Holy Ghost does justly fetch a Proof of the Greatness of God from thence.

SECT. XXVII. *Convictions from the Smallness of the Particles of Air.*

NOW tho' the innumerable Multitude of the Particles of Water only might seem sufficient to convince the most harden'd Atheist of the Direction of God in those great Events, which tend as well to the Advantage as Punishment of Mankind; yet if they can't satisfy him, let him consider the Air in the true State thereof: And if he has any Knowledge of Nature, he will admit it as an indisputable Truth, that the Substance of  
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the Air is a Collection of innumerable Diversities of small Parts, which acting upon each other, do oftentimes exert such a Power as surpasses even all Belief. Let him only read concerning this Matter, the Histories that give us an Account of the dreadful Force of Storms and Tempests, of Thunder and Lightning: Now 'tis plain, that all these terrible Effects are brought to pass by Particles, which are so small, and so light, as to be able to float in the Air; and that Lightning particularly finds no Pores of the very hardest Bodies so close and narrow, but what it can penetrate.

We have mention'd something of the Air above in *Señ. XIII.* but which falls far short of expressing upon those Principles the Smallness and Number of its Parts; and if in one Pulse or Second of a Minute there do proceed so many thousand Millions of Particles of Fire and Light from the small Flame of a Candle, how vast must the Number be of those that proceed from greater Lightnings, and how small each single Particle thereof?

Let then this unhappy Reasoner represent to himself the Air composed of such numberless Millions of Particles, and reflect upon the Force which they produce, when they operate in Storms and Tempests, so as to threaten the World with an universal Desolation; and then let him tell us whether he thinks it possible, that all these Aerial Armies are moved by *Chance*, and that they have not yet destroy'd all that is upon Earth; and consequently whether he does not think it absolutely necessary to own a Divine Direction and Government over all these things, and by which he and all that belongs to him, have been hitherto preserved, and the whole Earth render'd habitable: It is impossible but any Man who has long and seriously meditated upon these Things, and the

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Number and Strength of the Particles of Air, and of the Power that is requisite to keep them all in order, and to do good to the World after so many ways, by the things which might otherwise be very destructive Instruments, it is impossible, I say, but he must consent to the Truth of what we have here advanced.

### SECT. XXVIII. *Convictions from the Smallness of the Particles of Fire.*

AND for greater Conviction, let him farther add Fire or Light to Water and Air, and he will find not only that the Parts thereof are unconceivably Small and Numerous, but also that the Powers of it are most Terrible. Not to speak again of Lightning, which is an amazing Instance thereof, he who has ever read in History, how by the Violence and Number of these small Fire-Particles, Subterraneous Caverns have burst open, and caus'd Earthquakes; whole Rivers have flow'd with burning Matters; Cities and every thing in them, have been destroyed; Rocks and Mountains split asunder, and sometimes vast Pieces of them, which did not seem capable of being moved by any human Strength, toss'd up into the Air to an incredible Height; must he not acknowledge that all these stupendous Effects have been brought to pass by the most minute Particles of Fire, and such as could hardly be conceived for their Smallness? That he may satisfy himself thereof without much trouble, let him only look back to *Seet. XVI.* and consider what has been there said about it, namely, that from so small a Flame as that of a Candle, there proceeds in the Second of a Minute, a Number of 41,866 with 39 Cyphers following, of Particles of Fire and Light.

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Let him now compare therewith the Flames of Lightning, of burning Mountains, of all the combustibile Matters in the Earth, supposing them to be inflamed; that mighty Globe of Fire the Sun, and perhaps likewise thousands of fix'd Stars; and then let him reflect with Amazement, how great an Host of numberless Particles of Light and Fire are to be found in the World, for, that no Man living is able to compute the same, I believe he will readily agree.

Now since this dreadful quantity of Light and Fire Particles does not set the World in a Flame (and that it is possible for them to do so, has been already exemplified in Burning-Glasses) it is plain enough that they must have been restrained by some superior Power from making such a Havock and Destruction.

And now if a Sceptick is desirous to see, and as it were to feel with his Hands a divine Direction of these Particles of Light and Fire, he needs not Contemplate all the combustibile Bodies in which so many thousands of 'em lie dormant, and as it were lock'd up and fetter'd till the Time that they are to be put into Operation (which likewise proves the Direction of a Superior Power) but let him only consider the Optical Experiments, which will convince him, that all and every Particle of this vast quantity of Light, are so strictly bound to certain Laws, that falling upon reflecting or transparent Bodies, they are compelled to adapt their Motions to the Diversity of their Figures, and even to unconceivable Circumstances; with Instances of which, Sir *Isaac Newton's Optics* abound.



SECT. XXIX. *Convictions from all the foregoing.*

IF all this be not sufficient, let a Man who still doubts of these great Truths, represent to himself of what small Particles not only Water, Air, Light and Fire, but even without Distinction all other visible Bodies whatever are composed. To begin First briefly with Plants and Animals, which are subject to Combustion and Putrefaction; what small Vessels and Tubes through which yet smaller Particles of Saps and Juices do pass, are discover'd in the same by the help of Microscopes? (about which Mr. *Leuwenhoeck* and others may be consulted) How many Fat and Oleaginous Parts are to be found in the same? (of which likewise Candles are made from some Animals, an Inch of whose Fat is divisible into such an unconceivable Number of Parts by Inflammation, as we have shewn above, *Seet.* XV, and XVI.) How small and numerous are the Particles which from Putrefaction fill such great Spaces of Air with Stench? How much Water proceeds from thence by Distillation? which in *Seet.* XI. has been shewn to consist of so numerous and small Particles: And when all these, both Animals and Plants, have undergone the utmost Corruption, they are changed into a fruitful Earth and Matter: How many Particles, especially if viewed with a Microscope, might we find in the same Earth? Now if we cast our Eyes farther upon Metals and Minerals, those Glasses will likewise convince us of the smallness of their Parts; and yet more, if they be dissolv'd in *Aqua fortis*, and most of all, if they burn or tinge the Flame with their Particles.

To conclude; After having read all this, and what more can be met with upon the same Subject from other Inquirers, I think we may safely affirm, that every thing that is visible in the World, is compos'd of an unconceivable Number of various Particles. Let an Atheist therefore represent to himself this innumerable Quantity of thousands of Millions, and consider, *First*, Of how many different Kinds they consist, which are each of a particular Nature. *Secondly*, How many Kinds must be often made use of in the Composition of one only Body, as we find by the modern Observations of Chymists, and others, who extract from every Plant or Animal, Air, Fire, Water, Salt, Spirit, and Earth, in so great a Diversity; how many various Compositions they make; how from the same, Seas and Rivers, Air, Clouds, Winds, Sun, Stars, Trees, Shrubs, Herbs, Flowers, Fruits, Bodies of Men, and other Animals, such as Birds, Fishes, Beasts, Earth, Sand, Stones, Metals, Salts, and a thousand other Things, that have each their Singularities and Properties, are produced. *Lastly*, How, only by the Disposition of the Particles and Atoms which are in themselves invisible, this great, this wonderful Universe is maintain'd in its State and Condition, and all living Things are preserved.

And let him then answer us with Sincerity, and without Prejudice and Obstinacy, and especially without stopping at the fear of finding God therein, because he has blasphemed and deny'd him (*seeing there is Forgiveness with him, that he may be feared*) I say, let him answer us this Question: Supposing one should show him several fine Powders of beaten or grinded Colours, each one in its kind, mingled with Oil, and at the same time a noble Landkip of Men, Trees, Flowers, Rivers, Beasts, Birds, and such like, consisting

sisting only of these so differently mingled Colours; can he really fancy or persuade himself that the said Landskip existed without the Art of a skilful Painter, and that it was made by mere Chance; or will he pretend to say, that he knows any Laws in Nature, which operating without Knowledge, are capable of imparting such Perfection to the fine Piece? And as it is impossible for him to maintain such a Position, or to convince himself, or any other Man of the Truth thereof, will he still impiously deny that all those glorious Works, in Comparison of which the best Picture he ever beheld, is but botching and bungling, were produced by an infinitely wise Artificer? Since the Disposition of so many Parts, and of so many Properties as are necessary to the Production of the most despised little Herb, of a Mite in a Cheese, or any other yet smaller Insect (to all which no Knowledge can be ascrib'd) must convince him of the Wisdom of their Maker.

Now how invisible soever the aforesaid Smallness, especially of the Parts of solid Bodies is, and consequently unknown; yet we see the Supreme Wisdom plainly teaching us all the same Things in his Holy Word, *Prov. viii. 26. As yet he had not made the Earth, nor the Fields, nor the highest parts of the Dust of the World.* Could the inspired Writer express in more clear Terms, that the whole World is compos'd of very small Particles, which he here calls *Dust*?

And as if this were not sufficient, we see the same Spirit manifesting the same Thing by the Holy Apostle *Paul*, with no less Emphaticalness, in *Hebr. xi. 3. Through Faith we understand the World was framed by the Word of God, so that Things which are seen, were not made of Things that do appear*: Insinuating not obscurely, that every Thing which is *visible*, consists of such  
very

very small Parts, as that it does thereby become *invisible*, agreeable to the late Discoveries and Experiments, whereof we have treated above.

SECT. XXX. *Great Bodies are for the most part divided at first into small Particles, before God is pleased to make use of them.*

AND that we may see how often the wise Director divides great Bodies into such small Particles, before he thinks fit to make them become Instruments of his Power; let us consider of how little Use and Advantage Water, for Instance, would be whilst it remained Ice, or a great hard and solid Body, in Comparison of what it is when fluid, and divided into Millions of Particles: Whilst it remains Ice, can it so conveniently supply Drink to thirsty Animals, or Nourishment to Plants? Can it bear loaden Ships, and carry them through the whole World? Can it ascend into the Air, in order to come down again in Rains and Dews, or render those innumerable Services which Men reap from it when divided into minute Parts?

Whilst Fire being collected and shut up in Turf, Wood, Coals, and other combustible Matters, composes great and solid Bodies, what Effects can it produce in such a State? And unless those great Bodies be first divided into small Particles, and Flame produced by the Motion thereof, can they be any ways useful for Warmth, for Light, for melting Metals, for preparing Food, and other necessary Purposes?

The most active Matter that we know of amongst humane Compositions, is Gunpowder: What can it do whilst it is only Salt-Petre, Brimstone, and Coals? But when those smallest Particles of which it consists, are let loose and  
put

put into Motion, what is there in all Nature here upon Earth, and round about us, that can resist its Violence? Infomuch that even Thunder and Lightning, which are observed to be the most terrible Powers in the World, tho' they likewise are composed of such fine Particles as are capable of floating in the Air, are so exactly imitated thereby, that he who sees the Flame of the former, or hears the Noise, and sometimes feels the Earth trembling under his Feet, has oftentimes Reason to doubt whether it be not really natural Thunder and Lightning which produces those amazing Effects.

We may learn from hence, as from an Experiment made, and serving only for that Purpose, how great the Force of the Particles is, which, as far as our Inquiry can extend itself, must be esteemed the most minute of all, such as simple Fire and Light.

But to bring no other Instances, it seems plain enough from these, and the like, what we have undertaken to prove, namely, that the Almighty, in order to convince even the most obdurate Atheists, does ordinarily make none of the great Bodies, in the Operation of his most remarkable Wonders, 'till he has divided the said great Bodies into such fine and minute Particles, as are almost unconceivable by the Mind of Man.



## CONTEMPLATION XXVI.

### *Of Certain LAWS of NATURE.*

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#### SECT. I. *What a Law of Nature is.*

WE understand by this Expression, nothing more here than a kind of Property or Power producing something in or about Bodies or their Parts, and which may be experimentally proved in certain Circumstances to have always place in the same; but we shall not pretend to a deep Scrutiny here, whether they be produced immediately by the First Cause, or by Second or Intermediate Causes acting in or about them.

#### SECT. II. *The Laws and Powers of Cohesion.*

IF then we reflect on the inexpressible Number and unconceivable Smallness of the Particles of Matter of which the Universe consists, even the most obdurate Atheists cannot deny, that Laws are necessary in order to produce this beautiful World, and all that is to be found therein. And if every thing were moved by mere Chance, working without Rule or Order (just as if little Particles of Dust were blown by different Winds) no body that is reasonable, but must confess, he could expect nothing but the utmost Confusion from thence.

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The first Law or Power then that occurs to us, is that of *Cohesion*, whereby certain determinate Kinds of Atoms adhere to each other, in order to produce together certain determinate particular Effects.

Let then an unhappy Philosopher tell us, when he sees so many Men, Beasts, Plants, Heavenly Bodies, and whatever else can be reckon'd among Corporeal Beings, formed with so great Regularity and Order by such a *Cohesion* of Parts, whether there be not infinitely more Wisdom required thereto, than to build a House of the necessary Materials of Wood, Stone, Iron, Glass, &c. supposing them to be all prepared and brought together for that Purpose; and certainly he would not ascribe this latter to Chance, or the ignorant Laws of Nature only.

Now with how great a Force the Parts of some Bodies, such as Flints and other Stones, Diamonds, Iron, and other Metals do *cohere*, is manifest by Experience, and particularly from the Violence that is requisite in many, to separate the Parts from each other. But if any one should object, that this *Cohesion* is only produced by Rest of the Parts among one another, and that in order to continue Bodies in Rest, there is not so much Wisdom or Power necessary; he may learn from Mr. *Marriotte*, *de Percuss.* Part II. Sect. 2. and from Mr. *Huygens*, Sect. 3. that he is mistaken therein; those Gentlemen having proved, that a Body, how great soever, upon the least Percussion or striking of another, how little soever it be, loses its Rest and is put into Motion; which yet is never experienced in hard Bodies, the Parts of which (were they as hard as possible) if they only cohered by Rest, might be blown away and scatter'd with the Breath of one's Mouth, like a Heap of Dust.

Besides,

Besides the Greatness of this Force of *Cohesion*, it is likewise wonderful to observe the Variety thereof, by which every thing is and remains adapted to its proper Uses after a particular manner. Thus if all the Parts of the Tongue cohered, or were so strongly joyn'd together as those of the Teeth, it would be immoveable; and if the Teeth were as soft as the Tongue, they would not be fit to grind our Food: If the Parts of Corn and other Meats with which Men and Beasts are nourished, were as hard, and cohered as closely as Iron and Flints, the Earth would be soon dispeopled. If therefore any one be still so blind as not to discover in the Manner and Variety of Powers of this *Cohesion*, or of the Hardness and Softness of Bodies, an infinite Wisdom; why does not he maintain likewise (to make use of a plain Comparison) that our Beds and Blankets are soft, and the Wooden Frames belonging to 'em are hard by mere Chance, and without the Design of the Workman?

SECT. III. *The Laws and Powers of Separation.*

Now if all the Parts of Matter should be subject to no other Laws but only those of *Cohesion*, the World would be filled with all the Carcasses of Men and Beasts, with all the rotten and putrified Plants, as with an odious and loathsome Burthen; and every thing remaining without any Alteration in its Corporeal Figure, would be entirely useles to many Purposes. Now can an unhappy Sceptick observe herein no Wisdom of the great Governour of the Universe! Forasmuch as those very Parts, which in other Circumstances did before strictly cohere, are compelled to obey other Laws and Powers, and to separate themselves from each other. By this Means the World  
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is disburthen'd and released from so many unnecessary things, the Parts of which are divided from each other by Fermentation and Putrefaction; and afterwards again several other Matters are formed thereof, as for Instance, the most fruitful Lands, and many other Advantages do result from thence, of which a Multitude of Examples might be given; but we shall mention no more here, having already spoken of this Circulation of Matter upon other Occasions.

SECT. IV. *The Unattrition of such fine and tender Particles.*

BUT there's still a Law and Power, which will amaze every one that reflects upon it, namely, That these Particles of Matter, so small and so fine, should have continued for so many Ages without *Attrition*, or wearing away; notwithstanding that they have undergone so many *Frictions* or Rubbings, so many *Percussions* or Strikings among themselves, or against other hard Bodies, besides Motions innumerable; insomuch that it should seem, that in so many hundreds of Years they would have been entirely ground to Atoms, or all their Angles and Corners, being worn away, become round; which Figure Experience teaches us to be the last that all Bodies assume, before they be perfectly bruised or ground away: Who can imagine, that it should be possible that the Particles of Fire, after such dreadful and raging Motions among each other; the Particles of Air, after violently striking by Thunder and Lightning, by Hurricanes and Storms, against other hard Bodies; the Particles of Water, after so many Frictions, for Ages, against sandy and stony Beds, and against Rocks, should still preserve the necessary Forms, were it not  
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that

this Law of Unattrition of the smallest Particles did obtain in Nature? Or that others were continually produced in just the same Number, neither more nor less, in the stead of those that were consumed; both which prove a Divine Providence.

SECT. V. *Two Principal Laws of Nature, Percussion and Attraction, &c.*

FROM these Powers we shall now pass on to others, of which there are two principal ones, and according to the Laws of which most Bodies dispose themselves: The *First* is *Percussion*, the *Second* is, by very great Mathematicians of this Age, termed *Attraction*; to which some likewise are wont to add consequentially, the Power of *Repulsion*.

Two Bodies are said to strike when one of 'em runs against the other which is at Rest, or likewise if the last meets the first; as also when the last running slower than the first, is overtaken, whether the Way along which the Motion happens be in a Right Line or Oblique with respect to each other.

We don't here dispute whether some Philosophers are in the right, in deducing almost all Causes of natural Appearances from these Percussions; but that there is an infinite Number of such Motions at all times in the World, is unquestionable. Let us only consider the unconceivable Number of Parts of which Fluids consist, and imagine that many thereof, as Air, Light, Fire, Water, &c. are in continual Motion, which could not happen without Millions of Percussions against one another in an Instant: Now if there were no Laws observed by them herein, let us think what a Confusion all Things would be in.

Now what these Laws are, has been shewn by *Wallis*, *Wren*, and *Huygens*; and Sir *Christopher Wren* in particular has proved, that the same do experimentally agree with the Things themselves, which Mr. *Mariotte* has thought fit to describe in a distinct Treatise. Now let an Atheist consider whether it can be without a superior Direction, that so many thousand Millions of Bodies, all of 'em entirely ignorant of what they are doing, should have so strictly obey'd the Rules of Mathematicks for the Space of so many Ages.

And since among these Laws that are observed in the Percussion of Bodies, there are likewise found such which may indeed be deduced by Consequence from others that are intelligible; but of which notwithstanding the Manner how these Laws are performed, is incomprehensible to every one; let an Atheist think whether we ought not to conclude from the Incomprehensibility of the Manner of the Operation, the Incomprehensibility of the Operator himself, and thereby acknowledge a Wonder-working God.

To give an Instance thereof here: it is obvious to those that understand the Mathematicks (but who can comprehend the *How* thereof?) that a Body in the Percussion does communicate not only a greater Degree of Velocity, but also a greater Force and Motion to another, than it first had itself, and yet almost retain all its own. The great Philosopher for Motion, Mr. *Mariotte*, calls this, in his *Treatise of Percussion*, p. 153, 154, a very surprizing Paradox; and a few Lines below, a wonderful Thing; and that he might leave it past doubt, proves it experimentally.

And Mr. *Huygens* demonstrates, in what he has writ upon this Matter, that if one placed an hundred Bodies next one another in Rest, of which each following was always half as big as the preceding;

ceding, and in case the Motion begins from the biggest; the Velocity with which the smallest would proceed, would be 14,760.000,000 greater than the Velocity with which the biggest was moved; but in case the Motion begins from the smallest, the Greatness of the Motion in the whole will be so much the more augmented, as 4,677.600,000 is more than an *Unit*.

Mr. *Whiston* has transferr'd this from Mr. *Huygens* into his *Prælect. Physf.* p. 55. and names the first, a *wonderful Augmentation of Velocity*; but the last, a *more wonderful Augmentation of the greatness of motion*.

To pass on now to a second Kind of Powers:

It is said, that the Body A (*Tab. XXIV. Fig. 2.*) has an *Attractive* or a *Repulsive Force* (*Vim Attractivam vel Repellentem*) or otherwise, that the Body B gravitates to, or is repell'd from the Body A, when we see that another Body B is moved towards, or driven from A, without the Intervention of any other Bodies, which by protruding the said B, may be affirmed to produce such Motion.

A Philosopher who ascribes all to *Percussion* and *Protrusion*, must not think he has a Right to deny the Action of these Powers, because he can't comprehend the Manner after which Things thus happen; forasmuch as, according to such Notions, we might reject many Things likewise which Experience proves really to come to pass. Who can conceive the *How* of what has been shewn to happen about *Percussion*, or about the Operations of Light in *Contemplation XXIV*? How many Effects are there in Chymistry, as likewise in Hydrostaticks, of which we have not yet been able to comprehend the Manner how they come to pass? No more than of what has been said in *Contemp. XXIII.* about the Bodies and Roots of Plants, which perhaps would be as hardly admitted as this Do-

ctrine of *Attraction* and *Repulsion*, if nothing must be believed to be true, but that of which we can understand the *How* and the *Manner*. Those therefore who make other Scruples and Difficulties, may consult the famous Writings of Dr. *Gregory*, Mr. *Whiston*, and others, who have illustrated the *Physicks* of Sir *Isaac Newton*, and allow of so many of the Arguments which are there used to demonstrate this *Attraction* and *Repulsion*, as they think do fully prove the same.

Now to shew briefly, that these two Powers of Nature are not supported by a mere Hypothesis, but that we see by Experience, that one Body is moved towards the other, and one Body driven from another, while no Man has ever yet been able to prove, by any satisfactory Arguments, any such Matter, to the protruding Faculty whereof these Effects can be ascribed: Let those who are not yet convinced thereof, observe another Property of Matter, namely, that all Things are *heavy*, or do *gravitate* and *move* towards the *Earth*, or *Center* thereof: After the same Manner also the Planets are carried towards the Sun, the Satellites or Moons towards their primary Planets; and yet no Body has been able to shew to the Satisfaction of all, what has been the Cause thereof; and even the Arguments that are produced to prove the contrary, do not want their Weight; all which may be seen in the Works of the above-mentioned Gentlemen.

That which we have quoted in *Contemplation* XXIV. about *Light*, from Sir *Isaac Newton*, (which he says in his *Opticks*, p. 336. to be incomprehensible to such as follow the vulgar Hypotheses) is in p. 350. of the same Treatise so accurately solved by that Gentleman according to the Laws of *Attraction*, and confirmed by so many experimental Truths, that it would be very difficult, without

out supposing an Attraction, to discover any probable Causes of the same; besides this, Chymistry furnishes us with numberless Examples of such Motions in its *Efferescences* and Conjunctions of Bodies and Salts, and in its *Precipitations* or Separations of Bodies; both which do plainly represent an *Attraction* and *Repulsion*. The Causes, if there be any, among the Bodies that are near each other, we shall not here inquire into, and even Mr. *Mariotte* seems, in his Treatise of *Vegetation*, p. 15, to acknowledge such a Motion, which he calls a *Motion of Union*, and seems to understand thereby something analogous to this *Attraction*.

SECT. VI, and VII. *Gravity and its Effects.*

To come to the Particulars of some of these Laws of Nature:

One of these Appearances of Nature which are so familiar to us, that it is daily look'd upon by the most ignorant Men without any Surprise, namely, the *Gravity* of all Bodies, has often occur'd to me as an irrefragable Proof of a Wise, Powerful and Gracious God; and let him who has not yet been convinced by any other Arguments, seriously reflect with himself, whether it could have happen'd by mere Chance, and without any Design, that every thing which we call a Body, and which is to be found here upon Earth (for we shall not now take any notice of those things that are beyond it) falls, or is driven down with a certain Force, and by the shortest Way towards the Center of the Earth; and even when hindered by a resisting Power, or any other invincible Obstruction, still presses thitherwards, and oft-times with so great a Violence, that we see the Floors of Chambers, when loaden with too great

Burdens, and even whole Houses, sink down thro' the Force of such a Pressure.

And those who would deduce all these Effects from the Laws of *Percussion* only, must at least be convinced hereby (since such Pressures cannot be deemed compleat Motions) that there are other Laws that obtain in the World, and other Powers operating, than only those Percussions which proceed from *Local Motion*.

Particularly, that we may be convinced of the Direction of a Divine Providence, let us consider, *First*, What great things are brought about upon the Earth, by this simple Law of Gravity. By this alone it happens that the Globe of the Earth continues in its first State, and remains hanging upon its Center as upon nothing; that the Sea remains hanging upon its Bottom, which is heavier, and furnishes Men with all those Conveniencies we have formerly mention'd; by this Gravity Rivers flow, which would otherwise stand still, and be turn'd into putrifying and stinking Lakes; by this the Rains, Dew, &c. descend from the Clouds, and moisten the Earth, causing it to bear Fruits for the supporting the Lives of Men and Beasts, and providing Drink for all Creatures: 'Tis by this Gravity that Boats and Ships can sail upon Rivers and Seas, and that those Waters are disposed and rendered proper to bear vast and heavy Burdens upon their Backs; and whereby the Art of Men does produce so many agreeable Fountains and charming Cascades that adorn the Gardens of Princes, and cause Brooks to run from Mountains, and Pumps to raise Water, and innumerable other Uses, that are owing only to the Gravity of Water: 'Tis this that causes Fire and Smoak to mount upwards into the Air, and puts in Action the Elastic Powers thereof, which if the lower Air were not pressed by the Weight of

of the upper, would, after having once dilated itself, remain so, and then all Things breathing would be immediately suffocated, even the Fishes, as we have said before, could not continue under Water without dying; nor could one only Particle of Water (of which there are so many Thousand in one single little Drop) ascend into the Air when the superior Pressure were removed; as also the Water kept up in the Clouds, being at once suddenly poured down, all Rain and Dew would cease from thence-forwards; and thus this beautiful Globe of the Earth, together with Men, Beasts, Trees, Flowers, and Herbs, would be abandon'd to a general Destruction: And if we were to reckon up all the Uses of *Gravity*, any one that is but the least versed in natural Inquiries, must be convinced, that it is no Hyperbole to say, that they would fill a whole Book.

SECT. VIII. *Convictions from the foregoing.*

To conclude; Certainly an Atheist must be very unhappy, who pondering all these Things, and being taught by sure Experiments, and by this mere and simple *Gravity*, or rather by this only Motion and Tendency to the Center of the Earth, what strange Effects are brought about, is not able to discover that infinite Power which subjects all Things, all Bodies, from the very greatest to the smallest, and even the Particles themselves of Light and Fire to this Property; nor observe a Wisdom which by this simple Law of Nature does with so much Ease, and so little Trouble produce Effects capable of exciting Astonishment in the most experienced Philosophers; finally, who perceiving, that among all the Events produced by *Gravity*, there are hardly any, or rather there are none at all, which do not contribute to



his own, and all other Mens Happiness, yet cannot see the Goodness and Mercy of God therein:

SECT. IX. *Heavenly Bodies gravitate towards each other.*

BUT it is astonishing, what modern Observations have render'd very probable, namely, That this Natural Law of Gravity extends itself thro' the whole visible Universe, and seems to prevail over all, even over the great Heavenly Bodies, which gravitate towards each other in the same Manner as the sublunary Bodies seem to tend here with us to the Center of the Earth; upon which Foundation the whole Physical System of Sir *Isaac Newton*, who seems to be chiefly followed by the great Men of this Age in many Things, is built. But I don't here undertake to found my self upon the bare Opinions of any Philosopher, forasmuch as they are often contradicted by others, so long as the Experiments are not only not uncontestably, but likewise not sufficiently known: I shall therefore only endeavour to represent some few of those things that appear true by Experience, for the Instruction of those for whom we are here writing.

It is plain, by Experience, that all Bodies being once put into Motion, pursue their Way in one and the same Right Line, if they do not meet with any Obstruction, nor are turn'd out of their Way by another Power; so that whatever is moved circularly, as in *Tab. XXII. Fig. 1.* the Stone A in the Sling SA, being let loose, will pursue its Way according to the strait Line AF, which touches the Curve AHDE.

Now it has been proved by Observations, yea and admitted too, without any Dispute, by the most, if not all the modern great Astronomers, that

that the heavenly Bodies, as A, (*Tab. XXII. Fig. 5.*) which they call the Planets, move about the Sun S, in a Curve Line A H D Z, which is not circular, but what the Mathematicians call an *Ellipsis*, at least comes very near to it.

And again it is plain, by what has been said, that a Planet being in any Point, such as A G; &c. of this Ellipsis A E D Z, would pursue its Way according to the Right Lines A F, or G I, which touch the Ellipsis at A or G, and so would entirely forsake the said Curve Figure, which it describes, were it not that another Power did continually cause it to approach or incline towards the Sun S, whose Force the Lines F G and H I represent, so that we see, that from the Course of each Planet, a plain Proof may be brought, that there is an active Force that attracts it every Moment to the Sun S.

Lastly, Experience teaches us, that the same Power of Inclination obtains not only in the great Planets that move about the Sun, (*Tab. XXII. Fig. 1, and 2.*) with respect to the said Sun, but likewise in their *Satellites*; for Instance, in those of *Jupiter F*, and *Saturn H*, in relation to the same Planets, since these are commonly attracted to their primary Planets, after the same Manner as those Planets are attracted to the Sun, or exert a Motion by their Gravity towards the same.

SECT. X and XI. *A strong Proof that the Heavenly Bodies gravitate towards each other, and Convulsions from thence.*

BUT besides all this, I must not pass by a remarkable Observation related by Mr. *Whiston*, *Prælect. Phys.* p. 289. who shews experimentally, that besides this Gravitation or Attraction between

tween the Planets and the Sun, and between the *Satellites* and their Primary Planets, there may be visibly discover'd the like Attraction between one Planet and the *Satellites* of another. These are his Words, so far as they relate to this Matter.

*For as Saturn H (Tab. XXII. Fig. 1, and 2.) remained some Years ago a long Time about its Conjunction with Jupiter F, (that is, when Saturn and Jupiter are at the nearest to each other, and we see from the Sun S, Saturn at V, and Jupiter at F, in, or almost, in a strait Line) and consequently it must necessarily follow, that Saturn, by reason of the Greatness of its Body, and its Nearness to Jupiter, (for it is by both these that the Force of Attraction is regulated according to Mr. Whiston) must occasion some remarkable and visible Effects in the Satellites of Jupiter, if that Planet with its Satellites be attracted to Saturn; so the Matter is really; and the Satellites of Jupiter do change their usual Course in this Nearness of Saturn, agreeable to the said Law of Attraction.* So that even the so justly esteemed Astronomer, Mr. Flamsteed, who would not at first allow of this Attraction in the Heavenly Bodies, after having made the most accurate Calculations, did frankly confess, that this Law does likewise obtain among them in full Perfection.

Now let any one who hitherto has doubted of God's directing Power in the World, judge from these Experiments, whether there be not a wonderful Force acting upon these vast Globes (whose Magnitudes are not wont to be measured by Feet, Fathoms or Miles, but by whole Diameters of the Earth; and whereof one, namely *Jupiter*, is equal to 8000 Globes of the Earth) which Power so violently protrudes those Bodies without any Instruments, that no Cannon Bullet can be compared to the Swiftness of their Motion; and at the same times does so direct the manner of these

these violent Motions likewise, without using any visible Means, that they are obliged (in spite of the unconceivably strong Efforts, which they incessantly make, to fly out of their Orbits) to obey the prescribed Laws of *Attraction* or *Gravitation* towards each other in every the smallest Point of their Way; and thereby to determine their Motion within such narrow Bounds, even so far, that these Planets at a greater Proximity to each other, do, by the same Laws, continually depart farther from each other, and do render an Obedience thereto according to the most exact Rules.

*Finally*, After all this, let the unhappy Atheist consider, since all these Heavenly Bodies are driven or attracted with so dreadful a Force towards each other, whether it happens without Wisdom, that they having for so many Ages moved according to these Laws, have not at some time or another fallen foul or struck against each other in such a manner, as to burst in a thousand Pieces; the rather, because even some of the principal Mathematicians maintain, that it is possible that notwithstanding the regular Motions ascribed to the Comets, they may yet run against the Globe of the Earth, and so produce a Percussion between two such swiftly moving Bodies, which no Body can think upon but with Terror: But of this last sort of Heavenly Bodies, since we know so little of 'em, excepting what is liable to Disputes, we shall make no farther mention here. This is certain, that unless an Atheist does absolutely deny his own Principles, and allows that an unconceivable Wisdom and Power, working without visible Means, has place in the World, he will live in a continual Fear, that the like Misfortune may befall the Earth upon which he dwells: For that these Laws according to which such great Bodies, none excepted, do continually endeavour to approach

proach each other, can be ascribed to any other Causes than merely to the Will of the supreme Director, does not seem to me to have ever yet been proved by any Body.

SECT. XII. *The Operations of Gravity in Bullets and Bombs.*

NEITHER Time nor Place will permit us to produce here any more of all those Arguments from *Mechanicks* or the *Science of Motion*, by which we could plainly prove a Directing Wisdom; since all the Motions of Bodies running against, or among each other, even to the very Smallest, are found to observe certain Laws, which could not proceed but only from an Understanding and powerful Being, since they are regulated according to Reason and Judgment.

The aforementioned Gravity seems alone to give sufficient Proofs thereof in those Things which are every where observed among us upon the Superficies of the Earth.

And for greater Confirmation, what is there in the World more Untractable, more Ungovernable, than the Motion of the Parts of Gunpowder when 'tis set on Fire? And who could have imagined that those Motions in the discharging of Bullets from Guns, and tossing of Bombs from Mortars, do always observe the Laws of Gravity prescribed to them in their dreadful Force and Swiftness, with so much Accuracy and Niceness, as to become on that very Account the Objects of the Mathematicks? And yet we see that they don't move one Point forwards without continually obeying the same in their so swift a Course. And this Experience is even proper from whence to form fixed Rules in Gunnery and Bombarding, whereby Bodies protruded with so unexpressible a Force,

Force, in a Course so swift, as hardly to be restrained by any Powers, can be so exactly determined and regulated by the Design of Men, who have studied the Laws to which they are subject, as to be made to fall upon, or strike any particular Place, provided the same be within their Reach.

SECT. XIII. *The Operations of Gravity in the Catenaria, or Chain-Curve.*

WE could here produce numberless Cases in which it may be proved, that not only those prodigious flying Globes, such as Cannon-Bullets and Bombs, of which we have already spoken, but likewise thousands of Millions of others, and of the smallest Bodies, do describe Geometrical Curve Lines, wherein the Property of the Line, according to all the Laws of Mathematicks, is preserved in all its Points. Thus there run many thousands of Water-Particles out of the spouting Pipe of a Fountain, and not one of them shall transgress the Line which the Mathematician can shew that it ought to describe in those Circumstances. What Honour did that great Mathematician *Leibnitz* acquire, by shewing that he had attain'd to a perfect Knowledge of the Curve-Line, *ACB*, *Tab. XXIV. Fig. 3.* which is produced by the Gravity of the Parts of a Chain or Rope, fasten'd to two Nails, *AB*? And how much Esteem and Credit has it given to *Dr. Gregory*, to have been the first Discoverer of some new Properties of the same? How many Mathematicians have in vain turned all the Powers of their Mind towards these Discoveries, who notwithstanding that they sufficiently knew the Properties of Gravity, which was the only true Cause thereof; yet are forced to own, that they were  
unable

unable to describe rightly upon Paper the *Catenaria* or Chain-Line, for so the abovefaid Curve is named? And who can contemplate without Astonishment, how nimbly the ignorant Parts of which this little Chain consists, do dispose themselves by their Gravity into that Order, which is requisite to produce the same? And thus we might give many more Examples of the same Nature.

SECT. XIV. *There can be no ignorant necessary First Cause deduced from a Series of ignorant Causes operating together.*

I KNOW very well, that those who set themselves as much as possible against a Knowledge of God resulting from the Creatures, will answer, that these Laws of Nature, according to which all these Things happen, and this Disposition of the Parts of the *Catenaria*, this Motion of Fountain-Water in its Course and Line, this Direction of Bullets and Bombs in their Flight, are always necessary, and that it would be impossible it should happen otherwise; and this they maintain to be the Reason that those Mathematicians, who argue justly, can draw Conclusions agreeing with the Premises.

For Instance, it is known that there is a Law in Nature, that in case two Powers do equally act upon a Body A (*Tab. XXIV. Fig. 4.*) of which one acting in the Direction AK, and the other according to AL, would move the same Body: As the one or the other is more or less violent, that Body will be moved according to different Lines AD, AE, or AG, which are found and determined by drawing a Diagonal Line in the Parallelogram ABEF, AHGC, the Sides of which consist of the Lines along which the Body  
would

would be moved by each particular Power in the same Time, as here AB and AF, or AH and AC; from whence it then follows, that if in a Minute, or more or less Time, the Body A should be moved by one Power from A towards C, and by another Power from A to B; that the same Body A, by the Action of these two Powers, would equally in one Minute be driven, according to the Line AP, the Length AD, which is the Diagonal of the Parallelogram ABCD.

But in Case the first Power could move the same not from A to C, but to F, in one Minute; and the Second Power remained the same, it might describe the Line AE in a Minute: In the like manner also for the same Reason, if the Second Power that protrudes it towards AL, were greater, and could carry the Body in a Minute from A to H, if the First remained unchangeable according to AC, by both the Powers together, the Body A might in one Minute run the Space from A to G along the Line AG.

From which Principles Sir *Isaac Newton* has shewn briefly in his *Princip. Philos.* p. 14. and Mr. *Varignon* more largely in his *Nouvelle Méchanique*, that all the Laws of Motion, and the Rules of Mechanics do necessarily flow, and have given Instances thereof in all the Mechanical Powers.

It is likewise known, that the Flight-Line of a Bullet discharged from a Cannon, (*Tab. XXIV. Fig. 5. ADEFG*) is determined merely by this Law of Nature; forasmuch as there are every where two Powers acting upon it, *viz.* one, which being produced by the Force of Gun-powder, does continually impel it from A to K; and another, that of *Gravity*, which causes it to descend continually by the Lines AB, DL, EM, &c. which are at Right-Angles with the Horizon.



SECT. XV. *The First Motion proves a God; as does also the Continuation and Communication of Motion.*

SINCE the Philosophers, whom we are endeavouring to convince, are wont to enquire into, and to prove the immediate Causes of all Things from their Effects or Operations only, why do they not more seriously endeavour to ascend to the first Cause of all Things? They find that the most, if not all the Appearances in Nature that have been hitherto known, are caused and brought about by Motions; whether we may call them Protrusions, or (with some other great Men of the present Age) *Attractions* or *Repulsions*; they enquire what Laws of Motions must follow from either *Percussions* or *Attractions*. Now let them extend their Studies to the Cause that first produced these Motions, and immediately the Power of a Deity will appear to them from Mathematical Conclusions, especially if they will please to reflect upon what Experience has taught them and all Mankind; namely,

I. That a Body may be put into Motion, and may likewise be at Rest, or cease from Motion; and that in both those Cases it will remain a compleat Body, and preserve its Existence.

II. It follows from thence, that Motion does not belong to the Being of a Body.

III. Whereupon it may be here observed, that the famous Sir *Isaac Newton*, and the Commentator upon his Arguments and Demonstrations, Mr. *Whiston* in his *Prælect. Phys. Defn. I. p. 25.* (we Instance in both these Gentlemen, because no Body will dispute them the Title of very great Mathematicians) have rightly described or defined  
a Body

a *Body* to be an extended and solid Substance, not only indifferent to Motion and Rest, but likewise without any Power in itself, and simply Passive (*Substantia Iners & Passiva*) of which Mr. *Mariotte* gives a Proof by several Experiments, in the *Fifth Proposition of his Treatise about Percussion*, p. 31. shewing, that how much more solid a Body is, that is to say, how much more of Corporeal Matter it contains within the same Space, so much greater is the Resistance which it makes against Motion.

IV. So that from all this it is easy to conclude, that no such Thing as a Body can be the first Cause of those Motions, which nevertheless we find to obtain among Bodies.

What can then follow, save only that the first Cause thereof must be Incorporeal, and even wonderful and unconceivable in his Operations, forasmuch as not being a Body himself, he is able to move all Bodies.

Who is likewise the first Cause of every Thing that happens in the World, in which every Thing is performed by Motion; who is a Cause working freely; and according to his own good Pleasure, without any Necessity; because, tho' Motion cannot be made without a Body, yet tho' a Body exist, it cannot be proved by any Consequence that it must necessarily move; so that if it be endowed with Motion, the same must be deduced from a Cause operating without any Necessity.

Now this Cause must be infinitely Powerful, to be able to frame an Edifice of so vast an Extent as the Universe is, and to move such mighty Bodies as the Planets with so great a Velocity, as has been shewn above; he must likewise be infinitely Wise, since he is able to direct the Motions of

numberless great and small Bodies to such glorious Purposes. This I think no Body who understands what has been already said can deny with more Reason than he can slyly maintain, that a Ship can sail without a Rudder; that a Watch can shew the Hour without a Hand; that a Bell can sound without a Clapper, and so of many other Machines, that they are made without any Design. Now in all Matters where we can discover a determinate End and Purpose, it must be confessed, that a wise and understanding Being is concerned in the framing of them, since nothing that has no Knowledge can propose any End to itself. *Finally*, this Cause must be infinitely good, since by such Motion it imparts Life and Breath to all Animals, and bestows numberless other Benefits.

Besides all this, since it is here supposed that we have to do not only with a Sceptical Philosopher, but likewise with a Mathematician too, and who consequently, in order to support the preceding Objections, thinks himself capable to shew how the Laws of Motion may by a perfect Necessity be deduced from each other without any Divine Direction or Original; we intreat this Disputer, that he would only recollect the first Axiom, without which all Mathematical Argumentations would be in vain, and which therefore Mr. *Whiston* terms the most Fundamental of all, in his *Prælect. Phys. Mathem. Axiom the 1. p. 41*, and which likewise *Wallis* in his *Mechan. cap. 1. Prop. 11, 12. Huygens, Newton, Keil and Mariotte*, (the last of whom has endeavoured to render the same more plain by a particular Experiment) and many others have laid down for the Foundation of Mechanics; it is briefly this:

*A Body being once at Rest, or in Motion, ceases not from that Rest, or from being moved in a Right Line with the same Force, and without any Augmentation or Diminution thereof; unless another Force acting upon it produces a Change therein.*

This is allowed by every one, when a Body is at Rest; but when in Motion, 'tis doubted by many unexperienced Persons: But since our Philosopher is supposed to understand Mechanicks, he must be likewise convinced of the Truth of this Law of Nature, since a great Number of Experiments have been made by Machines to confirm the same, by which this Law is with sufficient Certainty proved *a Posteriori*. And it will plainly appear to him whom we suppose to have read the Writings of great Men, what Pains they have taken in seeking after a satisfactory Cause of this wonderful *Phænomenon*, which will therefore be unnecessary to mention here; and that some of them have asserted in express Words, that the Almighty God is the only Cause thereof. See *Keil's Introdust.* p. 118.

And if he still retains his Doubts, let him consider the following Law of Nature, according to which it has been allowed and experienced by every one; *That the Motions, and all their Differences and Changes in all Bodies are greater and smaller in Proportion, as the Powers which impress the same on those Bodies are greater or smaller.* According to this known Argument, that all Effects are proportionable to their adequate Causes: See *Wallis Mechan. cap. 1. Prop. 7.* So that if one certain Force causes one Motion, the same being doubled, will cause a double Motion, a triple Force, a triple Motion, and so on.

And let him suppose, that if a Man in the beginning of the World, or four or five hundred Years ago, had laid a little round Marble upon a

Table, and to put the same in Motion, had given it a Fillip with his Finger; the said Marble, according to the above-mention'd Law of Nature, would (if no other Force had oppos'd its Motion) have moved to this very Minute with the same Velocity in a Right Line, and without ceasing, would continue to run in the same Line such a Length, as no Man could determine the End of.

He knows that this is no vain Notion, but, as we have fully shewn before, a Law of Nature really obtaining in moved Bodies, confirmed by very many Experiments, and upon which almost the whole Science of *Mechanics* and *Percussions*, particularly the Properties of *accelerated and retarded Motion* are founded; Examples of which may be met with in the Demonstrations of the *two first Propositions of the Mechanics* of Dr. Wallis.

And let him farther consider with himself, if no Divine and Incomprehensible Power had place herein, which caused the Continuation of this Motion, and which obliged all Bodies continually to observe a Law, that otherwise was neither to be believed nor understood; whether he could imagine that the small and contemptible Force communicated by the Fillip of a Finger, could be the adequate Cause of such a Motion, by which this little Body can exceed in its Course all the Bounds that he or any Man living is capable of prescribing to it, without any loss of its Force and Velocity; and whether any one besides himself would say, that this so great an Effect can be accounted proportionable to so mean a Cause as the Fillip of a Finger; and if this does not satisfy him, if he be a Mathematician, he must know, *first*, that no Body can be so small, or move with so little Force, but that striking against another, (which is at Rest, and has no Obstruction) how

great soever this last may be, it will move it, and cause it to run forwards in a strait Line, so that both of them will proceed with equal Swiftnes; tho' such Swiftnes will be smaller than that which the first moved Body was endowed with alone. (See besides, concerning this Matter, *Wallis his Mechanics*, Ch. XI. in the *Scholium*, Sect. II.)

So that from hence it follows, that when a little Body, not so big as a Marble, but so small even as the finest Grain of Sand, being protruded by the Fillip of a Finger, runs or strikes against another Body, which we will suppose to be as big as the whole Globe of the Earth, or if you will, thousand of times yet bigger (provided that neither of them be Elastical, and consequently rebound from each other) this great Body will not only be protruded together with such a Grain of Sand according to a Right Line; but, unless some opposing Force or Obstacle do intervene, and hinder the aforesaid Motion, the great Body, as well as the little Grain of Sand, will by the Force of this Fillip, continue to be moved according to the said Line incessantly; and if they were to meet in their Way with a hundred thousand of other Bodies, and each of them were a Million of times bigger than the Earth, they would carry them all along with 'em in Consequence of this small Force, without any ones being able to determine how far.

Now that this, how wonderful soever it appears, is certainly true, no Mathematician can deny; but let this Sceptical Philosopher, who hopes by the necessary Deductions of one Law of Nature from another, to elude the Providence and Intervention of a God; I say, let him shew us from his Principles, whether he can any ways comprehend, not that such a thing actually happens (for this Mathematicks will teach him) but

how, and after what manner this Force of a little Grain of Sand so moved does act; so that any Percussion thereof does not only drive such unconceivable great Bodies with any Force, but likewise can continue the Motion of them without ceasing for Thousands of Ages. And it has been long a Question in Physicks, *How the Motion of one Body is communicated or transfer'd to another?* Which as far as I know, has never yet been rightly answered by any.

Then in case he could make no other Reply thereto, than that both the *Communication* and *Continuation* of Motion, is something which indeed he sees daily happening, and in the same Cases; but that yet the most internal Essence of Motion is not so well known to him, as that he should be able to say, after what manner it passes from one Body to another; and notwithstanding what is accounted the visible Cause (as the Phillip, which in this Instance produced such a Motion in the Sand) has long ceased to exist; yet the Effect may last not only in its Form or Being, but likewise in the same Force, such a Number of Years, as no Man is able to determine; for to shew the Greatness thereof, it is well known to those that understand Mathematicks, that according to this Law, a six and thirty Pounder being protruded out of a Cannon by the Force of the Gunpowder inflamed, would continue its Motion with the same Strength and Swiftnes for Thousands of Years, unless hinder'd by some other Force, notwithstanding that the Flame of the Gunpowder had ceased long before: Will he not then, even by this his own Answer, be compelled to acknowledge, that here, as before in the Motion of the Body itself, there is likewise an incomprehensible Power operating in the *Communication* and *Continuation* thereof?

TAB XXIV

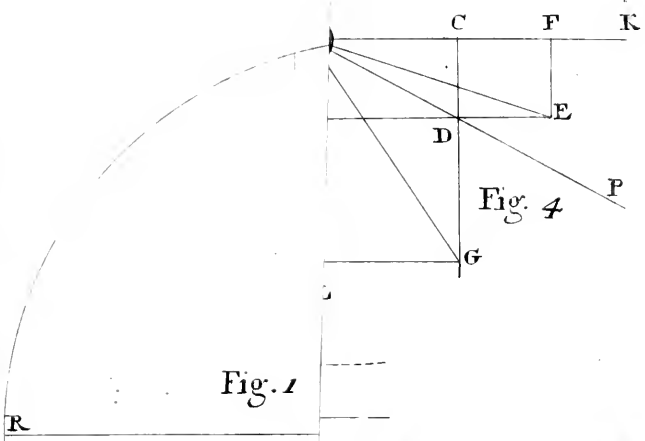


Fig. 1

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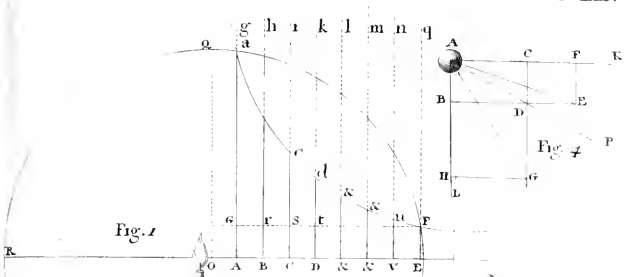


Fig. 1

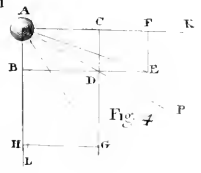


Fig. 7

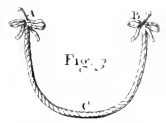


Fig. 3



Fig. 2

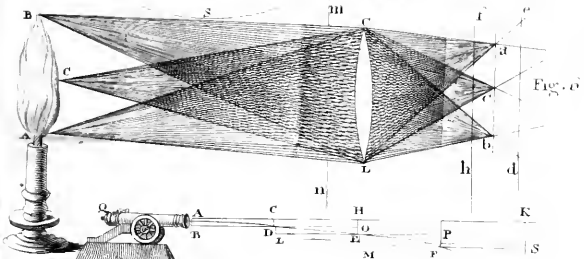


Fig. 5

Fig. 6

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G

SECT. XV. *The Reasons produced by some for the Continuation of Motion, seem too weak.*

I KNOW very well, that some great Mathematicians, who even confess that they can shew no Cause of this last Phænomenon of Divine Power, which maintains every Thing in its Existence, and by Consequence likewise this Motion of a Bullet in its Continuation, to illustrate the matter, affirm, that a Bullet being once put into Motion will always remain so; just as a square and a globular Body will always retain the same Figure: but I hope I shall be excused by them, if notwithstanding all the Esteem which I have for their Learning, I here add, that this Comparison, tho' produced with the best Design, which is to acknowledge God for the Cause, seems to me somewhat too weak, and not sufficiently analogous and proper: Since, *First*, tho' a Body being once turned from a Square into a Globular Figure, tho' it remains of itself Globular, yet the lasting Operation of the Globular Force does entirely cease: Whereas on the contrary, a Body that was once Still, and at Rest, being put into Motion, the lasting Operation of such moving Force will fully remain. *Secondly*, Since a Body cannot move of itself, being according to the Description of those Gentlemen, *a sluggish Lump of Matter*, and all Motion seems to require a Force which continually produces it; forasmuch as we see such dreadful Strength and Violence exerted by a Body once moved (as for Instance, by a Bullet shot out of a Cannon) which whilst it remained motionless, could not exert the least Force: So it seems to be a necessary Consequence, that a Body that has continued already a thousand Years in Motion, should not retain the same Motion for a

K k k 4

thousand

thousand Years following, without a Power acting upon it, and producing farther Motion; whereas in order to retain a circular Figure, there seems no farther Force to be necessary, than that a Body should at first assume such a Figure.

Nor is this opposed by any Mechanical Experiments or Rules; by which it plainly appears, that one Body running against, and striking upon another, which other is at Rest, both of 'em will continue moving with equal Swiftnes in a Right Line, till some other Power shall cause a change therein; but 'tis not maintained nor demonstrated, that with the Continuation of this Motion, the Power that protruded the Body, does not remain constantly acting.

Now whichsoever of these be true, it is sure enough; 1. That this Communication and Continuation of Motion are both obscure and entirely unconceivable, as to the manner of their Production. 2. That they are the Foundation of every Thing we are taught in Mechanics, and of all that happens in the World; insomuch, that nothing can scarce appear plain either in Mechanics or Physics, to such who have not inquired into the Laws thereof.

*SECT. XVI. GOD acts Reasonably, Incomprehensibly, and according to his own good Pleasure.*

I LEAVE it now to the Judgment of an Atheist himself, whether he must not confess and allow;

I. That there is a Power acting in Nature after a manner not to be comprehended by him, tho' the Effects are obvious to every one.

II. Whether all Things are not brought about in the supposed Cases by mere natural and ignorant Bodies, according to the most regular Methods of Mathematicks?

III. And

III. And consequently, whether there does not then appear a Power in this Universe, which acts not only Incomprehensibly, but likewise Rationally, that is to say, according to Laws reducible to right Reason, or otherwise, in shorter Words, whether he cannot discover a God in all these Things; who to the end that he may be found not only by those that seek him in his Works, but likewise by sceptical and irreligious Philosophers too, has impressed clear and manifest Tokens of his Incomprehensibility, and consequently of his Greatness upon the Origin of Physics, and the very Laws of Nature; to the end that an Inquirer into the Knowledge of Nature, how diligent and penetrating soever he may be in many Matters, yet if he be careless in this one great Point, may, before he proceeds any farther, be armed against this Temptation that has caused so many to wander and depart from true Knowledge and Wisdom; forasmuch, as because they observed the Necessity of Mathematical Consequences, and likewise that natural Things do always really adapt themselves to the same, they therefore began to imagine, that all Things come to pass by a blind Fatality; but if they had seriously and properly attended at the Beginning to the first and earliest Laws of Nature, they would have been convinced of the contrary: For let 'em tell us, as great Mathematicians as they pretend to be, from what Consequence it can be necessarily deduced, that there must ever have been any Motion in the Universe; and why it might not as well have remained without any Action, and without any Changes, entirely quiet and at rest? And again, on the contrary, what Necessity there is that all Motion should not be so dreadfully swift and disorderly, that every Thing should be thereby destroyed and confounded?

Can any Body likewise deduce these Principles from any Laws of Necessity, that is to say, from Laws that cannot be exerted otherwise, nor otherwise understood? And yet this just Disposition of Motion is the very first Principle of all that is delightful, of all that is necessary, and of all that is wonderful in the World.

S E C T. XVII. *Other Reasons against the Necessity of Natural Laws.*

ONE might alledge many Things to prove this; as for Instance, since all Bodies running or striking against one another (tho' they be hard or soft, provided they be not Elastical) do either totally or partially lose their Motion; and falling upon an immoveable Obstacle, such as a Wall, and the like, remain perfectly still without exerting any farther Force; which Laws are known to all the Mathematicians, and may be found in *the first Proposition of Percussion by Wallis and Mariotte*, p. 88. What Necessity is there that has prevented the Motion, whereby every Instant so many Millions of Bodies throughout the Universe strike against each other, from ceasing either totally, or in a great measure, in so many thousand Years? If it should be said that it continues, and is maintained, because the most and even the very hardest Bodies are endowed with an Elastic Force, by which a new Motion is communicated to other Bodies striking against them, as we find it true in several Cases; yet this farther Question still remains; What Necessity can the best Mathematician shew for Bodies being endowed with any such Elasticity; especially since it appears, that there are so many Bodies that have no such Faculty in them, and consequently that it does not result from the Nature of Bodies? If it be  
supposed

supposed that this is brought to pass by what they call a *Subtile Matter*, (not to examine now whether such a Matter be capable to produce this Force, and even tho' we should grant it) yet it is nevertheless plain, that if the foregoing Effect, or the Elasticity be a necessary Quality, the Cause that is alledged thereof must likewise be necessary.

Now it is needless to shew, that the greatest Philosophers are not able to deduce this Motion of such fine Matter, as necessarily resulting from the Nature of Bodies themselves, (which are entirely unactive) or from any thing besides.

Moreover, since such a Body being driven against any Obstacle, which it cannot remove by its own Force, does presently lose that Force, together with its own Motion, what Necessity is there, that it should happen otherwise in the only Case of Gravity? So that when a Body, falling down upon another Body that stops it, strikes against the same; it ceases indeed to move any longer, but yet does by no means lose its Force, but oftentimes proceeds to press with so much Violence, according to the same Right Line or Direction, that we see thereby great Bulwarks, Walls, and the like, overturned thereby; and tho' as many Causes thereof should be alledged, as there are particular Hypotheses, who can prove, that the said Causes do necessarily result from the Nature of Bodies?

So that if indeed we could continually and properly trace them back from Cause to Cause, we should unquestionably find, that the first, which is the Spring of all the rest, acts without any Necessity, both as to the Things themselves, as also to the Manner thereof.

For which Reason, the Wisdom that appears in these Operations, and the Power being joined together,

together, we need not search any farther for a Great, Glorious, and Adorable God; who, to the end that all Men might be convinced that the true Original of all Things which happen in Nature, is only to be deduced from his infinite Perfections, has deposited, and does still preserve the undeniable Proofs thereof, in the first Natural Principles of all Things.

SECT. XVIII. *The Proof of a God from the Motions of the Particles of Light.*

BUT to turn into the Way again from this Digression, which yet was, in some manner, necessary to convince some unhappy Mathematicians, not so much of their preposterous Ways, as of their Neglect and Omission in justly reasoning about the first Cause of all Things; let us then pass on to other Matters, and produce one Proof, (which will appear undeniable to all Persons) of a God directing every thing even to the smallest Particles and Atoms, as we shall shew from the Motion of the same.

How many Millions of Millions of the Particles of Light do issue, in one Instant, from the Flame of a Candle? How much, yea, how unconceivably swifter are they than a Cannon-Bullet? Concerning which the Reader may consult the XXIV and XXV *Contemplations*; and if we would see how exactly they obey the Rules prescribed to them, in all their Number and Velocity, let us suppose the Flame of a Candle at AB (*Tab. XXIV. Fig. 6.*) and hold with one Hand a common Spectacle-Glass at GL, at a pretty good Distance from the Candle, and with the other Hand a white Paper at *fb*, just behind the Glass, which being carried backwards to *ed*, you will meet with a Place, as *ab*, where you will see

see the Light which at first appear'd confusedly upon *fb*, representing perfectly and distinctly the Flame of a Candle inverted.

Now we know that this exact inverted Picture at *ab*, is occasioned no otherwise than that the Rays coming from the Point *A*, and making the Cone *AGL*, after having passed through the Glass *GL*, are all collected at the Point *a*, as those from the Point *B* at *b*, from *C* at *c*, and so those that come from all the Points of the Flame are all collected in so many Points upon the Paper at *ab*, and there cross each other; for which Reason the Pictures or Images, at *fb* and *de*, remain wholly confused; because the Rays coming from a Point of the Candle, as *A*, upon that Place, do fill a large Space, and are mixed with one another, as has been shewn before.

This being done, and the Course of the Light understood, let any Man whatever cast his Eyes upon this Figure, and observe in what a vast Number the Particles of Light run, and are mingled with each other, just before the Glass; so that all the Cones of Rays *GAL*, *GBL*, *GCL*, and others that have their Tops or Vertices in each Point of the Flame, as *A*, *B*, *C*, &c. (of which there are but three represented here, tho' they be numberless) do compose a confused Heap of an unconceivable Number of Particles of Light, at *mn*, before they come from the Flame upon the Glass; which Particles run an infinite Number of Ways obliquely and transversely among one another, as they fly towards the Glass: Let him likewise farther consider, how many thousands of Percussions will happen in that Place among the said Particles of Light flowing with such an amazing Swiftnes, and how many of them seem thereby to be driven out of their Way: In a word, let the greatest Philosopher tell us, whether this Motion



tion of the Particles of Light, among each other can seem to him like to produce any thing but the greatest Confusion.

Now if one should endeavour to make an Atheist, who had never seen this Experiment, conceive all these Things, and if some Body should tell him, that all the Rays proceeding from each Point of the Flame *A, B, C, &c.* tho' mix'd together between *mn* and *GL*, having passed thro' the Glass *GL*, should again be mingled at the other Side of the said Glass, between *GL* and *fb*; and notwithstanding all this, be afterwards distinctly collected in just so many other Points, *a, b, c, &c.* in so exact an Order as to represent the Figure of the Flame *AB* (save only that it is inverted) in all its Circumstances at *ab*, better than the best Painter in the World; I say, if one should tell him all this, would he not look upon it as the greatest Impossibility? But if now one should convince him, that the same is experimentally true, and that these many Millions of Particles of Light, so swiftly moving among one another, do, without Delay, and after such an amazing Manner, submit themselves to this Law; as often as any one holds a Glass between the Candle *AB*, and the Paper *ab*, tho' they themselves are not only entirely ignorant of any such Law, but likewise of their own Motions and Crossings; let him seriously reflect, whether those Principles upon which he founds his unhappy Philosophy, can prove to his Satisfaction, that this does happen without the Direction of an Omnipresent Power, extending its Care over all Things, even the smallest of Bodies.

Let him consider after all this, whether he cannot discover a God herein, who to the End that those that despise and deny him should remain inexcusable (at least all such as understand  
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the Motions of Light) has been pleased that they shall never open their Eyes without meeting and receiving an irrefragable Proof of a Wonder-working Deity, which so directs and regulates the unconceivable Multitude of all the Rays of Light flowing from all Parts, and mingling among each other, and seeming capable of producing nothing but an irretrievable Confusion before the Pupil of his Eye, as it was before the above-mention'd Glass, I say, does so regulate them all, that they can serve for a distinct Sight to all Creatures.

SECT. XIX. *The Existence of a God proved likewise from the Laws of Mechanism in general.*

MOREOVER, all who understand Mechanics, or the Science of Motion, know that the same in its greatest Extent, does consist of nothing else than Consequences that are deducible by Argumentation from some few natural Laws; and that Bodies wholly ignorant of what they are doing, observe the same in all Circumstances with the utmost Exactness, even so far, that before they depart from the same, they operate Things which to many Men that have not seen them, seem incredible; and to those that have seen them, wonderful; Numbers whereof are to be met with in the Books that go under the Name of Natural Magic-Books, and Mathematical Recreations: But since we don't write here only for Mathematicians, we shall not produce any Particulars thereof, but only ask those who still doubt, whether upon their reading a Book of any learned Author, in which are contained the Principles of Mechanics, (for Instance, that of *Stevin, Wallis, la Hire*, and others, who have writ particularly upon that Subject) tho' such a Book consists of Paper, Ink, and other Materials, in which there  
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is neither Sense nor Knowledge, yet they will pronounce, with great Assurance, that it must have been writ by somebody who was Wise and Learned, and that understood all these natural Laws and their Consequence.

SECT. XX. *Transition to some Hydrostatical Laws.*

BESIDES the Laws by which the great Director regulates the Motions of Solid Bodies, there are others that have place in Fluid Matters, and which if they do not very much differ, even in the first Fundamentals, yet do they so at least in the Phænomena, or Appearances, resulting from thence.

Now since we know, *First*, that the greatest Part of the Universe consists of Fluid Substances, such as Water, Air, Light, &c. *Secondly*, That all these Fluid Substances are heavy, and consequently produce many Things according to the Laws of their Gravity. *Thirdly*, That these Fluid Substances are the principal Instruments of which the Director of all Things does mostly make use. *Fourthly*, Since in this Operation of Fluid Matters, the Wisdom, Power, and free Pleasure of the Creator of the World does shine out after the clearest manner:

We shall proceed to a short experimental Demonstration of some of the said Laws of *Hydrostaticks*, to the end that when we proceed to speak of the *Law of Pressure according to the Depth*, which has place in Fluids, and from thence deduce so many Wonders of the great Ruler of Nature, any one may be entirely convinced of the Certainty thereof; which Demonstrations, those Readers who think they stand in no need of such Assistances, may pass by, and go on to what follows them.

*Experimental*

*Experimental DEMONSTRATIONS of the Law of the Pressure of FLUIDS, according to their Height or Depth.*

SECT. XXI. *General Terms and Positions in Hydrostatics.*

To begin then:

I. As to the Terms of *Liquids* or *Fluids*, we mean here the same Thing by them, tho' some do not allow all Fluid Matters to be properly Liquid. For, according to them, the *Air* is indeed a Fluid Matter; but not Liquid, as Water, Oyl, and the like; but for Brevity sake, we shall make no Difference.

II. All the Parts of a Fluid, when at Rest in a Vessel which is immoveable, do yield to the smallest Force acting on them; and so yielding, have their Parts easily separated, which immediately by their Gravity do again come together. The Proof of which is obvious to every Man's Experience.

III. The Superficies of all Fluids, upon which there is immediately incumbent either another Fluid Substance, or nothing else that is heavy, or that operates by another Power, will, according to the Action of Gravity, become Horizontal or Level, that is, settle itself parallel to the Horizon.

In order to see such an Horizontal Superficies (which may also tend to make us the more easily apprehend some of the following Terms and Expressions) we need only pour into a pretty large Glass, first some Water, and then some Oyl of  
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Turpentine for the Purpose; by which Means the Superficies of the Oil, and the Separation of those two Liquors, will shew the aforesaid Horizontal Plane; and the like will be obvious in almost all other Liquids that are unmixable.

We shall not here inquire whether the Superficies of a Stagnating Liquor be not likewise part of the Convex Superficies of the Globe of the Earth; but it is sure enough, that it may be suppos'd, without Mistake, that it does not differ visibly from a Horizontal Plane in so small a Space as we are treating of.

IV. I add moreover, that we do not here pretend, with some Mathematicians, to demonstrate every thing from Mechanical Principles; but only to shew Experimentally the Action of Pressure or Gravitation of Fluids, as they are govern'd by the aforesaid Laws of Pressure, according to their *Height* or *Depth*, that we may render them plain and intelligible to every Body, and even to such as are not conversant in Mathematicks.

SECT. XXII. *The Order of the Experiments that are to be made for the Foundation of Hydrostatical Laws.*

To proceed now, after premising these Things, to the Law itself of the Pressure according to Height, we can perhaps do nothing better in order to be more plainly understood, and to give a true Conception of our Meaning, even to the most Ignorant, than to set before the Reader a few easy and not costly Experiments; for which Purpose I shall relate them just as they stand upon my Notes, taken about 16 or 17 Years ago, and in the same Order too, namely, That the first Experiments are made by one only Liquor, not so

fo much becaufe it is the ufual Manner in which Philofophers treat thefe Hydroftatical Subjects, nor becaufe Water, which is the Fluid commonly made ufe of for thefe Purpofes, has no other Fluid Matter over, or above it, fince Air is always above, and preffes upon it; but merely becaufe thefe Demonftrations are more fimple, and therefore more plain to Beginners, and that becaufe the Air gravitating with equal Force upon equal Parts of the Superficies of Water, this Liquor may be much more conveniently ufed and obferv'd, than if any other Fluid Matter were incumbent on it.

The fecond Sorts of Experiments do herein differ from the former, that they represent to us the Action of feveral Fluids upon one another.

SECT. XXIII. *Of Fluids in Curve Tubes of equal Bignefs.*

BUT before we enter upon thefe Experiments, we fhall premife what, among other Things, has been firft found to happen in Curve Tubes of an equal Bore.

To wit, That in order to caufe a Fluid Matter in the Curve Tube AID, (*Tab. XXV. Fig. 1.*) to quiefce or flop at the Height AB, in the Side AI, and to hinder it from defcending on account of its Gravity, you muft fill the other Side ID, with the fame kind of Fluid, up to the like Height. This is plain enough in itfelf, and the Experiment may be eafily made.

SECT. XXIV. *An Experiment to fhew the great Force of the Gravitating Power of Water.*

THE firft Experiment which was about the *Gravitation of Water*, was the following :

I. I put into a large Glass Vessel *A B C D*, (*Tab. XXV. Fig. 2.*) a Curve Tube *Y X Q*, and a streight one *Z t*, after tying them in such a manner to a Piece of Wood that lay a-crofs, or horizontally upon the Rim of the Glass, not only as to make Right Angles, but likewise that their lowest Orifices, *P Q* and *rt*, which were of equal Bigness, were equally deep, that is, stood in the same Horizontal Plane *L M*.

Then pouring Water into the Vessel as high as to *a b*, we might perceive the Water in both the Tubes to rise up to *de* and *nm*; and as far as it appeared to us, it ascended as high in the Tubes (which were chosen large for that Purpose) as it did in the External Vessel.

II. Now forasmuch as the Water could not of itself rise as high as *de* in the Curve Tube *Y X Q*, nor remain suspended there, unless a Force press'd it down at *P Q*, as appeared, because upon stopping the said Tube with one's Finger at *Y*, and lifting it out of the Water in the Vessel by the Piece of Wood *E F*, if we removed the Finger from *Y*, we saw that the Water did not only not remain at *de*, but subsided to *uw*, driving out that which stood in its Way at the Orifice *P Q*.

III. From whence therefore it was obvious, that whilst the Tube was in the Water, a Gravitating Power acted upon the Part *P Q* of the Horizontal Plane *L M*.

IV. Now to inquire into the Properties of this perpendicularly Gravitating Force :

It appear'd, *First*, that the Force which press'd the Part *P Q* of the Horizontal Plane *L M*, did by

by no Means regulate itself according to the Surface or Breadth of the Water  $ab$ , nor yet to the Quantity of the whole Mass of Water  $abLM$ , which was incumbing upon the Horizontal Plane  $LM$ , of which  $PQ$  was a Part; of this we assured ourselves, by putting the Tube  $YXQ$  as low as  $de$ , in a much larger Vessel; for Instance, in a Bucket or Tub; in which Case we found, that notwithstanding the greater Breadth, when the same Depth of Water was incumbing upon  $PQ$ ; yet the Pressure upon the Part  $PQ$  was not greater, since it could not cause the Water in the Tube to rise higher than to  $de$ .

V. It appear'd, *Secondly*, that this Gravitating Force upon  $PQ$ , adapted itself most nicely and exactly to the Depth of the Water  $aL$ , which was the Column of Water incumbing upon  $PQ$  and  $LM$ .

For pouring gently some Water into the Vessel, till it ascended on the outside of the Tube to  $AB$ , we likewise observed the Water within the Tube, to rise from  $de$  to  $RS$ .

But on the contrary, when by sucking or letting out some of the Water out of the Vessel, it was reduced to the Depth of  $ab$ , or lower, the internal Water did also subside to  $de$ , or yet lower, but so as always to continue of the same Height with the External.

VI. Now it has been shewn before, and it also follows from *Set.* XXXIV. that if the Curve Tube  $YXQ$  were extended from  $PQ$  to  $NO$ , or higher, and then fill'd up to the Height of  $gb$  or  $ab$  of the Vessel, the Pressure of this Column of Water  $PQbg$  would be great enough to sustain the Water in the other Shank of the Tube to  $de$ .



VII. So that we may conclude from hence, that the whole Mass of Water in the great Vessel  $aLMb$ , does not gravitate more or less upon  $PQ$  than this same Column of Water,  $PQbg$ , but precisely as much.

VIII. Now since this Column  $PQbg$ , is equal to a Column whose Basis was the Part  $PQ$  of the Horizontal Plane  $LM$ , and whose Height is the perpendicular Height  $Pg$  or  $Qb$  (or otherwise  $La$  or  $Mb$ ) or the Water incumbing from  $ab$  upon the Horizontal Plane  $LM$ ; a famous Proposition in Hydrostaticks is deducible from hence, namely, That if we suppose a Horizontal Plane passing thro' a stagnating or quiescent Fluid, the Force whereby a Part thereof, as  $PQ$ , is gravitated upon, or press'd down, is equal to the Weight of the aforesaid Column  $PQgb$ , whose Basis is the Area of  $PQ$  Part of the Horizontal Plane  $LM$ , and the Height of which is  $aL$ , or  $Mb$ , or the whole Height of the Fluid incumbent upon the said Horizontal Plane, measuring the same directly upwards.

IX. This Column, because it extends itself from the suppos'd Horizontal Plane to the uppermost Superficies of this single Fluid, (and, if there be more Fluids incumbent on each other, to the uppermost Superficies of that Fluid which is highest) and contains all the perpendicular Heights of all the Fluids impressing or incumbing on each other, we shall hereafter, for Brevity's sake, call the Column of *Altitude*.

X. Now to shew that there happens not only to this one, but to all equal Parts, as  $PQ$  of the same Horizontal Plane  $LM$ , one and the same Pressure, and each equal to the Weight of this Column,

Column, we remov'd the little Piece of Wood ET, with the Curve Tube YXQ that was tied to it, from one Part of the Vessel to the other, so that the Orifice PQ fill'd at every Turn a new Place of the said Horizontal Plane, but we always found the Water flopping at *de*, or at the same Height; and consequently, that every Part equal to the Area PQ of an Horizontal Plane LM, is always press'd down with an equal Force, which is also equal to that of the Column of Height.

XI. And to shew farther, that the different Figures of Vessels did not alter the Case, or that it is not necessary that this gravitating Column PQ *bg*, should be always directly perpendicular to the Part PQ that it presses, we thrust a Piece of Wood IK, GH, with a flat Bottom GH, or a Beer-Glass, or a Phial with the Bottom downwards, to a certain Depth, as GH, under the Superficies of the Water *ab*, and held it there immoveable; after which we turn'd the Tube YXQ quite about, bringing the Orifice PQ to *pq*, directly under the aforesaid Bottom, and we observ'd, that notwithstanding the gravitating perpendicular Column over *pq*, could not extend itself higher than to GH, yet the Water remain'd in the Tube at *de*, and consequently at the same Height, as if the whole Column of Altitude PQ *bg*, were supported by or rested on PQ.

XII. So that it appear'd from thence, that each Part PQ, *pq*, &c. of the Horizontal Plane LM, was not always just press'd by the Column of Altitude itself, but by a Weight equal to that of the said Column; and consequently that this Law obtains in Vessels or Figures, of which, tho' there be here but one single Instance given,

and numberless Vessels might be propos'd for Trial, yet it sufficiently confirms our Position with the Concurrence of all that are vers'd in *Hydrostaticks*, and abundance of Experiments in all Kinds of Vessels.

XIII. I must however endeavour to remove one Difficulty, which, it may be, renders what we have just now said obscure to some People, and then pass on to somewhat else.

It is this, If a Drinking-Glass or Cup  $k l 7 8$ , be filled with Water, and then inverted suddenly, so that the Mouth  $7 8$ , descends below the Superficies  $a b$ ; and if one continue the Cup or Glass in the said Posture, it will be found:

*First*, That the Water will descend either to  $k L$ , or  $c f$ , according as there was more or less of it in the Glass, but by no Means so low as  $9$  or  $10$ , or as the external Water  $a b$ .

*Secondly*, That in Case the Curve Tube  $Y X Q$ , in which the Water is at the Height of  $d e$ , be turn'd about in its String, and shov'd forwards, if necessary, with the Piece of Wood  $E F$ , so that the said Tube  $Y X Q$  be brought to  $1 4 6$ , and its Orifice  $P Q$  to  $5 6$  directly under the Glass  $k l 7 8$  (continuing still in the Horizontal Plane  $L M$ ) we shall find that the Water will remain in the said Tube immoveably at  $2 3$ , the same Height as  $d e$ , and as the external Water  $a b$ .

Now since each Part  $P Q$  and  $5 6$  of the Horizontal Plane  $L M$  is press'd by the Column, the Height of which is equal to the Height of the Water, and forasmuch as there is no more Weight upon  $P Q$  than the Column  $P Q g b$ , and since there seems to be incumbent on  $5 6$  a Gravitating Column  $5 6, f c$ , of a greater Depth, and consequently of a greater Weight than that of  $P Q b g$ ; it seems that it ought to follow like-  
wise

wife, that the Pressure upon 5 6 should be much greater than that upon P Q; and therefore that the Water in the Tube at 1 4 6, should ascend much higher than 2 3 or *d e*, but on the contrary, the Water at 2 3, or *d e*, continues at an equal Height with the external *a b*.

This Experiment would be a notable Objection against what we have advanced, were it not that all who are any Ways vers'd in *Hydrostatics*, know, that what is said before, is only meant when there is no other gravitating Fluid upon the Water *a b*; and that the Pressure of the Air, which always gravitates upon the Water *a b*, is only the Cause here that the Water continues suspended in the Glass or Cup at *c f*. That in case no Air press'd upon the Water *a b*, the Water in the said Glass *k l 8 7* would not continue higher than the external Water *a b* or 9 10, tho' the Glass be inverted; as is well known to those that use Air-Pumps.

So that this Objection is properly of no Weight against what we have asserted, since we only treat of Cases in which the Pressure of the Air produces no remarkable Alterations, or at least, in which we may suppose them.

S E C T. XXV. *Experiments proving the Fluids press upwards.*

XIV. To proceed now to the Pressure of Fluids upwards:

That in Water and other Fluids a Pressure upwards has likewise Place, may be inferr'd from many Water-Works and Fountains that throw up Water.

This will also appear by the strait Tube *Z r t*: For unless the Water at the Part *r t* of the Horizontal Plane *L M* were press'd upwards, it would  
not

not be possible that the Column  $rtm$ , which lies upon the Superficies of the External Water  $ab$  in the Vessel, could keep its Station at  $nm$ , since it is continually press'd downwards by its own Weight.

To give then an Instance thereof: Stop the empty Tube  $Zrt$  with your Finger at  $Z$ , and thrust or put it down into the Water as far as  $rt$ , you will thereupon find that the said Tube will remain empty from  $Z$  to  $rt$  or thereabouts; excepting perhaps, that by the Pressure upwards of  $rt$ , the Water may rise a little, or so much higher in the Tube than  $rt$  (if let down into a great Depth where the Pressure upwards is stronger) as the Force of the said Pressure can contract or squeeze together the Air which is in the Tube.

But in order to know with what Force  $rt$  is pressed upwards, you need only remove your Finger away from  $z$  the Orifice of the Tube, and so give a free Passage to the internal Air which is driven against the Finger by the Pressure of the Water from below, and you will find (in case the external Water be as high as  $ab$ , and the Tube be tolerably large, so that there be not too great an adherence of the Particles of the Water to the sides of the Tube, on account of its narrowness) I say, you will find that the internal Water will not only rise as high as the external Surface  $ab$ , or  $nm$ , but much higher at first, for Instance, up to  $TV$ ; and that it will afterwards fall down from thence below  $nm$ , and not till after some Vibrations up and down, continue at  $nm$ .

From which Motion, or Ascent and Descent of the Water in the Tube  $Zrt$ , it is plain that it is not only hinder'd by a Resistance from falling down, as if it were oppos'd by a solid Body at  $rt$ ; but that a real and actual Power obtains here, and operates like Weights in the Scales of a Balance,

lance, which do likewise fluctuate or dance up and down, before they arrive at a just Equilibrium.

Finally, this Force pressing upwards, seems to be fully proved by the following Experiments.

Take a crooked Tin Tube (*Tab. XXVI. Fig. 1.*) ADF, which is of such width at EF, as to be exactly cover'd with the Top or Lid of a little wooden Box EGHF. Put it down into a Vessel NTCO fill'd with Water up to the Surface NO, and you shall find that the little Lid \*EGHF, tho' much lighter than the Water, will subside like a Stone, and how deep soever it be placed in the Water, will remain immoveable on the Orifice EF of the said Tube, until the Water insinuating itself between the Lid and the Tube, raises it self upwards, or till filling the Tube to 1, 2, 3, 4, the Air at 3 4 EF, raises up the said Lid.

Hence it is plain, that if a lighter Body than Water (for Instance, so thin a Substance as this little Piece of Wood) is not rais'd by a real *Force pressing upwards*, that it will by no means float, but subside like heavier Bodies. We shall shew hereafter, that Water can even raise and cause Lead to float by the like Force; but what we have advanced, is sufficiently confirm'd by the present Experiments.

SECT. XXVI. *An Experiment to shew the Greatness of this Force pressing upwards.*

XV. FROM this Water suspended in the Tube Zrt (*Tab. XXV. Fig. 2.*) we may judge, *First*, of the Greatness of the Force pressing upwards at rt for

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\* N. B. *The best Way to make this Experiment, is to keep the Lid down with your Finger close to the turn'd up end of the Tube EF, till it be about an Inch or two under Water.*

for Instance ; for since there is one Force acting by a Pressure upward, and another by a Pressure downward upon  $rt$ , as has been prov'd before, it is plain, if the Fluid at  $rt$  does neither ascend nor descend, but remains at the same Point, those two Forces or Powers must be equal to each other ; for if either prevail'd, the Water at  $rt$  would be moved according to the Direction of that Power.

Now since  $rt$  is prest downwards by the Column of Altitude  $nmrt$ , as is shewn before ; it is plain that  $rt$  is also prest upwards by a Force equal to the Weight of this Column of Altitude.

This may be further prov'd another Way.

Take a Tube, which for Convenience sake should not be too large, and thrust it down into the Water as far as  $11, 12, rt$ : Stop the Mouth of it with your Finger at  $Z$  ; then if you lift it up perpendicularly out of the Water, the inclos'd Fluid will remain suspended at  $11, 12, rt$ , as is known to those who try Wines ; then put the said Tube again into the Vessel fill'd with Water up to  $ab$ , so as the internal Water  $11, 12$ , may be below the Surface of the external  $ab$  or  $nm$ , or else above the same.

If then you remove your Finger from  $Z$ , you will see in the first Place, that the Force which presses  $rt$  upwards, is greater than the Weight of the Column  $rt 11, 12$  ; and that it will cause the Fluid to rise from  $11, 12$ , to  $nm$ , or to an Height equal to the external Water  $ab$ .

On the contrary, if you take away your Finger from  $Z$ , when the Fluid  $11, 12, rt$  is up at  $TV$ , or higher than the Water  $ab$ , you will find that upward-pressing Force at  $rt$ , is less than that of the Column of Water  $rt TV$ , and consequently that the said Column will descend, notwithstanding the Force which presses upwards, as low as  $nm$ , or  $ab$ .

Only

Only if you thrust down the Tube with the included Water suspended for the Purpose at  $nm$ , till the said  $nm$  be parallel with the horizontal Plane  $ab$ , or till the internal Water  $nm$  be of an equal Height with the external  $ab$ ; you will see, that upon removing your Finger, the Water in  $rtmn$ , will remain there without rising or falling.

From whence it may be inferr'd, that the Forces which prest upwards and downwards, are in this Case equal to each other; and therefore that a Part  $rt$  of the Horizontal Plane, as it is prest downwards with the Weight of the Column of Altitude  $rtnm$ , is likewise prest upwards in Stagnating Fluids, with a Force equal to the Weight of the said Column.

XVI. IF now, upon removing the Tube  $Zrt$  fasten'd to the little Piece of Wood  $EF$ , and carrying it along all the Parts of the Horizontal Plane  $LM$ , the Water remains continually suspended in the Tube at  $nm$ ; it follows, that every Part of the said Plane equal to the Orifice  $rt$ , is prest upwards with an equal Force.

XVII. Now that this Force pressing upwards, adapts itself exactly to the Depth, but by no means to the Breadth, nor to the Quantity of the Water standing above a Horizontal Plane, may be shewn here, as it was before, by the Force that presses downwards. For if you pour Water into the Vessel till it ascends from  $ab$  to  $AB$ , the Pressure upwards will be proportionably greater at  $rt$ , and cause the Fluid in the Tube to rise from  $nm$  to  $TV$ .

But if afterwards you draw off so much of the Water in the great Vessel, as to bring it down from  $AB$  to  $ab$ , or lower, the Force pressing upwards



wards will proportionably lessen; and whereas it was able before to raise the Internal Fluids as high as  $TV$ , it can't now keep it up beyond  $nm$ .

Thus we see every Thing adapts itself to the Height or Depth.

And if you have a mind to make this Experiment with a Bucket or Tub of Water, or with any other Vessel greater or smaller than that we used, you will find that the Breadth or Surface of the Water makes no Alteration, nor will the upward pressing Force produce any greater or lesser Effect, than to continue the Fluid  $nm$  in the Tube suspended at the Height  $ab$  of the external Water.

SECT. XXVII. *The Laws of Pressure up and downwards.*

XVIII. FROM all this it is easy to conclude, with respect to the upward and downward Pressure compared together, that,

If we suppose a stagnating Fluid (*Tab. XXV. Fig. 2.*) an Horizontal Plane from  $L$  to  $M$ , a Number of equal Parts taken at Pleasure, such as  $PQ$ ,  $rt$ ,  $pq$ ,  $nm$ ,  $56$ , &c. each of these Parts

Being, *First*, press'd upwards with an equal Force:

And *Secondly*, downwards, with one and the same Force as another, be it what it will.

*Thirdly*, (and which is of great Use in *Hydrostatics*) that one Part, as  $PQ$ , taken at Pleasure, is press'd with as much Force downwards, as another that is equal to it, as  $pq$ ,  $rt$ , &c. likewise taken at Pleasure, is press'd upwards.

And also on the contrary;

That the first Part  $PQ$ , is press'd with as great a Force upwards, as  $pq$  or  $rt$  are press'd downwards.

*Fourthly*, That the Force which presses each Part upon the other, is equal to the Weight of the perpendicular Column of the Fluid.

All

All which is plain enough from what has been said.

SECT. XXVIII. *An Experiment of the Pressure downwards of different Fluids upon one another.*

XIX. HITHERTO, like many others, who write about *Hydrostatics*, we have only consider'd Water as a Fluid that has no other Fluid upon or over it. But forasmuch as there is another Fluid which is usually incumbent on it, namely the Air, and which in some Cases does often and notably exert its Power, as we have shewn above, *See*. XIII; it will not perhaps be displeasing to such as have not been much conversant in *Hydrostatics*, if we should here consider some of the Properties of different Fluids lying upon each other.

The *Experiment* therefore which we made some Years ago for this Purpose, may be perform'd with all unmixable Liquors; as these two are in which we see Brandy that has stood a while upon Pot-Ashes, to which we may join Oil of *Turpentine* for a third unmixable Fluid. We only try'd the same with two, to wit, with Pickle or Water, in which there was as much common Salt dissolv'd as could be, and with Oil of *Turpentine*.

We therefore took two little Sticks, *cd* and *ef*, and bound them to a Piece of Wood *gb* (*Tab. XXV. Fig. 3.*) which, as in the foregoing Experiment, we placed upon the Horizontal Rim of a pretty large and deep Glass-Vessel, so that the said Sticks made right Angles with the Piece of Wood, and descended Perpendicularly into the Vessel; to one of 'em we ty'd the Curve Tube *CGB*, to the other the Streight one *DEF*, in such manner, that the upper Orifice of each, *C* and *D*, was a good way below the Rim of the Glass-Vessel, and the lower Orifices *AB*, and *EF* (which

(which as the Tubes themselves were of about the same Size) were placed as near as possible in the same Horizontal Plane HE.

XX. Now to give a rough Notion of the Pressure of the Air; we pour'd some Pickle into the Vessel up to HI, which running into the Tube BGC, at the Orifice AB, ascended in the opposite Leg up the Height  $kl$ , being parallel to the external Liquor HI, and there it staid.

When we remov'd the Tube, as in the former Case, from one part of the Superficies of the Pickle HI, to another, we always found that the Liquor within the Glass remain'd unchangeably at  $kl$ .

From whence it appear'd, in case the Air gravitates, which we suppose here, that it presses upon equal Parts, such as AB,  $ab$ , &c. of the Surface of the Pickle with equal Force: Since otherwise, if the said Pressure were greater on some Parts, and less on others, the Fluid  $kl$  in the Tube, would have risen or fallen; if otherwise (which follows from what has been shewn already) the Air in the Tube CG incumbent upon  $kl$ , and higher, does continually press upon the said  $kl$  with equal Force. But this by the way.

XXI. HAVING pour'd in more Pickle, up as high as LM, we found the Liquor in the Tubes to rise to  $xy$  and  $z4$ ; or as in the first Experiment, to the same Height as the external Liquor.

But when we pour'd upon the said Pickle LM, Oil of *Turpentine* to the Height NO, the Liquor in the Tubes rose from  $xy$  to  $no$ , and from  $z4$  to  $pq$ ; but remain'd below ON, or the Superficies of the Oil.

From whence we may infer, that a lighter Fluid like the said Oil NOLM, being incumbent upon a heavier, as the Pickle, produces a Pressure  
both

both upwards and downwards: Since AB must be prest more downwards to make the Pickle rise from  $xy$  to  $no$ ; and EF with a greater Force upwards, to raise the Pickle from  $z_4$  to  $pq$ , and keep it there suspended.

XXII. AFTER this we thrust down a Crane or Syphon with a long narrow Tube thro' the Oil NOLM, till it came below LM, or till it reached the Pickle; of which as we drew some part out, we observ'd, that the Depth of the same Fluid in both the Tubes decreas'd proportionably, falling below  $no$  and  $pq$ , but rose again as more Pickle was put in.

The same Thing happen'd upon taking out, and letting in again any part of the Oil NO.

And so did the last, with lifting upwards the Orifices of the Tubes AB, and EF.

From whence it appears, that in several Fluids incumbent upon each other, as well as in one alone, the Pressures which raise and fall the Parts of any Horizontal Plane in each of the Fluids, are likewise adapted to the Depths of the incumbent Fluids.

But they are no ways affected by the Breadth of Fluids, since it is sufficiently known to all that understand *Hydrostaticks*, that in Case the Height of the Fluids over AB and EF continues the same, the Effect would be the same; and the Pickle at  $no$  and  $pq$ , would continue at the same Height in Vessels of all kinds of Breadths.

XXIII. WE likewise found, that if we carry'd the Orifices of these Tubes AB and EF laterally along the Parts of the Horizontal Plane of the Pickle HI (the same may be said of the Oil too) the Liquor in the Tubes preserv'd the same Depth

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or Height in every new Place upon the same Horizontal Plane, as was observ'd in the first.

From whence it may be concluded, as before, that all equal Parts of a Horizontal Plane, whether the said Plain runs thro' the uppermost Fluid, or thro' any other which has more Fluids incumbent on it, are prest upwards and downwards with equal Force.

SECT. XXIX. *Oil gravitates or presses on Pickle, in the same manner as Air does on Water.*

XXIV. To represent now in a short Sketch, how Air operates upon a Fluid below it; we need only pour in Oil till it rises up to P Q, or above the upper Orifices of the Tubes C and D; which by that means running into the said Tubes, it will cause the Pickle within them, to subside from  $no$  and  $pq$ , to  $xy$  and  $z4$ , or to an equal Depth with the external Pickle at LM, just as if the Air prest upon it.

SECT. XXX. *The Greatness of the Pressure Upwards and Downwards in several Fluids incumbent upon one another.*

XXV. *Lastly*, LET us again suppose NO to be the upper Superficies of the Oil. Now to shew with how much Force every equal Part of a Horizontal Plane HI, such as AB, EF, &c. are prest upwards and downwards, when there are several Fluids incumbent on each other; we poured Quicksilver into the Curve Tube ABGC, till it rose to an equal Height in both Legs, namely, to AB, and  $kl$ . Then we pour'd into the great Vessel, Pickle as high as LM, and Oil of Turpentine as high as NO, and so thrust down the Tube BGC thro' the Oil into the Pickle, as

far as HI; and when all was quiet and settled, we found that the Quicksilver had subsided in one Shank from AB to TU, and risen in the other from *kl* to *rs*.

This remaining so, we fill'd another Curve Tube of equal Legs (*Tab. XXV. Fig. 4.*) 7 8 9, first below to a certain Height (as here also AB and *kl*) with Quicksilver, and bringing forwards the Curve Tube CGB, *Fig. 3.* close to the side of the great Vessel, we measured with Compasses as nicely as we could, the Height of the Pickle UW above the Quicksilver TU.

We also pour'd Pickle into the other equal Leg'd Tube 7 8 9, *Fig. 4.* till it rose to the same Height as WU above the Quicksilver that was in it, equal to the Pickle in the Vessel. After which, measuring in the like manner the Oil in the Vessel at MO, we also pour'd Oil into the Equicrural Tube to the same Height WX; so that the Pickle and the Oil, as well in the said Tube, as in the Vessel, were both suspended at an equal Height above the Superficies of the Quicksilver TU.

I should add here, that in order to bring Pickle and Oil into the Equicrural Tube *Fig. 4.* to the same Height with that in the Vessel, you must take care you do not pour them in at first to the Height required; because the Tube not being very large, when that which sticks to the Sides at pouring in comes to subside, it will cause it to rise higher than in the Vessel. This may be obviated perhaps by first filling the Tube *Fig. 4.* and then by pouring Pickle and Oil into the Vessel. They that have a mind may make the Trial.

Afterwards having measured with Compasses the Height *ru* (which the Superficies of the Quicksilver *rs* in one Leg had above the Superficies TU in the other) in both Tubes in and out of

the Vessel, we found the same Height  $ru$  to be equal in both.

XXVI. FROM whence we plainly perceiv'd that all the Fluids incumbent on each other in the Vessel above  $TU$ , and consequently also above  $AB$ , did equally gravitate upon  $AB$  in the Vessel, and neither more nor less, than if the said Fluids had been in a narrow ascending Tube, each in its streight perpendicular Height.

For since the Tubes both within and without the Vessel (*Tab. XXV. Fig. 3 and 4.*) were about the same Width; if the Side-Fluids in the broad Vessel gravitated more upon  $AB$ , than the perpendicular Column  $ABYX$  in the Equicrural Tube upon  $AB$ , *Fig. 4*; it would follow, that the upper Superficies of the Quicksilver  $rs$ , in the Vessel, would rise higher above the former Superficies  $uw$  of the said Quicksilver than in the Equicrural Tube.

XXVII. THE contrary of which being found to be true in all the Parts of a Horizontal Plane, as  $HI$ , where-ever the Orifice of the Tube  $AB$  is placed, it shew'd, that when Fluids are incumbent upon each other in a Vessel, supposing in one of them a Horizontal Plane, as  $HI$ , no Part thereof will suffer either more or less Pressure from all the incumbent Fluids, how broad soever the Vessel is, than of a Column  $ABXY$ ; the Basis of which is  $AB$ , and the Top of it reaching up to the upper Superficies of the highest Fluid  $NO$ ; and this is what we have call'd *the Column of Altitude*.

XXVIII. NOW as we have describ'd above the Column of Altitude in a Fluid, it may be concluded how the same is so plainly describ'd in this Case;

Case; to wit, that in several Fluids incumbent upon each other, *the Column of Altitude* consists of a Pillar, whose Basis or Bottom is  $AB$ , or  $EF$ , for Instance, or some part of a supposed Horizontal Plane  $HI$ , and whose Top is the upper Surface of the uppermost of all the Fluids that are incumbent upon each other; as for Instance,  $BZ$  compos'd of the several Depths of the Pickle  $BW$ , of the Oil  $WX$ , and of the Air  $XZ$  (imagining that  $XZ$  extends itself to the upper part of the Air) in such manner, that each Height, as  $BW$ ,  $WX$ , and  $XZ$ , presses downwards with the particular Weight of every Fluid of which it is the Height.

XXIX. It should be observed here, that it is not necessary that each Part should be always prest with such a perpendicular Column, since  $ab$  suffers the same Pressure, notwithstanding (if we suppose  $K$  to be a solid Body) that the Column directly incumbering upon  $ab$ , or  $abmi$ , can't extend itself in a streight Line higher than to  $mi$ , provided the Surface of the upper Fluid be at the same Height as before; but the meaning of all that has been said is, that both  $ab$  and  $AB$  are pressed with a Weight which is equal to the *Column of Altitude*, Num. XXVII.

XXX. So that in order to inquire into the Nature of any Water-Works, with respect to the Pressure of the Water upwards and downwards, you may single out a Part  $AB$ , *Fig. 4.* of a Horizontal Plane  $HI$ , upon or over which the whole Column of Altitude  $ABZ$  may be placed; or otherwise you may lengthen out the Horizontal Plane  $HI$  towards  $N$  or  $I$ , even beyond the Vessel that contains the Part  $AB$ , (*Tab. XXV. Fig. 3.*) upon which we seek for the Pressure, and moreover



take an equal Part  $AB$ , (*Tab. XXV. Fig. 4.*) of the said Plane extended from  $I$  to  $B$ , on which the Column of Altitude may be set and represented, if we continue the Superficies  $ML$  and  $NO$ , &c. of the Fluids incumbent on each other as far as  $W$  and  $X$ .

So that to know with what Weight  $ab$ , in the Vessel, is prest; it may be answer'd, with the Column of Altitude  $ABZ$ , which is represented in *Fig. 4.* out of the Vessel; of which Column  $BW$  is the Pickle,  $WX$  the Oil, and  $XZ$  quite to the Top is Air.

We might also conceive the Column  $abmi$  incumbent upon  $ab$ , as passing thro' a solid Body  $K$ , only by ascribing to the Height of each Fluid in it, its particular Part and Weight.

SECT. XXXI. *Of the Pressure upon equal Parts of Higher or Lower Horizontal Planes.*

XXXI. IT is unnecessary to add farther, that (*Tab. XXVI. Fig. 2.*) the Part  $d$  lying in the Horizontal Plane  $GT$ , is prest with so much more Force upwards and downwards, than the Part  $c$  in a higher Plane  $EF$ , as the Column of Altitude  $fm$  upon  $GT$ , is heavier than the Column  $fb$  incumbent on the other Plane  $EF$ . This every one may apply to a Part  $e$  in a lower Plane  $NH$ , as also to several Fluids lying upon each other.

SECT. XXXII. *Hydrostatical Laws of several FLUIDS incumbent on one another.*

XXXII. FROM all which then, there follows this great Hydrostatical Proposition (which does likewise very much contribute to discover the Powers and Motions in *Hydraulicks*, or *Water-Works*) after a short and plain Manner.

It is thus:

If several Fluids be incumbent upon each other, and we suppose one Horizontal Plane, as HI (*Tab. XXV. Fig. 3.*) passing thro' one of 'em:

Two or more equal Parts thereof (as AB, *ab*, EF, &c.) will each of 'em be press'd upwards and downwards, with the Weight of their Columns of Altitude, and consequently with equal Force.

From whence it follows,

That one of these Parts, such as AB, is press'd downwards with the same Force as another *ab*, or EF, upwards.

And on the contrary,

That the first AB is press'd with as great Force upwards, as another *ab* or EF downwards; which we shall therefore, for Brevity's sake, call here the *Law of Altitude or Depth*, because it adapts itself only to the Height (or Depth) of Fluids, but by no means to their Breadth or Surface.

XXXIII. It must be here observ'd, that in the Pressure upwards and downwards on equal Parts of the same Horizontal Plane (we do not now speak of higher or lower Planes) it is meant of such Parts AB, *ab*, EF, &c. which have a Communication with each other in the same Fluid; that is, such as a Thread or Line, may be suppos'd to be drawn from the one to the other, without being obliged to pass thro' another Fluid or Solid Body.

It is necessary to lay down this Caution here, because this so general Proposition may otherwise not succeed in some Cases.

SECT. XXXIII. *The Pressure upwards proceeds only from Lateral Fluids.*

XXXIV. WE have no occasion to prove expressly, that all Parts, as *rt*, (*Tab. XXV. Fig. 2.*) of a Horizontal Plane LM, are press'd downwards by their own Weight, and that of other incumbent Fluids; but that they are never press'd upwards, but by Fluids that are not only higher, but also lateral; and other Parts of the same Horizontal Plane LM press downwards: So that all Pressure upwards proceeds from these Lateral Fluids, as from their nearest Causes.

For take away the Lateral Fluids that are in the Vessel *aLMb*, on the Outside of the Tube *rtTV*, the Liquor in the said Tube losing its Pressure upwards, will immediately subside.

SECT. XXXIV. *Oblique Pressures do likewise adapt themselves to the Height of Fluids.*

XXXV. Now to say something concerning the *Oblique Pressures* of Fluids.

That Fluids may be press'd and protruded in various Obliquities, is so plainly proved by the Cocks and *Ajutages* of many Fountains, as not to require any farther Demonstration here.

But that these oblique-pressing Fluids do also adapt themselves to the direct perpendicular Height of the said Fluids over the press'd Part, as the foregoing, and by no Means according to their Quantity or Obliquity, shall be likewise briefly shewn.

Take a Recurve Tube (*Tab. XXVI. Fig. 3. and 4.*) ABCD, which being continued from CD, assumes the Form of CEFND; pour Water into it up to A, whereupon you will find that

that the Water will spread itself till it attains to an equal Height in the other Leg  $EF$ , of whatsoever oblique Shape the said Leg  $CDEF$  be, with respect to the press'd Part  $CD$ .

Now we know, that if the Tube were extended from  $CD$ , streight up to  $CGHD$ , and were full of Water as high as  $GH$ , or at a Height equal to  $AL$ , and  $EF$ , the perpendicular Column  $CGHD$ , would keep the Water in the Tube  $AB$ , to the same Height  $AB$ , just after the same Manner as here in the Oblique Pressure  $EFND$ .

Consequently the Horizontal press'd Part  $CD$ , undergoes an equal Pressure from the streight Column  $CGDH$ , as from the Curve or oblique one  $CDFND$ .

And this would be just the same, and remain so, though the Curve Tube (*Tab. XXVI. Fig. 4.*) were widen'd as at  $CEFKD$ , or even narrow'd in any other Manner, so as to contain a greater or lesser quantity of Liquor; as likewise in which Obliquity one of the said Tubes stood upon the Plane  $BCD$ , and press'd the Part  $CD$ ; if only the press'd Horizontal Part  $CD$  preserv'd the same Magnitude, and the Perpendicular Height  $GC$ ,  $HD$ , or  $FM$  of the Fluids upon the Plane  $CD$  continued the same.

SECT. XXXV. *The Hydrostatical Laws of Oblique Pressures.*

XXXVI. So that the foremention'd Law of Altitude, is here also of such Force in the Case of Oblique Pressures; and the following Proposition is true:

If a Part  $CD$  of a Horizontal Plane  $BCD$ , is press'd by a Curve or Oblique Column of Water  $CEFN$ ; the Pressure it undergoes is neither

ther greater nor leffer, than that of the Column of Altitude; that is, of the Perpendicular Column CGHD, which has for its Basis the press'd part CD, and for its Height the streight Perpendicular Lines FM, or GC, which are extended from the press'd Part CD, to the uppermost Superficies AF of the highest Fluid, supposing there to be more than one.

**SECT. XXXVI.** *Lateral Pressures do likewise adapt themselves to the Heights or Depths of Fluids.*

XXXVII. IT now remains to inquire into the Force of the *Lateral Pressure of Fluids*, whereby they are thrust or press'd along the Horizontal Line.

That this kind of Pressure does also obtain in Fluids, appears from the fitting or placing Cocks in the Sides of Barrels, &c.

Or otherwise, fix a Tube EF (*Tab. XXVI. Fig. 5.*) horizontally, or into the Side of a Vessel ABCD, fill'd with Water to the Height MN, and you will see the Water gushing out in a Stream FGH; so that at EF it runs horizontally, and at FGH inclines or bends itself to the Earth.

And in order to know that this Lateral Pressure does also adapt itself to the Height, you need only fill the Vessel up to AB, so that there will then be a greater Height or Depth of Water EB above the Tube EF; and you will find that the Stream FIK gushes out so much farther, and horizontally to K; but that in Proportion to the Decrease of the aforesaid Height, by letting out the Water, the horizontal Force does also decrease, and continually incline nearer to the Vessel, as first at H and then at P.

Now

Now that this Lateral Pressure does by no means adapt it self to the Breadth or Quantity of the Water, may be seen, if by continually pouring Water into the narrower and wider Vessel, such as ABCD (provided it be not too narrow) the Water be kept at the same height AB; for then in both Cases the Stream FIK will preserve the same Horizontal Line.

SECT. XXXVII. *The Method of discovering the Greatness of the aforesaid Pressure.*

XXXVIII. BUT now in order to compare the true Force of the Lateral Pressures with that of the Height or Depth of Fluids upon equal Horizontal Planes, as we have done in other Pressures, we must bestow somewhat more Pains.

For if we take a quadrangular Vessel (*Tab. XXVI. Fig. 6.*) A Q P K with plane perpendicular Sides A Q, and P K; and in it conceive the Part A E of the Side A Q, against which the Water, wherewith it is fill'd up to A K, presses laterally, and if you moreover conceive another Part E I in the Horizontal Plane O E, and equal to A E; it is clear that upon each Point F, G, H, I, there is an equal Depth of Water *a*F, *c*G, *e*H, *g*I, and consequently that each of the said Points is press'd downwards with an equal Force; but nevertheless, that each of those Points B, C, D, E, in the perpendicular Part A E, suffers an unequal lateral Pressure; because, as we have shewn before, the lateral Pressure accommodates itself to the perpendicular Height of the Water, and so is greater or less accordingly; and each Point, as A, B, C, D, E, has a different Height of Water above it, or rather above the Horizontal Plane in which each Point lies.

Accordingly,

Accordingly the Point A, or the Horizontal Plane AK, has no Height of Water above it.

The Point B, or the Plane BL, has the Height AB or *ab* over it.

The Point C, or the Plane CM, the Height AC, or *cd*.

The Point D, or the Plane DN, the Height AD, or *ef*.

The Point E, or the Plane EO, the Height AE, or *gi*.

So that from hence it is manifest, that in order to know how much greater or smaller Pressure the Horizontal Plane EI undergoes from the Water that lies in equal Height upon all its Points, than the Perpendicular AE, which has different Heights of Water over all its Points; that by reason of the great Difference of the Height of Water lying over the highest and lowest Points of the perpendicularly press'd Part AE; to avoid Mistakes, we must, *First*, inquire how much greater or smaller the lateral Pressure (for Instance) upon one of the Points B or C, &c. is, than the Pressure downwards on one of the Points *b* or *d*, &c. which have the same Height of Water over them.

And, *Secondly*, when this is known in each Height *a, b, c, d, e, f, g, i*, that we compare the Sum of all these different lateral Pressures upon all the Points or little Planes that make up EA, with the Pressure downwards; which all the Points or equal Breadths compriz'd in EI, do bear together.

*Thirdly*, It is plain, that the smaller the Parts or Points are into which AE and EI are divided, the lesser is the Difference of the Heights or Depths of Water over the uppermost and undermost Points of the Part of AE, and consequently these Diversities of the Heights will produce the smaller Change in the Calculations, which,

if

if these Parts were taken very large, might occasion great Difference; whereas they may be now safely enough taken, if we consider the Parts of *AE*, such as *A*, *B*, *C*, &c. as very small, and mere Points.

SECT. XXXVIII. *The Comparison of the Lateral and Perpendicular Pressure of the Air upon an equal Part, shewn by an Experiment.*

XXXIX. To shew the *First* experimentally, to wit, that the lateral Pressure which such a little Part as *B*, having a Height of Water, as *AB*, above it, undergoes in the Perpendicular *AE*, is equal, or at least does not sensibly differ from the Pressure downward, which a Horizontal equal Part *b*, that has an equal Height of Water *ab* over it, suffers from the incumbent Fluid, may appear from what follows, propos'd, if I mistake not, first by Mr. *Marriotte*, but with another View.

Having try'd the same in the Year 1696, and several times since, I find among others, the following Remarks, which every Body else may also make by the help of the little Glass Instrument invented by Dr. *Musschenbroek* for the same Purpose, with little Charge and Trouble.

We caus'd a little Hole *ab* to be drill'd or bored in the Plane Side *VQ* of a Bottle *ABPQ* (*Tab. XXVII. Fig. 1.*) and another somewhat bigger at the Bottom of the said Bottle at *P*, which last might be stop't by putting something into the Hole, and the Mouth *AB* was stop't with a Cork *CDFG*, thro' which the Glass Tube *EW* was thrust, and the Joints were so well cemented with *Emplastrum de Minio*, that no Air could pass neither between the Tube and Cork, nor the Cork and the Mouth or Hole.

Then



Then stopping the little Hole *ab*, and the Glass Tube *E* with the Finger, we pour'd Water into the Vessel thro' the biggest Hole *P*, with a Funnel that had a very slender Nose, till it ascended to the Height *RT*, or higher than the little Hole *ab*, which otherwise requires no Bounds.

Moreover, having clos'd the Hole *P* with a Cork or a Plug, we thrust a little Tube *abgb* across in the Orifice *ab*, which Tube being shut, or hermetically seal'd at *gb*, had a Horizontal Orifice at *fg*, as that at *ab*.

Then setting the Vessel up an end again, and stopping the Orifice *fg* with the Finger, we fill'd the Tube *EW* almost to the Top with Water. After which I removed my Finger from *fg*, whereupon the Water spouted out of the said Orifice *fg*, and subsided in the Tube *EW*; but without producing any other Alteration or visible Diminution in the Height of the Water *RT* in the Vessel, than what might be justly ascribed to the Contraction or Expansion of the Air incumbent on the said Water *RT*.

Finally, All being at Rest, it appear'd, that as the Water in the Vessel continued at *RT*, that in the Tube *EW* stopt at *du*, at the same Height with *fg*, or with the Horizontal Plane *dg*, which passes thro' *du* and *fg*.

Whereby we perceiv'd that the Column of Air *fgK*, by its perpendicular Pressure upon the Water at *fg*, could keep the same suspended at the Height of *du* in the Tube *EW*, and ballance an equal Column of Air *duH*, which was incumbent upon *du*, according to *Scct. XLI, &c.*

Now to compare the lateral Pressure upon *ab*, with the perpendicular Pressure *fg*, we took the little Tube *abbg* out of the Hole *ab*, and found that every Thing continued in the same State, and that hardly any Water flow'd out of the said  
Hole

Hole  $ab$ ; the Water also in the Tube  $EW$  remaining at the same Height  $du$ .

For if it had fallen in the said Tube, but a Hair's Breadth, down to  $ew$ , by reason of the Difference of the Air's Height at  $a$  and  $b$  (which however was not observable) the same by making the Hole  $ab$  smaller; would have dwindled to nothing.

XI. Supposing then that the Water in the Tube  $EW$  did continue at the same Height, whether the Air press'd downwards upon  $fg$ , or across and sidewise, upon  $ab$ , without the little Tube  $abgb$ , it was plain, that the Air press'd with much the same Force by its Weight directly downwards and laterally or sidewise, when these press'd Parts  $fg$  and  $ab$  were taken so small, that the Heights  $Ia$  and  $Ib$  differ so little.

SECT. XXXIX. *An Experimental Comparison of the aforesaid Pressures in Water upon an equal Part.*

XLI. BUT since the above-mention'd Experiment does only shew the Equality of these Pressures in Air, to the end, that the same may be represented in some other Fluid, as Water for Instance, we placed the aforesaid Bottle  $ABPQ$ , with and without the Tube  $abgb$ , in a Vessel of Water  $LMNO$ : So that the Water in the Vessel was as high as  $LO$  above that in the Bottle, and we observ'd in both Cases that the Water in the Tube  $EW$ , rose and continued at  $rz$  an equal Height with that in the Vessel  $LM$ , and consequently higher than that in the Bottle  $RT$ . So that the Water in the Vessel  $LMNO$ , whether pressing perpendicularly upon  $fg$ , or laterally against  $ab$ , exerted an equal Force and Pressure upon equal Parts, as  $fg$  and  $ab$ , when taken small enough.

SECT.

SECT. XL. *The Greatness of a Lateral Pressure upon a Plane.*

XLII. FROM whence it follows, that we may return again to our former Thread, and to *Tab. XXVI. Fig. 6.* and compute what a Force of Pressure a perpendicular Part *A E* suffers laterally from the Water as high as *A K* in the Vessel *A Q P K*, in Comparison of the Force which an equal Part *E I*, lying horizontally, undergoes from the incumbent Water *A E i g*; we must first suppose the press'd Parts or Planes *A E* and *E I* to consist of other smaller Parts, or of very small Points, *A, B, C, D, E, F, G, H* and *I*.

*Secondly*, That each of these Points or little Particles *B, C, &c.* does sustain just as strong an Action from the lateral Pressure, as *b* and *d* from the Pressure downwards of the visible Heights *a b, c d, &c.* of their incumbent Water.

XLIII. Let us then for Conveniency suppose, that *A E* alone does consist of five equal Parts, *A, B, C, D, E*, and *E I* of five Parts also, *E, F, G, H, I*: Tho' we should proceed more surely, if we supposed these Parts to be much smaller, and that *A E* as well as *E I*, did consist of some Thousands or Millions of the said Parts; forasmuch as then the Heights *ab, cd, &c.* of the highest and lowest Ends of these Parts would hardly be different, as has been already mentioned above.

We have however taken such a small Number as 5 here, it being so represented in the Figure, and because, whether the Number of the Parts be great or little, the Issue of the Calculation will be the same.

To come to it therefore ; If it be supposed that the Height *ab* contains 1 Pound, that of *cd*, 2 Pounds, *ef*, 3 Pounds, *gI*, 4 Pounds, and so on, if more Parts be taken, it has been proved before, that there is an equal *Lateral* Pressure upon the Point.

A, as <i>downwards</i> on <i>a</i> , and because there	}	1 lb.
is no Height or Column of Water in-		0
cumbing on <i>a</i> , it bears		
On B as on <i>b</i> , and by reason of the	}	1
Height <i>ab</i> , the said <i>b</i> bears		
On C as on <i>d</i> , and because of the Height	}	2
<i>c</i> , it bears		
On D as on <i>f</i> , and because of the Height,	}	3
<i>df</i> , it bears		
On E as on <i>I</i> , and because of the Height	}	4
<i>gI</i> , it bears		
So that the Weight which all the Points	}	10 lb.
together bear, is		—
Furthermore : Each of the Points E, F,	}	
G, H, I, have incumbent on them a		
Height or Column of Water equal to		
<i>gI</i> , and consequently each bears 4 lb.		20 lb.
which being multiply'd by 5, there		
being so many Parts suppos'd in AE		
and EI, the whole EI bears		

SECT. XLII. *The Hydrostatical Law of Lateral Pressures.*

XLIV. FROM whence therefore results this Principle concerning the lateral Pressure of Fluids, namely, that the lateral Pressure upon AE being, in this Case, 10 lb. is the half of 20 lb. or of the Pressure downwards, which the said AE if it lay horizontally at EI, level with the lowest Point E, would suffer from its incumbent Water AEI*g*; so that in order to know the Water being at the Height

A K, how great is the Pressure which A E bears, we must set off A E horizontally on E I, which bears the Pressure downwards of its incumbering Water A E I g; and draw E I, which will take in the pressing Fluid A E I A, or the half of A E I g.

XLV. It must not be thought, that if the Number of Parts, of which A E or E I are compos'd, were much greater than 5, it would alter the Proportion; since, let the Number be never so great, all the Numbers from 0 forwards, being continually multiply'd with the Unit, do always make up the half of their greatest Number, so often taken, as (the 0 or Cypher being reckon'd among them) their Quantity amounts to.

This is plain to Mathematicians, and any Body else may, for his Satisfaction compute it with a greater Quantity.

SECT. XLII. and XLIII. *Two Experiments about Lateral Pressures.*

XLVI. You may find what we have said *Num.* XLIV, and XLV. demonstrated after another manner by Monsieur *Stevin*, in his *Hydrostatics*; but since we, in order to render our Conclusions more certain, are wont to deduce our Proofs from Experiments, we will here add the following Experiment, as we find it standing upon our Notes some Years ago, omitting the whole Calculation for Brevity's sake.

We caus'd to be made a Quadrilateral Vessel (*Tab.* XXVII. *Fig.* 2.) the Height of which MK was about 26 Inches, with a square Hole that could be stopp'd with a Piece of Wood H D R S of the like Dimensions, being of the Breadth of a Foot at R D, and of the same Length at H D; which Piece of Wood was adapted to the Hole after

after such a manner with a Leather fix'd to its Edges, as to prevent the Water from oozing out at the Joints.

This Vessel being fill'd with Water up to BD, we knew that there was the Weight of a Foot of Water pressing laterally upon the Piece of Wood HDRS, because the Height of the Water was equal to DR, or to the Height of the uppermost Part of the said Piece of Wood.

Having then examin'd into the Force of this lateral Pressure of the Water by Means of a Balance AEF, the Arms of which AE and EF were Rectangular at E, to which the Weight Y was suspended, we found that this Wood being press'd inwards at EA by Y, could resist a Weight of between 31 and 32 Pounds; but upon adding more, it immediately burst inwards.

So that the Rule mention'd in *Sett.* LII. was sufficiently verified hereby, since a *Rynland* Foot of that Water was about twice as heavy.

It is to be observ'd, that the pressing Part A of the Balance AEF, must be placed exactly upon the Point of the Wood A, where the Center is, or where the lateral Pressure is strongest.

In order to do so, Care was taken that by the Means of the cross Piece of Wood VW, the Axis E of the Balance might be thrust up or down; and we found that when the Balance press'd higher or lower than A, the flat Piece of Wood (the Water being at highest) yielded to a much smaller Weight or Pressure; which shew'd that the true Point was at A.

XLVII. We then fill'd the Vessel quite full of Water up to GK, so that the upper Part DR of the wooden Plane DRSH, which bears the lateral Pressure, was not equal to the upper Superficies of the Water, but was below it the

Length of  $KD$ , or of  $\frac{1}{3}$  of a Foot, that is 8 Inches. Wherefore, if what is said before be true, and that  $HK$  were  $1\frac{2}{3}$  of a Foot, or 20 Inches, we should have seen the lateral Pressure on  $HD$   $RS$  resist a greater Weight.

Having therefore rais'd the Axis a little higher, so that  $A$ , the End of the Ballance, being hereby apply'd to the Centre of the Pressure, was also higher, we found that by putting on the Weight  $Y$  of 77 Pounds, the wooden Plane immediately gave way, but that the lateral Pressure held good against 73 or 74 Pounds.

This agreed pretty near with the foregoing Rule, as we found by computing after the following Manner:

Let *Tab. XXVII. Fig. 2.* be transferr'd to *Fig. 3.* and that the Water is from  $HS$  to  $KZ$ . Then  $HK$  equal to  $1\frac{2}{3}$ , or  $\frac{1}{3}$  of a Foot is equal to  $PH$  (if we suppose this same  $HK$  to be lying horizontally) and  $HS$  is a Foot: So that the whole Body of Water of this Breadth, Length and Depth  $\frac{2}{3}$  of a Cubical Foot; and the half of it, which presses laterally upon  $KHZS$  will be  $\frac{2}{3}$  of a Foot. If now we subtract from thence the Water's lateral Pressure upon  $KDRZ$ , to wit,  $\frac{4}{3}$  of a Cubical Foot, it being the Half of  $\frac{4}{3}$  a Foot of Water (which last expresses the Magnitude of a Body, the Length whereof  $RD$  is 1 Foot, the Breadth  $mD$   $\frac{2}{3}$ , and the Height  $KD$  likewise  $\frac{2}{3}$  of a Foot) there will remain the lateral Pressure of  $\frac{2}{3}$  or  $\frac{2}{3}$  of a Foot, or otherwise  $1\frac{1}{3}$  of a Cubical Foot of Water that is (supposing such a Foot of Water to be 63 Pounds, or somewhat more) of  $73\frac{1}{2}$  Pounds against  $HD$   $RS$ ; which sufficiently agrees with the Rule mention'd *Sett. LII.*

SECT. XLIV. *The Lateral Pressure adapts itself to the Height, and not to the Breadth of Water.*

XLVIII. WE likewise observ'd upon placing a flat Board or Partition (*Tab. XXVIII. Fig. 2.*) *Tab*, after such a manner, that the Water, which before press'd upon *D H R S*, became divided, or had not above the half *a K* of its former Breadth *K G*, that the lateral Pressure was not lessen'd, whilst the Water continued at its first Height *K G*.

So that from hence also it appear'd, that the Powers of the lateral Pressure remain the same, whether the Breadth of the Water be increas'd or diminish'd; but that upon augmenting or lessening the Height of Water, those Powers are accordingly augmented or lessen'd.

SECT. XLV. *The Lateral Pressure of Water, with Air pressing upon the same.*

XLIX. BUT forasmuch as in these Experiments of Lateral Pressures we have supposed Water to be the uppermost Fluid, so that, for Instance, in the Vessel *ABCD* (*Tab. XXVII. Fig. 4.*) we are to suppose there is no other Fluid Matter above the Superficies of the Water *AC*, the following Difficulty seem'd to arise, namely, that the lateral Pressure of the said Water *AC* upon *AB* would be much greater than it is found to be by these Experiments; because the Air between *AC* and *ooo*, &c. actually pressing upon *AB* with the Weight of 30 Foot of Water (according to the Barometer) the lateral Pressure against *AB* would appear to be considerably increas'd.



But upon the whole Matter, we shall shew by the following Calculation, that the lateral Pressure of Water in the Vessel *ABDC* upon *AB*, is not so much increas'd by the Weight of the Air above *AC*, as that the Force which *AB* withstands, or which should press inwardly against *CD* (like the Weight in the foregoing Ballance, *Fig. 2.*) could be sensibly augmented thereby.

Let the Vessel *ABDC* (*Tab. XXVII. Fig. 4.*) be fill'd with Water up to *AC*; above which let us suppose a Column of incumbering Air as high as *oooRooo*; we know that the said Air being also on the other Side of *AB*, at *A, B, i, n*, will press likewise against *AB* laterally from the Side of *ni*.

Now to find what Pressure *AB* undergoes by the Water on the Side *DC*, and by the Air on the Side *ni*, and how much the first Pressure exceeds the last :

Let us call the Weight of the Air gravitating upon each Point in the Plane *nN*, to wit, *nO, mO, EO, &c.* by the Name of *a*.

Let the Gravitation of the Water *KF* on the Point *F* be *b*, then *LG* is *2b*, and *MH* *3b*, &c.

Let the Air-Weight of *kf* on the Point *f* be *c*; then is *Lg*, *2c*; *mb*, *3c*, &c.

Whereupon (according to the Calculation in *Scet. LI.* if we do here also suppose five Points of Pressure) the Force of the superior Air, and of the Water in *ABCD*, which press *AB* laterally towards *ni*, will be *5a* with *10b*. And on the contrary, the Force of the upper Air, and of that Air which is at *niBA*, which press'd *AB* laterally back towards *DC*, will be *5a* with *10c*. So that these two Powers pressing laterally against each other, being drawn by each other, the Force wherewith *AB* is press'd laterally towards *ni*, will be *10b* less *10c*.

Now

Now without the superior Air, the lateral Pressure of the Water (according to *Seç.* LI and LII.) would be equal to 10  $b$ ; and  $c$  is equal to about  $\frac{1}{1000}$  part of  $b$ , if we suppose Water to be 1000 times heavier than Air. So that the surrounding Air does only lessen the lateral Pressure of the Water  $\frac{1}{1000}$  part; which in the foregoing Experiment can make no sensible Alteration, and consequently the abovesaid Difficulty is obviated.

SECT. XLVI. *The Augmentation and Diminution of the resisting Force of Fluids produces Motion, and the Force thereof.*

L. HITHERTO we have consider'd the upward and downward Pressures of Fluids which are quiescent or stagnant, either by reason of Powers really acting upon and against each other, or else by the Resistance and Obstructions of Motion; we should now naturally proceed to inquire into the Powers of those Fluids that are in actual Motion; but forasmuch as this would require a whole Book to account for it, and since what we propos'd to shew here concerning the *Law of Altitude or Depth*, may likewise be conceiv'd by the Pressure of stagnating Fluids; we will not enlarge this Digression, which to those who understand Hydrostatics, may seem already much too long.

We shall only observe further concerning the Powers pressing upon each other, that if in *Tab.* XXVII. *Fig.* 5. The Tube  $bkg$  is equally fill'd with Water up to  $a$  and  $f$ , since  $d$  is press'd upwards by  $ab$ , and downwards by  $fd$ , the Part  $d$  will quiesce or stand still, if the Powers  $ab$  and  $fd$  are equal; but if one of 'em be lessen'd to  $ed$ , or the other increas'd to  $bb$ ,  $d$  will be removed towards that Side where the Force is smallest, or in this case to  $g$ ; and even with as much Force, as

the Difference of both Powers is, that act on each Side upon *d*. This may be easily try'd, and wants no further Proof.

SECT. XLVII. *Fluids are moved by, or rather after taking away a Resistance, and the Force thereof.*

LI. MOTION may likewise be produced, by removing a Resistance which obstructed Motion.

For Instance, blow into a Tube at *g*, which is fill'd in both its Legs with Water up to *a* and *f*, till the Water subsides from *f* to *e*, and rises from *a* to *b* on the other Side; then presently stop the Orifice *g* with your Finger; whereupon all will stand still, and your Finger will become the Impediment or Resistance of Motion. This appears by removing your Finger, upon which the Motion will ensue.

Now by what has been said it is obvious, that whilst the Finger continues upon *g*, and the Fluid is stagnant, the Part *d* is press'd upwards by *bb*, and downwards by *dg*; and that the resisting Power or Finger is press'd upwards by the difference of the Powers *bb* or *dg*. So that this Resistance or Finger being taken away, a Motion will be made towards the Side of the Resistance; and even with that Force with which the Resistance was press'd when the Fluids were quiescent, unless upon removing the Resistance, no other actual Force begins to operate.

SECT. XLVIII. *Transition to Hydraulics, or some few Hydrostatical Examples.*

Now that Fluids do so exactly observe these Laws; that, *First*, every thing which is deduced from thence by good and just Consequences (all Circumstances being rightly observ'd) is likewise  
 expe-

experimentally verify'd in the same; And, *Secondly*, that these Fluids, before they recede from *this Line of Altitude or Depth*, do moreover produce Effects, which, to such as are unexperienced in Hydrostatics, appear to be so many Wonders, and of whose manner of operating, even the greatest Mathematicians acknowledge themselves ignorant, or at least uncertain, we will prove by some few Instances.

SECT. XLIX. *Calculation of the Force of a Syphon.*

LII. THE First Instance, that we may begin with one that is simple, shall be the Operation of a *Syphon*.

ABCD is a Vessel fill'd to the Brim with Water (*Tab. XXVIII. Fig. 1.*) in it there is placed a Curve Tube or Syphon EGHK, likewise full of Water, the Orifice whereof IK is for that purpose stop't with the Finger or otherwise.

If now you remove your Finger from IK, every Body knows experimentally, that the Water will run out from IK to Z, rising up in the mean while in that part of the Syphon EG, which is shortest, and coming down in the longest HK, as long as the Water in the Vessel continues higher than the Mouth of the shortest Leg EF.

Now to know from the foregoing Principles, the Force and Manner whereby, and whereon this Operation of the Syphon is brought about:

Stop the Syphon again with your Finger at IK, by which means the Water in that, and in the Vessel will stagnate.

Suppose then WX to be the upper Place of the Air which presses here upon the Water, and produce the Horizontal Plane of the Water AD, thro'

thro' PQ to RS, whereof LM, NO, PQ and RS are equal Parts; thereupon, according to the preceding Rules, the Part LM will be press'd with the Weight of the Column of Air incumbering on it.

Let us for Brevity sake call the Pressure of Weight thereof upon LM,  $a$ , or if you please 100 Pounds more or less; especially if People be not used to this Way of Letters.

Accordingly we will express the Weight of the Water Column PQIK by  $b$  or 10 Pounds, and that of the Air RSTV, being of the same Height, by  $c$  or 1 Pound.

Now since LM, NO, PQ, which are all equal Parts of the same Horizontal Plane AQ, and all Water, and to all which we may suppose, that a Line or Thread may be drawn, without passing thro' a solid Body, or any other Fluid besides Water.

And since by the Action of the Syphon the Plane LM moves, or is press'd downwards, that of NO upwards, and that of PQ again downwards, if every Thing be reduced to Rest by stopping the Orifice IK, the Powers whereby the said Planes were press'd up and downwards will be equal, according to *Señ. XLI, &c.* and LM being press'd downwards by the Weight of the Air-Column LWM, that is, by  $a$ , or by 100 Pounds NO will be press'd upwards, and PQ downwards by the same.

If now we join to the Weight of this Air-Column of  $a$  or 100 Pounds, which presses PQ downwards, the Water-Column PQIK of  $b$  or 10 Pounds, by which IK is likewise press'd downwards; the Force or Weight that presses IK will consist of  $a$  join'd to  $b$ , or of 100 and 10 Pounds, to wit, of the Air and Water-Columns together

together. And so it is with this Force, that the Water gravitates downwards to Z.

If now the Horizontal Plane passing thro' IK be extended to V, and TV suppos'd equal to IK, then will TV be press'd downwards by the whole Air-Column TVX, that is by RSX of  $a$ , or 100 Pounds (the same being equal to LMW) and by RSTV of  $c$  or 1 Pound; that is, of  $a$  and  $c$ , or 100 and 1 Pounds together.

Now with just so much Force (according to Sect. XLIII.) is the Part IK, or rather the Air pressing against IK, or the Finger (if we do not consider the Thickness thereof) press'd upwards.

So that we see here two Powers pressing against each other on IK, or the Separation of the Water and Air, operating and acting against one another.

Of which, that, that presses IK downwards, has been found already to consist of  $a$  added to  $b$ , or 100 and 10 Pounds. And that which presses IK upwards, to be no more than of  $a$  and  $c$ , or 100 and 1 Pounds; so that this last,  $a$  and  $c$ , or 101 Pounds, (*i. e.* the smallest Sum) being subtracted from  $a$  and  $b$ , or 110 Pounds, the Remainder is  $b$  less  $c$ , or 10 less 1, that is 9 Pounds.

And this shows the Force wherewith IK is press'd downwards more than upwards, and it is equal to the Weight by which the Water-Column RQKI,  $b$  or 10, exceeds the Air-Column PSTV,  $c$  or 1.

So that if you remove your Finger from IK, and suffer these two reciprocally gravitating Powers to act against each other, it is plain, that the Water at the Orifice of the Tube IK, is by the lately mention'd difference of Weight between the two Columns PQKI and RSTV, that is  $b$  less  $c$ , or 9 Pound Weight (supposing all the Numbers

to be as above) press'd or protruded downwards to Z.

Thus we see the Force wherewith a Syphon flows, deduced from the aforesaid Principles, and the Fact is obvious to every one.

But we must beg our Readers to take notice here, as well as to remember hereafter, that we do by no means pretend that these Numbers of 100, 1, 10, &c. are the just Proportions of the Weight of Water and Air; but that we only mean thereby, to show that a Column of Water is much heavier than a like Column of Air, and to consult the ease of those who are not accusom'd to Letters in Calculations.

SECT. LI. *Of a Fountain that spouts or springs higher than the Water that supplies it.*

LIII. LET us now propose an Instance that is a little more compounded than the former.

*How to make a Fountain whose Stream rises much higher than the Water above in the Cistern, which causes it to spring out without the Application of any Force Pumps, Bellows, or other Instruments, and without any other Means whatever, saving the Gravity or Weight of the Water itself.*

This may be done after the following manner:

ABCD (*Tab. XXVIII. Fig. 2.*) is an open Cistern, from which an open Tube NR is carried downwards thro' the Covering EH of another Cistern EFGH, shut so close that no Air can get in, passes down to R, almost to the Bottom of the Cistern FG.

From the upper Part of this lowest Cistern EH, there rises a second Tube ST, passing on almost as high as TD, or the Lid of a second Cistern DCKI, which is likewise closed; and from thence there is again derived a third Tube to

LMQ

L M O, which is stop't with a Cock that has a large Orifice at M O.

Moreover, in the Cistern D C K I, there is a Hole at P, which can be open'd and shut by another Cock or Stopper.

To set this Machine to Work:

Pour in Water at the Orifice P into the Cistern D C K I, till the Tube L Z Q O be full, shut the Cock M O, continuing to pour in Water at P, till the Water rises in the said Cistern to the Height T Y, or level with the Mouth of the Tube T.

Then shut the Cock P, and pour Water into the Cistern A B C D till it rises to the Height 2 T. This is not indeed absolutely necessary here, but is prescrib'd, to the end, that by taking the same Height of Water in both the upper Cisterns, the Calculation may be the more simple, and consequently more intelligible to unexperienced Persons.

This being done, and every Thing at Rest, upon opening the Cock M O, you will see the Stream of Water rising up to V thro' the middle Orifice of the flat Plate 5 6, or at least to a very considerable Height above the uppermost Superficies 2 T of the Water which is in the Cisterns A B C D and D C K I, and which presses up the Stream 6 V.

It must be here observ'd, that forasmuch as the Water of the upper Cistern A B C D descends into the lower E F G H during the Play of the Fountain, there must be a Hole in the latter from whence the Water may be discharged; which being done, it must be stop't, if you would play the Fountain again.

Or otherwise (which I find most convenient in mine) you may place a little Pump at 2 thro' the Tube N R, down to the Bottom F' G, and then  
pump



pump the Water out of the lower Cistern EFGH thro' N, the Cock being open'd in the Cistern DCKI.

To know then with what Force the Stream rises from the Cock NO, or the Orifice 5 6 :

Let the said Cock be turn'd or shut again, whereupon the upper Cisterns and Tubes being fill'd with Water, all will be still; and let it be suppos'd (that we may not repeat the same) that all the Tubes as well the real ones, NR, TS, LZ, as the imaginary ones W 2, X 4, and 4 5, are of the same Width. Tho' this likewise is only requir'd for Calculation's sake, since we may otherwise use for this Purpose, such a Part only of a larger Tube as is equal to the Width of a smaller.

Let then WX be the uppermost Plane of the external Air; and let that of the Water TY be continued to 4. Consequently, as we have shewn before, the Part 2 of the Superficies of the Water in the upper Cistern ABCD, will be press'd downwards by the Column of Air W 2.

Let us again call the Weight of the said Column  $a$ , or 1000 Pounds.

After the same manner we will term the Weight of the Water-Column R 2,  $b$ , or 100 Pounds; as also that of the Air-Column T 3,  $c$  or 10 Pounds too: The second Water-Column YZ shall be express'd by  $d$ , or 80 Pounds, and the second Air-Column 4 M by  $e$ , or 8 Pounds.

To proceed then.

The Part R of the Horizontal Plane R 3 is press'd downwards under the Tube NR by the Weight of the Air-Column W 2, or  $a$ , otherwise 1000 Pounds jointly with that of the Water-Column 2 R, or otherwise  $b$ , or 100 Pounds; and consequently by  $a$  and  $b$  together, or by 1100 Pounds.

But

But all Things being quiescent, we know according to the foregoing *Set.* XLIII. that with the same Force as R is press'd downwards, the equal Part 3 is press'd upwards; so that the Force which drives the Part 3 upwards, is likewise equal to  $a$  added to  $b$ , or 1100 Pounds together.

Now the Air-Column T 3, nam'd  $c$ , and suppos'd to be 10 Pounds, does also gravitate with the same Force upon 3 downwards. Wherefore Subtracting this downward-pressing Weight  $c$ , or 10 Pounds, from the Force that presses 3 upwards, or from  $a$  and  $b$ , that is 1100 Pounds, the Force with which the whole Air-Column T 3, and consequently also its Superficies T, by the Difference of both these acting Powers is moved upwards, does result from thence. And the same must be express'd by  $a$  and  $b$  together, less  $c$ ; or by 1100 less 10, that is by 1090 Pounds.

Again, since T is a Part of the Air's lowermost Horizontal Plane TY, which Air presses upon the Water in this Cistern DCKI, and since Y is an equal Part of the said lowermost Horizontal Plane, it follows according to the above-mention'd Laws of Hydrostatics, that Y is press'd with as much Force downwards as T upwards; so that Y is press'd downwards with a Force equal to the said  $a$  and  $b$  together, less  $c$ , or with 1090 Pounds.

To which if we here add the Weight of the second Water-Column YZ, that is, of  $d$ , or 80 Pounds, the Part Z 9 will be press'd more strongly downwards with this Weight than the Part Y; and consequently the Weight which presses Z 9 downwards, will be equal to  $a$ ,  $b$  and  $d$  together less  $c$ , or 1000, 100, and 80 together, less 10; that is, 1170 Pounds.

And

And since Z<sub>9</sub> and MO are equal Parts of the Horizontal Plane ZO, MO, prefs'd with the same Force upwards :

If now the Cock at MO had no considerable thickness, and yet hinder'd the Water from springing out, it would appear that MO were prefs'd downwards with the Force of the whole Air-Column MX, that is of X<sub>4</sub>, *a*, or 1000 Pounds (for this is equal to W<sub>2</sub>) and <sub>4</sub>M, *e* or 8 Pounds, that is, taking in all together, MO is prefs'd downwards by *a* and *e* together, or 1008 Pounds.

And it has been shewn before, that it is prefs'd upwards by *a*, *b* and *d* together, less *c*, or by 1170 Pounds.

Wherefore, if we suffer these up and downward pressing Powers to operate on each other, as they do, when the Cock is open'd at MO; it is plain that the Water which presses upwards at MO being strongest, will over-balance the opposite Power that presses the said MO downwards, and be driven upwards by the difference of the Powers acting against each other.

This Difference is found by Subtracting the smallest downward pressing Force *a* and *e* together, or 1008 Pounds, from the greatest *a*, *b* and *d* together, less *c*, or 1170 Pounds.

So that the Difference, or the Force wherewith the Water ascends at MO, is equal to *b* and *d*, less *c* and less *e*, or to 1170 Pounds.

Or to express the same by Words that may be apply'd to the Fountain, and to take these Things for the Letters which they denote : The Water will be protruded out of the Cock MO, with a Force equal to the Weight of both the Water-Columns 2 R and YZ, Subtracting the Gravity of the two Air-Columns T<sub>3</sub> and 4 M.

Now since the Weight of the Air with respect to that of Water, is as  $\frac{1}{1000}$ , it may be omitted in  
this

this Calculation, as making no considerable Alteration therein. And we may advance, without committing any Mistake worth Notice, that this Fountain spouts with as much Force, as if the gravitating Water in the Cistern had the Height of both the Water-Columns,  $2R$  and  $YZ$ , that is, of  $b$  and  $d$  placed one upon the other.

So that from hence it is easy to infer, why the Stream  $MV$  springs much higher than the highest Water  $Az$  in the Cistern, since the Height thereof alone is equal to that of a Water-Column  $2R$  in this Contrivance of a Fountain. And that Experience agrees with these Propositions, every Body that pleases to try, will find as well as we.

SECT. LII. *Of a Fountain of Hero, the Stream whereof is longer than the Fountain high.*

LIV. SOME Years ago, I caus'd to be made another kind of a Table-Fountain, of the Nature of that of *Hero Alexandrinus*; but with this Difference, that whereas in that of *Hero* it is not possible to make the Stream that spouts out to attain to the Height equal to that of the Fall of the Water, or of the Fountain itself; yet in mine, notwithstanding the Height of the Machine was no more than  $3\frac{1}{2}$  Foot, the Jet rose strongly five Foot higher than the Water in the upper Cistern.

The Structure is thus:  $GAFH$  (*Tab. XXVIII. Fig. 3.*) is the uppermost Cistern, being open, and having under it two smaller, and every where Air-tight Cisterns  $ABCD$ , and  $DCEF$ ; each of these has an Orifice or Hole, one at  $M$ , t'other at  $N$ , and both of 'em may be render'd also Air-tight, by stopping them with a Cork covered with a wet Bladder, or a Cock. There are likewise two close Cisterns below,  $STRP$ , and

PRQO. From the Bottom AF of the uppermost Cistern GAFH, there passes a Tube KI downwards almost to the Bottom RT of the Cistern PRTS; but in such a manner that the same, or whatever it contains, has no Communication with the Cistern DCEF, through which it passes. And from 3 in PS, there is carried a Tube 3L upwards, just below the uppermost Plane DF of the Cistern DCEF; from the Bottom of which CE, there descends again at 9 a Tube at 9b, terminating in the other Cistern QOPR very near the Bottom of it QR. And this same Cistern QOPR sends again a Tube 4Z upwards, which beginning at 4 is carried on to Z, exactly under the uppermost Plane AD of the Cistern ABCD. *Lastly*, At AD there is a Tube *pr* close folder'd at 5 6, which rises to *rb* only, or a very little higher than the Plane AD; and passes downwards to P, or nearer to the Bottom BC.

On the Top of this last Tube, we fix'd another *r8*, which at W8 was cover'd with a flat Plate, having a small round Hole in the Middle of it, thro' which the Stream was to pass, and we clos'd it at the Joint *r* with *Emplastr. de Minio*, so that it was impervious either to Water or Air.

Now to set this Machine to Work :

We inverted or turn'd it upside down, so that the Cistern GAFH was undermost, and having fill'd both the Cisterns ABCD, and DCEF, with Water at the Orifices M and N, we stopt the said Orifices very close with a Cork and Bladder, putting a Finger in the mean time upon the Hole in the little Plate W8, to the end that the Water pour'd in at M, or so much of it as was above *p*, might not run out.

Then suddenly placing the whole Machine in its former State, so as that the Cistern G A F H was again uppermost, we pour'd without delay some Water that was at hand in the said Cistern; whereupon, presently afterwards, we saw a Stream 8 7 rising out of the Tube  $r 8$  thro' the little Hole, which Stream, when measur'd, was much longer than the Height of the whole Machine, as has been already said.

It will not be necessary to give an Account here, how the Water subsiding, or sinking from G A F H thro' the Tube K I presses the Air out of the Cistern P R S T thro' the Tube 3 L upwards, which finding no room any where but by pressing downwards the Water in the Cistern D C E F, and in the Tube Y b, protrudes the said Water towards the Cistern O Q R P with a much greater Force than that of its own or single Gravity. At which Place the Water likewise ascending, the Air is protruded with the same Force from O Q R P thro' 4 Z to the Cistern A B C D, which (without counting the Air in the Tubes L g and Z c, because of its Levity and small Resistance) causes the Water to spring out of the Tube p 8; after this manner with almost the Force of both the Weights of the Water Columns Y b and K I. In the same manner we may deduce the Operations of the foregoing Fountains, Syphons and others, whereby, without any Calculation, we may also form a general Idea of their Properties. I thought it sufficient to give my Readers one only Instance here, it not being my Design to write an entire System of Hydrostaticks. They who would impute the Force wherewith the Water issues out of the Fountain exactly, may do it after the Method of the aforementioned Examples.

But before I proceed any further, I must add, that this Machine may be form'd after a much

more convenient manner, so as that one need not invert it, nor yet stop the little Hole of the Column W 8 with the Finger, or any thing else; this may be done by Stop-Cocks in other Places, and by making the Orifices MN above at AF, as is known to every Body that has any Skill in these and other kinds of Water-Works. Yet I have rather chose to express it in the present manner, because it is that in which I made the Experiment, and in a Place where we could form this whole Structure of no other Metal than Tin, nor could have the Assistance of such Workmen as are necessary in such Matters. Whereas the other Fountain was prepar'd by a Person of good Judgment, and who was well instructed concerning the Frame and Make thereof.

Nor will it be difficult to one that rightly understands this, and the foregoing Disposition of a Fountain, to cause a Stream of Water to rise up to a given Height by a requisite Multiplication of Cisterns and Tubes, the Height of the Descent of Water being likewise given. It is certain at least that all this may be deduced by Argumentation, and confirmed by Experience.

#### SECT. LIII. *The Motion of Water in a Curve Tube.*

LV. IN the last Place we shall add something, which, tho' of little Importance, yet at first Sight has appear'd wonderful even to some Mathematicians themselves, to whom we have several times communicated it; and which serves to confirm the foregoing Laws after a strong manner.

Y *m n* Z is a Cistern or broad Vessel (*Tab. XXVIII. Fig. 4.*) fill'd with Water up to the Brim; P O N M is a Cylindrical Glass, with the Bottom P O upwards, and the Mouth M N just under the

the Surface of the Water in the Cistern, and containing, before it was inverted, some Water in it, which (the Mouth of the Glass being thus turn'd downwards) continued suspended therein at the Height  $QR$ .

Moreover,  $LBV$  is a Curve Tube, both Legs of which being fill'd with Water to the same Height  $L$  and  $r$ , I put my Mouth to the Orifice  $V$ , and blow'd it back from  $r$  to  $A$ , thereby causing it to run out at  $L$ .

The Water by this means being contain'd between  $L$  and  $A$ , to prevent its subsiding at  $L$ , and rising at  $A$ ; I presently stopt the Orifice  $V$  with my Finger, whereby the Water remain'd so much lower at  $A$  than at  $L$ .

Then I put the said Tube  $LBA$  under the Glass  $MNOP$ , so that a Column  $TL$  of Water, (and the Glass being not quite full) a Column also of Air  $tu$  was above the Orifice  $L$ .

Thus the Water being at unequal Heights in the Tube, under the Glass, and in the Cistern; (forasmuch as that in the Leg of the Tube  $LB$ , was not only the entire Length  $SL$  or  $Ar$  higher than in the other Arm  $bV$ ; and besides the Water-Column  $TL$  press'd yet more upon the Orifice  $L$ , without counting all the Air  $Tu$ ) who could at first sight, unless he were well vers'd in *Hydrostatics*, imagine otherwise, than that by the greater Height of Water, at  $SL$ , or rather at  $ST$ , the Water would be forced upwards at  $A$ , when the Finger was remov'd from  $V$ ?

And yet we find by Experience, that instead of  $A$  rising to  $r$ , the Water will subside from  $A$  to  $F$ , as soon as ever the Finger is taken from  $V$ .

To discover therefore the Reason of this Phenomenon, so surprizing to some People, nothing more is necessary than to trace the same back to the before-establish'd *Laws* of *Fluids*, when you have



again blown the Water down to A, and stopp'd the Orifice V, and reduced all to its former State.

Let us then again suppose WX to be the upper Superficies, and AE a Horizontal Line drawn parallel to YZ. Now let the Air-Column WE equal to XA (the Finger being remov'd from V) be each call'd  $a$ , and the little Water-Column AF be call'd  $b$ ; and the little Air-Column GE of the same Height with AF, be  $c$ ; each of the Water-Columns Hg and DT be  $d$ ; and the little equal Air-Columns tg and uT be  $e$ : Whereby, according to the foregoing Method, the Force may be computed with which the little Water-Column AF is prefs'd down to F, or to the Depth YZ.

But this may be likewise more briefly done after the following manner: The Part G is prefs'd by the Air-Columns WE and EG, or by  $a$  and  $c$ ; but (according to *Sect.* XLIII.) the Part F lying in the same Horizontal Plane YZ, is prefs'd upwards with the same Force  $a$  and  $c$ , when upon stopping the Orifice V with the Finger, all is still; forasmuch as there can be drawn a Thread from G to F, without passing thro' any other Solid or Fluid Matter: But if now you remove the Finger from V, the Part will be prefs'd down by the Air-Column XA  $a$ , and the little Water-Column AF,  $b$ ; so that the Force which presses F upwards, is  $a$  added to  $c$ , that which presses the same downwards is  $a$  added to  $b$ .

Now since  $b$  is Water, and  $c$  Air, the downward pressing Force upon F, or  $a$  added to  $b$ , is greater than the Force pressing upward express'd by  $a$  and  $c$ ; and consequently the Part F is prefs'd downwards by the Difference of this Force, or by the Force of Gravity wherewith the little Water-Column

Column exceeds the equal Air-Column  $E G$ , that is by  $b$  less  $c$ .

From whence it appears, that whilst  $A F$  or  $b$  is Water, and heavier than  $G E$  or  $c$ , which is Air, the Part  $F$ , and consequently the Column  $A F$ , will be press'd or move downwards, and never cease till  $A$  subsides to  $F$ , and the Column  $A F$  becomes Air likewise.

And then the Difference of  $A F$  and  $G E$ , or  $b$  less  $c$  will be nothing, and the Force pressing up and downwards upon  $F$ , equal; for which Reason the Water in the Tube  $V b$  will not be higher than at  $F$ , or equal to  $Y Z$ , when all is quiescent by its Weight only. And the same is conformable to Experience.

We might here subjoin the Demonstration, that if  $L$  the Orifice of the Tube  $L B V$  stood out at any Height above the Water  $Q R$  in the Air  $P Q O R$ , the Water would not subside so low as  $F$  or  $Y Z$ , but that it would remain and rest proportionably as much higher above  $F$  or  $Y Z$ , as  $L$  should be above  $Q R$ .

I cannot forbear shewing here, how necessary the last Observation made (*See* XLIII.) is in this Calculation; to wit, that since the Orifice  $L$  of the Tube  $L B V$ , being under the Water at  $Q R$ , a Thread can be drawn from  $G$  to  $F$ , that passes thro' no other fluid Matter than this Water; we may presently discover after a much shorter manner the Pressure upwards of  $F$ , by the Pressure downwards of  $G$ .

But when the Mouth  $L$  of the Tube  $L B V$  happens to be above the Water  $Q R$ , in the Air  $P Q O R$ , we shall find that the Thread which we would have drawn from  $G$  to  $F$ , must first pass thro' the Air  $P Q R O$  out of the Water to the Orifice  $L$ , before it reaches  $F$ ; for which Reason the aforesaid short or abridg'd Computa-

tion can't be made true, since, for this Reason, F and G will not be press'd with equal Force upwards and downwards, the Finger being upon V, tho' they be equal Parts of the same Horizontal Plane. This will appear clearly to every one that shall compute it after the manner of those Examples mention'd, *Seet. LX, and LXI.*

But this may suffice to give a short experimental Example of these *Laws of Hydrostatics.*

This Experiment may be made with little Trouble or Charge, if you put a Curve Glass Tube in an Ounce Vial almost full of Water, adapted to the Mouth of the Vial, that no Water can run out of it when inverted or turn'd upside-down.

SECT. LIV, LV, LVI. *A Hydrostatical Paradox shewn by two Experiments.*

LVI. Now that these many thousand Parts of which Fluids consist, how ignorant soever of what they are doing, observe so accurately these *Laws of Height*, that before they depart from them, they produce Effects incredible to many Persons, will appear from what follows.

Let (*Tab. XXVIII. Fig. 5.*) DC be a round streight Tube, of as great a Length and Breadth as you please, in which two other Tubes AC and BC do open, or even as many more Tubes as the Circumference of the first Tube DC will contain, and these also may be as large as you will; but for the sake of Plainness, we will suppose there to be no more than three, and of equal Bigness.

Then fill all these Tubes with Water to an equal Height, which upon opening the Cocks G, E, F, will press upon the Base C of a Vessel of Communication CTH, fitted to the Cocks and

and Tubes ; and upon removing the Base or Bottom, would run out thro' C.

Now according to the foregoing Laws, it is obvious to all that understand *Hydrostatics*, that if all the Cocks G, E, F, be shut, and upon opening any one of them, the Water contain'd in each of these Tubes severally, will press on the Bottom C with the same Weight ; and that therefore if the Water in D C only (supposing the Cock E open, and G and F shut) presses on the Bottom C with the Weight of 100 Pounds, the Water in the Tube A C only (the Cock G being open, and E, F shut) will press the bottom C with the same Weight of 100 Pounds ; and so likewise will the Water in the Tube B C.

Now since the Water in each of these Tubes does alone, and without the Weight of the other two, press upon the Base C with 100 Pounds ; let one who has never seen these *Hydrostatical Experiments*, nor heard of 'em, ask himself with what, or how much Weight all the Water in the three Tubes acting jointly, and the three Cocks being open, will press upon the Base C ; and let him tell us, whether he do not find himself at first dispos'd to answer (as I have known many learned and ingenious Men do) that since the Water in each single Tube presses upon C with 100 Pounds, all three of 'em operating together, will press with thrice the Weight, excepting the little Water at T H F E G, which lies between the Cocks and the Bottom C, and always remains the same ; which however, if the Tubes be taken long enough, makes no remarkable Difference.

But in Case we should tell him : *First*, That far from answering rightly, he has quite mistaken the Matter ; and that altho' the Water in each of these Tubes does singly press upon the Bottom C with  
the

the full Weight of 100 Pounds; yet when all three of 'em act upon the said C together, the Pressure is no more than of 100 Pounds, even tho' the Tubes were larger, and more numerous, and consequently contain'd in them a greater Weight of Water; for Instance, if each Tube like N B F were of the Size and Figure of N F R, or any other; provided only that the Water in each of the Tubes should continue at the same Perpendicular Height D H, or R S, and the Base which bears the Pressure, of the same Extent.

And, *Secondly*, That the same happen'd by virtue of the aforementioned Hydrostatical Law, that no Part, as T H, of a Horizontal Plane T S, does ever bear a greater Burden than the Weight of the Column of Altitude, which has T H for its Basis, and D H or R S for its perpendicular Height: He will see indeed that this is a just Consequence of this Law; but undoubtedly also confess, that the manner after which the Water must be dispos'd in these three or more Tubes, so as not to gravitate more with a triple or greater quantity of Water, than with one third thereof, is unknown to him.

The rather, since he sees that such Pressure is perform'd not by a Fluid actually put in Motion, but by a quiescent one.

LVII. And to the end, that they who read this, should not doubt the Truth of the Experiment, which, unless they were thoroughly vers'd in *Hydrostatics*, they could hardly avoid, let them please to compare the following Experiments therewith, which are only made to support the Truth of the former against those who question it. I find them thus describ'd among the Experiments which I noted some Years since on my Journal.

I caus'd a Machine to be made after the following manner: M N Q R (*Tab. XXVIII. Fig. 6.*) is a Tin Tube having a Cock at K, which can stop and open the Communication between the upper and lower Part of the Tube. From this Tube at S, there rises another oblique one T S, growing wider and wider to the Top O T P, after the manner of a Funnel, having likewise a Cock at L, which can open and shut a Passage between the Fluid that is above and that below it; at the end of this Tin Tube at Q R, there is another Glass one Q R G H stuck into the former, and both cemented with *Empl. Diachylon*.

Then I took a large Cylindrical Glass A E F B, and fill'd it up to C D with a strong Pickle, and binding the Tin Tube together with the Glass one, fast to a transversal Piece of Wood X V; being empty, I let them down into the Pickle to a certain Depth.

Whereupon pouring gently some Oil of *Turpentine* into the Funnel and Tube (both Cocks being open) after that a part of it ran out at G H, and produced a Cream of floating Oil upon the Pickle at A B C D, we found that the said Oil being lighter, and consequently kept up by the Weight of the Pickle, at M N O P, for Instance, or at least much above the Superficies of the Pickle, remain'd in that Condition in the said Funnel and Tube.

Having then stay'd till all was perfectly still, we observ'd a drop of Oil hanging below at the Bottom of the Glass Tube G H, which immediately, upon pouring some little quantity of Oil into the Funnel at O, or the Tube at N, by such a small Accession of Pressure fell off from G H, and emerged in the Pickle. After which (the Piece of Wood V X being ty'd very close to the Glass Vessel, that it might not stir) when another Drop  
of

of Oil was hanging at GH, we softly turn'd both the Cocks at K and L, and made them fast; and then found that whether one or both of 'em were open'd, the Pressure was not so much alter'd, as to cause this suspended Drop of Oil to fall off, tho' we had seen before, that it always so happened by the Addition of a small Weight, which was not to be compar'd to that of the Oil in the Funnel.

From whence (not to recapitulate all the Consequences deducible from the many *Hydrostatical* Laws which we have before laid down and proved) it appear'd that the Pressure of the Oil in the Tube NH, was neither increas'd nor diminish'd; whether it was that the Pressure of all the Oil which was in the Funnel SPO, acted and pressed downwards, or whether it was hinder'd from doing so by the Cock L.

LVIII. For the same Purpose we join'd a Curve Tin Tube DEF, *Fig. 7.* to the preceding Instrument BCD, and sticking into it a Glass Tube FA, clos'd 'em together as before at D and F. Then the Cocks being open, we pour'd common Water into the Funnel C, till it rose to the same Height ABC in the said Funnel, and both the Tubes A and B: And moreover having opened and shut each of the Cocks K and L, and afterwards both together, we could not observe the least sinking or rising at A; so that it also appear'd from hence, that the Pressure of the Water in the Tube BD, whereby the Water in EF was sustain'd at the Height A, did neither increase nor diminish, but continued entirely unalterable, whether the Water in the Funnel gravitated on it downwards or not.

From both which Experiments, what is said above in *Señ. XLIV*, seems to be sufficiently confirm'd,

firm'd, as strange as it may otherwise appear to any one at the first Sight, altho' it be obvious enough to such as understand *Hydrostatics*.

SECT. LVII and LVIII. *Another Hydrostatical Paradox confirm'd also by an Experiment.*

LIX. ANOTHER Instance concerning which, even the greatest Mathematicians freely own their Ignorance (or at least their Uncertainty) as far as relates to the Manner of the Water's working, we will here offer, not according to the little Measure or the Instruments wherewith we perform'd it, but as in the former, so as to render it more Intelligible, and to make a greater Impression.

Let ABLM (*Tab. XXIX. Fig. 1.*) be a Vessel represented here in its Profile or Section; and for the sake of Perspicuity, suppos'd exactly square, and the Dimensions of its Length and Breadth to be 12 Foot: This Vessel must likewise be supposed to be shut close with a flat Horizontal Covering AB, of the same Breadth, having at VR a lesser square Orifice, in Length and Breadth 2 Inches, or  $\frac{1}{6}$  of a Foot, from whence there rises a square perpendicular Tube RQSV, of the same Bore as the little Hole VR, but its Height QR of 36 Foot; let the Height of the Vessel WA be eight Inches or  $\frac{2}{3}$  of a Foot.

Below, at WZ, the Cistern ABWZ is quite open, but there is a loose wooden Bottom Frame lying upon the Brim of the Cistern MN, LO, tolerably strong and inflexible, and so placed, that when the Water is at any Height, nothing can pass between the Frame and the said Bottom. We had put under a much smaller Bottom, which we had used for this Purpose, a thick wet  
Piece



Piece of Leather, which lay upon the Points of the upwards bent Tin Brim O and N, and which by the Gravitation of the Water upon the wooden Brim being press'd downwards, kept the Water intirely in the Cistern.

There was besides a Ring fasten'd at E in this Bottom, from which a String passing thro' the square Tube, was ty'd above at F, to one end of the Ballance HGF; so that by drawing the said String FE upwards, the said Bottom WZ could be rais'd up at the same time.

Then pouring Water into the Cistern ABZW, up to the Brim AB, it is plain that the Length and Breadth of the said Cistern being 12 Foot, the Area thereof will contain 144 Foot, which being multiply'd by the Height AB or  $\frac{2}{3}$  of a Foot, or 8 Inches, the Solid Contents of this Cistern, or of the Water in it, will give 96 Cubical Feet, weighing (if you allow 63 Pounds to a cubical Foot of Water) 6048 Pounds.

Wherefore the Weight I, equal to so many Pounds, being put into the Scales suspended at H, the same (if you except the Weight of the Bottom WZ, and the Friction besides) will equiperate the Water in the Cistern ABWZ; and if it were but little more augmented, it would be able to raise the Bottom WZ with all its Water AB, tho' neither the Cover or Lid AB, nor the Tube RQSV, were over the same. And this whole Matter is obvious to every Body.

But if we proceed farther, and do also fill the said Tube with Water, which Tube being 2 Inches or  $\frac{1}{6}$  of a Foot Wide, and 36 Feet in Length, it will exactly contain a cubical Foot, or 63 Pounds of Water, according to the foregoing Supposition.

This being done, since the loose Bottom WZ may be here consider'd as a Scale suspended to  
the

the Ballance FH at E, upon which the Water in the Cistern AZ, and in the Tube QR, weighs against the Weight put into the other Scale suspended at H; let any one that has not nicely observ'd these Singularities in *Hydrostatics*, or been conversant in these Matters, I say, let such a Man retire, and seriously reflect with himself, that, forasmuch as the Weight I is in *Equilibrio* with the Water in the Cistern ABWZ (exclusive of the Cover AB, and the Tube RQ); and since the whole Tube QR does alone contain a cubical Foot, or 63 Pounds, of Water; whether he might not safely enough conclude, that the Weight I, being augmented by another Weight W, weighing considerably more than the said cubical Foot of Water; for Instance, by adding 100, yet even 1000 Pounds thereto, the loose Bottom WZ, or the other Scale with the Water upon it, might be very easily raised up; the rather since the same is found to hold true in all solid Bodies, and even in the Water itself, if turn'd into Ice, provided it were not frozen to the Sides of the Cistern or Tube; as is affirm'd by Monsieur *Varignon*, in the *Act. Lips.* 1692. p. 365.

But he that has read and consider'd the above-shewn Laws of *Hydrostatics*, will see (*Seet.* XXXVIII.) that in the Horizontal Water-Plane AB, just below the Cover of the Cistern AB, the Plane VR is press'd by a cubical Foot of Water, or 63 Pounds; for which Reason every equal Part *Re*, *ef*, and *Vm*, *mn*, of the said Horizontal Plane, according to the said Law, (*Seet.* XXXVIII.) the Water being quiescent in the Tube and Cistern, will be press'd downwards equally in all its Parts; so that therefore this one Foot of Water, or 63 Pounds, in the Tube QR, does equally gravitate on the loose Bottom WZ, as all that quantity of Water that would enter  
into

into the Cavity *ABTP*, in Case the Cistern *AWZB* were a perpendicular square Vessel of 36 Foot in Depth or Height, and 12 Foot in Length and Breadth.

Now we may discover the Weight which this Water would amount to, by multiplying first the Breadth and Length of the Cistern, or 12 Foot, by each other, whereby the Area or Base will contain 144 square Feet. This being again multiply'd by the Height *QR*, or 36 Feet, makes the solid Contents of the Vessel *ABTP*, 5184 cubical Feet; each of which being again suppos'd 63 Pounds, the whole Mass of Water will weigh 326592 Pounds: With which Weight the loose Bottom *WZ* is burden'd and press'd downwards by the little Water in the Tube *QR*.

Wherefore, far from raising the Bottom *WZ*, by adding another Weight *W* (of 100 or 1000 Pounds either) to the Weight *I* in the Scale hanging at *H*, there wou'd be requir'd a Weight of above 326000 Pounds, only to equiponderate, or rather to put in Motion the 63 Pounds of Water thus dispos'd in the Tube *QR*.

And let no Body doubt of the Truth of what has been advanced, provided the Cistern be every where strong enough to withstand this terrible Pressure. The Matter is well known to all the Moderns skill'd in *Hydrostatics*, and has been Experimentally prov'd by many, as well as by us in smaller Vessels.

LX. We don't only discover these Wonders in the Pressure downwards of Fluids, but we experience them too in the Pressure upwards thereof, according to the same Laws: for since *VR* is press'd downwards by 63 Pounds when the Tube *QR* is full, according to *Sett.* XXXVIII, every equal Part *ef*, &c. in the same Horizontal Plane *AB* will be press'd upwards with as much Weight,

Weight, and consequently the whole square Cover A B, will be rais'd up with the Force of 326500 Pounds, including the Orifice V R, and that which presses on it.

We have a remarkable Example of the latter in Mr. Mariott's *Mouv. des Eaux.* p. 106. He took a Tub A B C D, *Tab. XXIX. Fig. 2.* both Bottoms whereof, A M D, and B C, were bent inwards, and making a Hole in one at E, he fix'd in it the Tube E F, of 1 Inch in Breadth, and 14 or 15 in Length, so that no Air could pass between the Tube and Hole; then filling the Tub with Water, he set two Weights of 800 Pounds P Q upon it. After that he also fill'd the Tube with Water, and found that this last small Quantity of Water did not only lift up the Lid or Bottom of the Tub, together with the said Weights, but likewise bent the said Lid outwards; all which appear'd by a little Piece of Wood I L, which was set for a Mark, and which almost touch'd the Tube at H; the said Mark at H being rais'd above I L by the said Pressure upwards.

The End of the Experimental Demonstrations, &c.

SECT. LIX. *Convictions from the surprizing Force of Water.*

I LEAVE now an Atheist to consider, whether this Law of Pressure according to the Depth, and therein the dreadful Force of so small a quantity of Water, ought not to be look'd upon as wonderful; and unless Experience had prov'd the Certainty of it, whether he could have thought it credible, and whether he would not have reject'd the Principles from whence it is deduced; and that he may see what the greatest Mathematici-

ans think thereof, let him consult the *Act. Lips.* 1692. p. 365, and he will find, that M. *Varignon*, whom the whole World allows to be so great a Mechanist, gives it the Name of a *famous Paradox*; of the Truth of which he says, the modern Mathematicians are sufficiently convinced; but that they differ about the Manner according to which the same is produc'd by Fluids; and Mr. *Mariotte* calls it a *surprizing Effect of the Equilibrium*. Mr. *Whiston*, *Prælect. Phys. Math.* p. 247, says of this Law (of which all these Wonders are plain Consequences) that it is a well-known Rule in *Hydrostatics*, but which has hardly yet been proved either Naturally or Mathematically, concerning which he gives us his Opinions in Liquids really moved, but not in such as are stagnating; so that all the appearing Wonders are not yet compleatly solved thereby.

At least it now seems, that no Atheist can come so far without charging himself with Folly, as to imagine that he is capable of proving, that the Works of Nature must be caused or produced by a blind Necessity, which he is forc'd to own he does not well understand; and which far from appearing to him as necessary, he must look upon as impossible, or absolutely incredible, were it not that he was convinced thereof by Experience. And whether he can ascribe all these Wonders (that are produced with so much Constancy and Regularity, that they plainly adapt themselves to all the Consequences that can be deduced by the Mathematicians from preceding Laws) to mere Chance, I leave to him to consider.

SECT. LX. *Convictions upon another Foundation.*

I MUST add this in General, that tho' many have endeavour'd to deduce both from the Laws of Mechanics, and particularly from the following: That in order to raise a Weight of a hundred Pound as high as one Foot, the same Force is requisite, as to raise one Pound the Height of a hundred Foot, at the same time; concerning which *Mariotte* and other Mathematicians may be consulted; yet no Body has been able without Difficulty, to explain the Manner after which Fluids, even in Rest, adapt themselves to obey these Laws to produce such Wonders; and Mr. *De la Hire* (see his *Mechanique*, Prop. 106. p. 331.) and Mr. *Varignon* have very ingeniously invented a new kind of Levers, the Effects of which are so very analogous to the Powers of the Fluids, that being shut up into a square Box or Chest, and put in order, gravitated or press'd against its Cover, Bottom, and Sides, after the same manner, as if the said Box were fill'd with Water; but how great an Analogy soever may be proved from hence with Fluids, neither those Gentlemen, nor any Body else, can easily be persuaded that Water, Oil, or any other Liquids, owe their aforementioned Motions to the like Machine.

SECT. LXI. *Without the Laws of Fluids, all Things would soon be in the utmost Confusion.*

IN order to be convinced of that which happens in the World by this *Law of Pressure* according to the Depth, let the Philosopher who deduces every Thing from mere Chance, or a natural Necessity, attend to the following Matters

which he may have already found to be true from the Premises; or if he be an experienced Mathematician, has been already assured of it by his own Study and Experience.

Certainly he will not be able to contradict this, namely, that all the Chambers of Houses, from the meanest Cottages to the Royal Palaces, would be nothing else but fatal Caverns and a heap of Rubbish to all that dwell in them, in case the Air should exert its Gravitation and Pressure, not like a fluid Substance, but like a Heap of small solid Bodies, and consequently, that there were no other than a perpendicular Pressure, without any Consideration or Effect of the *Law of Pressure* according to the Depth; whereby all the like Parts in the same Horizontal Plane are pressed alike, whether the perpendicular Column of Air be great or small, quite otherwise than what happens in accumulated solid Bodies. Let it be then consider'd, what Confusion and Misery would be hereby occasion'd to all Creatures that want a Shelter against the Inclemency of the Air, such as Cold, Wind, Rain, &c.

To represent this yet more plainly, let it be supposed that some Body is sitting in a Chamber *W* (*Tab. XXIX. Fig. 3.*) and is cover'd with a Ceiling thereof *ABC*, the Height of which, from his Mouth by which he breathes, is as *MO*; and the Height of the external Column of Air which has a Communication with that in the Chamber, is as *QS*. If now there were no greater Pressure of the Air at *LM*, than from that Column thereof which is here represented by *LNOM*, (as it would happen if the Air gravitated like solid Matters) the Pressure thereof would be very small, and consequently its Elasticity also; as soon as the Air should be rarified by

by the Removal of the Pressure to which it is used to accommodate itself.

For since the Mercury in the *Barometer T*, is usually rais'd to 28, 29, 30, or 31 Inches, by the external Air *P Q S R*, which Mercury is fourteen times heavier than Water; if we suppose the Height of the Mercury to be 30 Inches, there will be required fourteen times 30, that is, 420 Inches of Water to balance the Air; and since Water is commonly found to be 800, 900, or 1000 times heavier than Air (supposing this last Sum to be truest) the Air being compressed in the same manner as it usually is with us, the Height of it will be 1000 times 420, or 420,000 Inches (for we take no notice here of that greater Height which it may have upwards, because of the lesser Weight it bears, and consequently is more expanded) and then we must suppose *Q S* to represent the aforesaid Height.

For Conveniency sake, let us now suppose *N O* to be the Height of 14 Foot, that is, 168 Inches; accordingly the Depth of the Chamber, *A D* or *B K* must be computed at the rate of 18 or 19 Foot at least, which is higher than common Chambers are used to be; and the Pressure of the Air at *L M*, which is the Weight of the aforesaid Column of Air *L M O N* of 14 Foot, or 168 Inches, Is to the Pressure of the external Air *P Q*, As the Column *L M O N*, Is to the Column *P Q R S*; or As 168 To 420,000 Inches, or just as 1 To 2500.

Consequently the Pressure at *L M* within the Chamber is only as  $\frac{1}{2500}$  Part of that which happens at *P Q* by the Air out of the Chamber. Now this last raises the Mercury in a Barometer up to 30 Inches, according to which the Air in the Chamber at *L M*, would only raise the said Mercury



up to  $\frac{3}{20}$ , or scarce  $\frac{1}{8}$  Part of an Inch, or about  $\frac{1}{7}$  of a Line which is  $\frac{1}{12}$  of an Inch.

This being supposed, every one that ever saw a living Creature put under the Receiver of an Air-Pump, near which a Barometer was likewise placed, has been convinced with the utmost Certainty, that long before the Mercury subsided down to  $\frac{1}{7}$  of a Line, that Creature would fall into Convulsions, and for the most part expire too.

So that from hence, and other Experiments made by the Air-Pump (one of which we have quoted above in the XVIIth *Contemplation* from Mr. *Otho Gueric*, which had almost cost a Man his Life) it is plain enough, that if the Air in the Chamber at LM, bears no greater Pressure than that which happens to it from the Height of the Ceiling ON, all the Creatures that live either upon the Earth, or in the Air, would immediately die in the said Chamber. And that all Chambers and Houses would therefore be useless, were it not alone that this great Inconvenience is prevented by the aforesaid *Law of Pressure*, every way according to the Depth of the Fluid, to which all fluid Substances obey, and by which the Pressure in the same Horizontal Plane PM is equally strong upon the like Parts PQ and LM, whether within or without the Room.

For the same Reason it would not be possible that a Ship could go under a Bridge without occasioning a sudden Death to all that were therein. No Fish could even swim under a Bridge without being in danger of losing its Life, because the Air that is under a Bridge, would gravitate much less upon the Water; just as it happens to such Fish that are put into the Air-Pump, when the Air is beginning to be exhausted from thence, when the Rarefaction of the Air, and the Diminution of its Pressure of the Water first puts them

them into Convulsions, and soon after kills them; that the same does not likewise happen under every Bridge, is alone owing to the Laws of *Hydrostatics*.

To this may be added, that the Air at LM in a Chamber undergoing so small a Pressure, that it can hardly keep up the Mercury in the Barometer to  $\frac{1}{7}$  of a Line, wou'd become so thin, as to be incapable of conveying Sounds to their Ears, of which we have already given Instances in the XVII. *Contemplation*; so that tho' one should be able to live in such an Air, yet no Man could speak to another therein: Not to mention that Fire will not burn in such a thin Air, nor Smoak ascend; that none of the Particles which are the Object of Smelling, could pass from any Bodies to us, besides many other Things which wou'd be occasion'd by the Thinness of the Air.

If against this it should be objected, that altho' the Air in the Chamber undergoes so little Pressure and Expansion, yet the more compressed Air would run thither from P QRS; as Water itself would do, tho' there is little or no Elasticity in it, if it were in the Place of the Air. To which we answer, that this Objection has no other Foundation but the very Action of Gravity, and *the Law of Pressure, &c.* which is only peculiar to Fluids, which in this Case we do not suppose to obtain, since we only endeavour to shew what would happen if the Particles of Air operated by their Gravity, not like Fluid, but other solid Bodies.

To illustrate this Matter, let *Tab. XXIX. Fig. 4.* be a high Sand-bank (only consisting of solid Bodies for that Reason) and of the Figure represented here by ABCDMHN; 'tis plain then, that the Body G is pressed with the Sand above it at EFCD, and if you will, with that on the

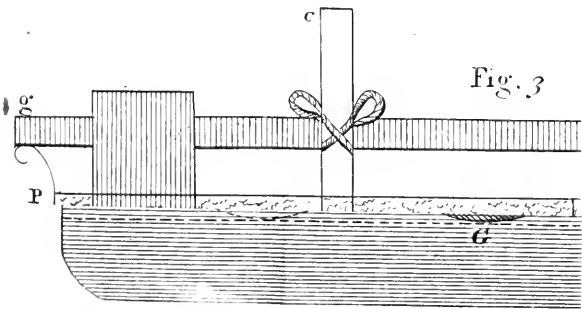
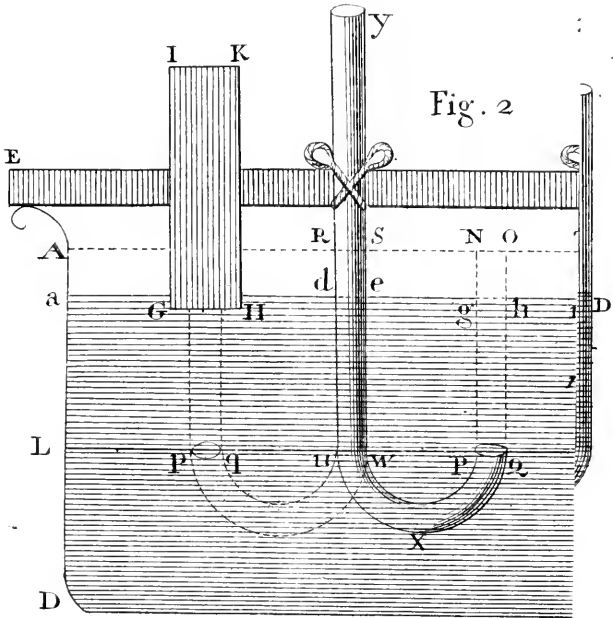
side of it at QR; but if there be in the same Horizontal Plane BH, another Body equally as big as K, which is no more than a Hand's breadth LS below the Sand, every one knows, that this K bears a small Pressure, and much less than the Body G, tho' all the Sand were contained in a Vessel equal to the whole Circumference of the aforesaid Bank; and therefore that a Man that were at G under this heavy Sand-Bank, would not be able to stir from thence, whereas, if he were at K, he could raise himself with little Trouble.

But now, if instead of this Sand, there were a Vessel of liquid Matter in the very said Form, the Body K would be pressed as strongly as G, in Consequence of the *Law of Pressure*. From whence it is manifest, that if we rightly distinguish the Action of Solid from that of Fluid Bodies, this Objection will fall itself.

SECT. LXII. *Convictions from the foregoing Observations.*

AT least, without insisting upon any farther Particulars, it will be unquestionable to such as are versed in the modern Natural Experiments, that without the Operation of this *Law of Pressure*, &c. in fluid Matters, Men would be entirely deprived of the use of their Houses, and greatest Conveniencies.

And this being so, what Reward would not a Man have deserved that had invented a Method to hinder the same, or that could have prescribed such a Law to fluid Bodies? Would not every one, even an Atheist himself, think he was very much wronged, supposing he had only prevented all these Inconveniencies after a much more imperfect manner, if instead of returning  
him

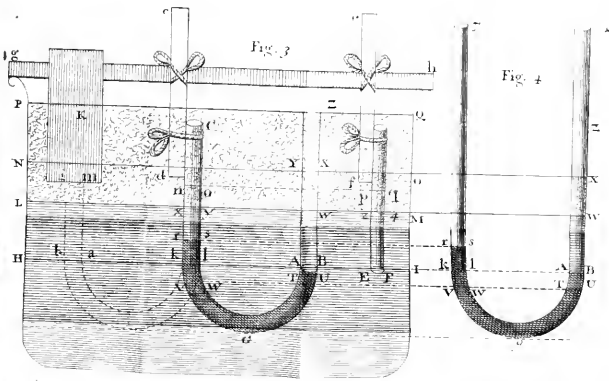
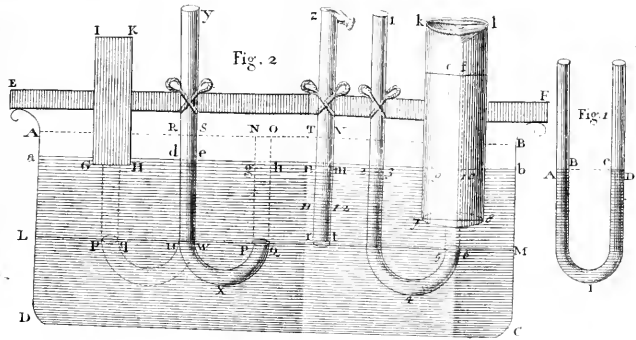


LS below the Sand, every one knows, that this K bears a small Pressure, and much less than the Body G, tho' all the Sand were contained in a Vessel equal to the whole Circumference of the aforesaid Bank; and therefore that a Man that were at G under this heavy Sand Bank, would not be able to stir from thence, whereas, if he were at L, he could raise himself with little

of this Sand, there were a Matter in the very said Form, that could be pressed as strongly as G, by the Law of Pressure. From this it is manifest, that if we rightly distinguish between solid and Fluid Bodies, they will all fall itself.

*Conclusions from the foregoing Observations.*

Without insinuating upon any farther, it will be unquestionable to such as are conversant in the modern Natural Experiments, that the Operation of this Law of Pressure in Fluid Matters, Men would be enabled of the use of their Houses, and of their Conveniences. Being so, what Reward would not be offered to that had invented a Method of raising himself from the same, or that could have presented a new Use to fluid Bodies? Would not even an Atheist himself, think he was wronged, supposing he had only preferred these Inconveniences after a much different manner, if instead of returning



k

Fig. 1

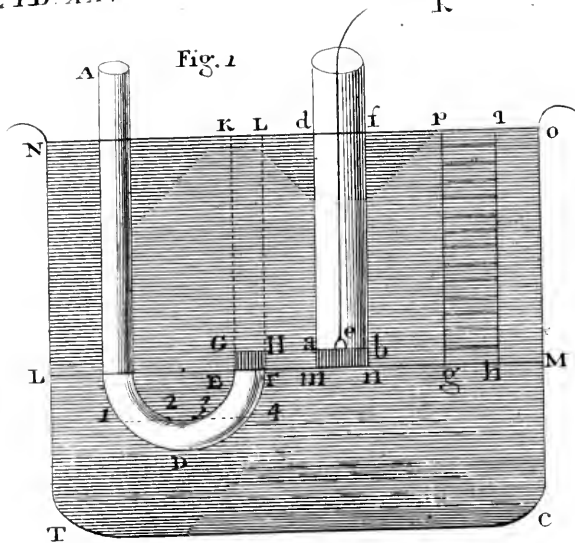


Fig. 3

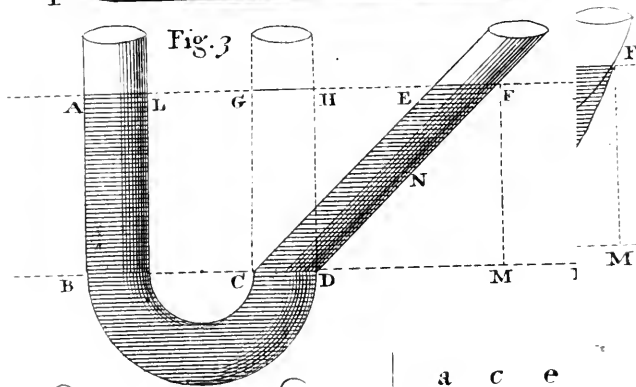
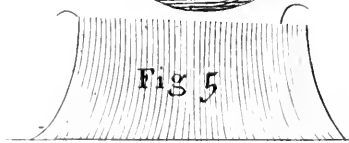
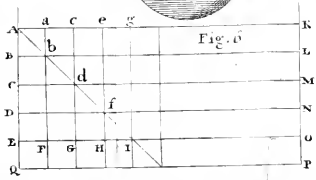
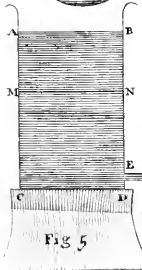
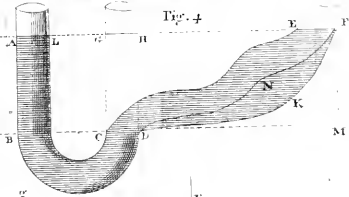
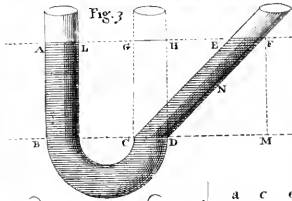
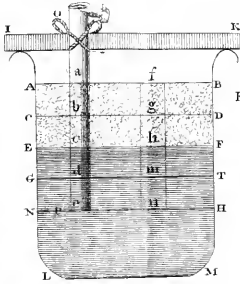
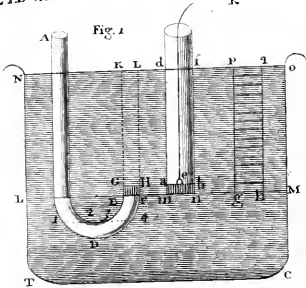


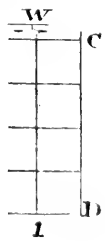
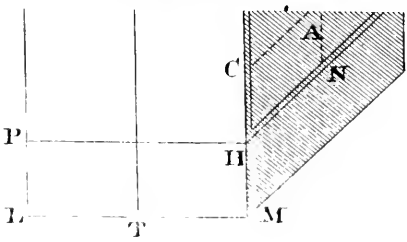
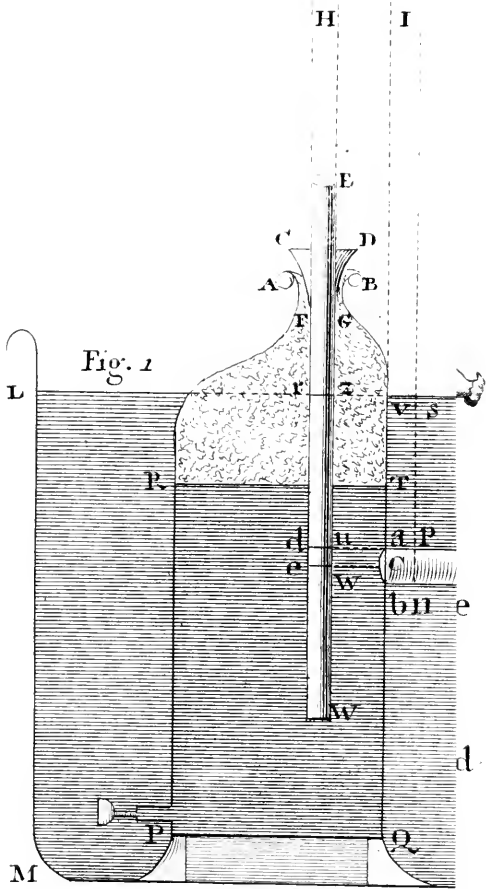
Fig 5



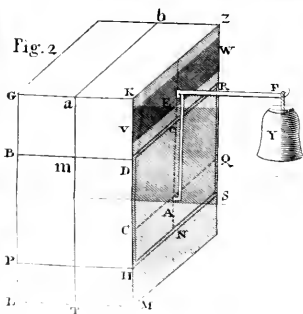
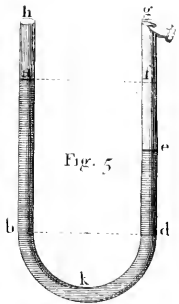
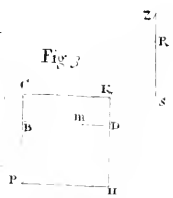
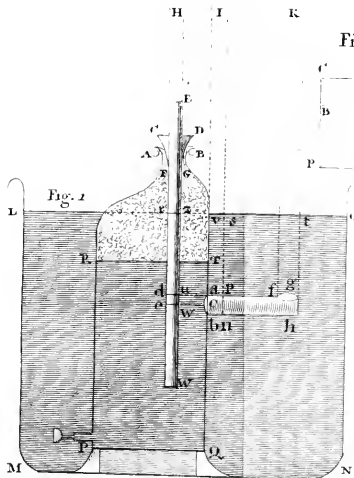
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P H K







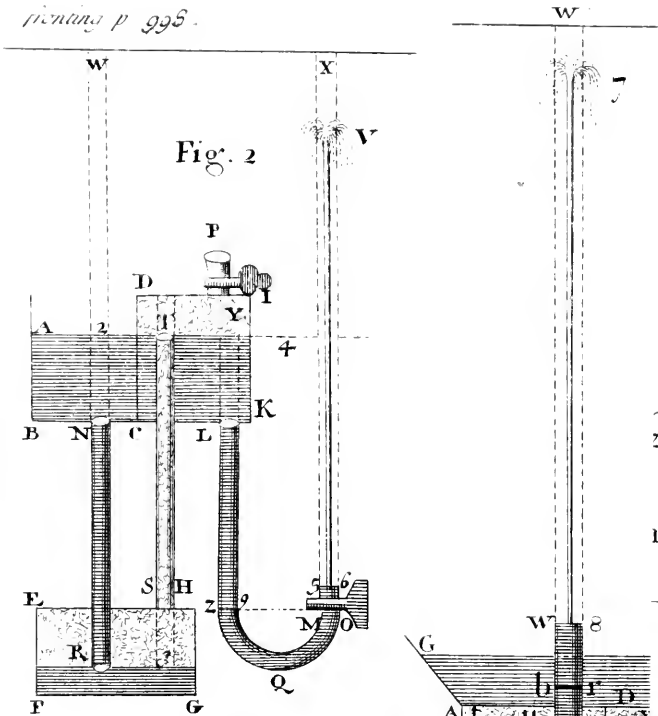


Fig. 2

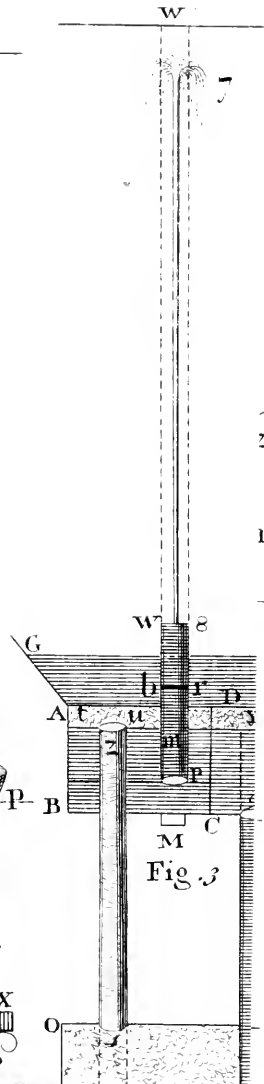


Fig. 3

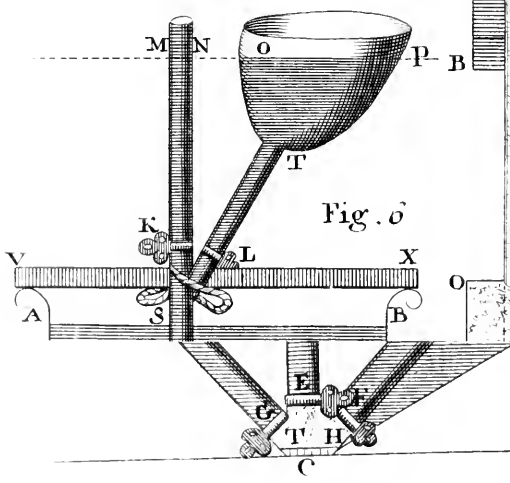


Fig. 6

Fig. 2

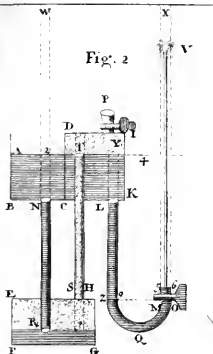


Fig. 4

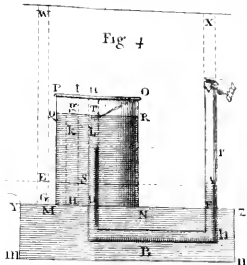


Fig. 1

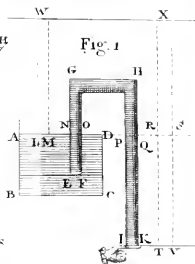


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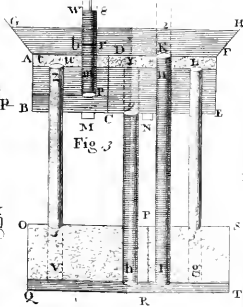


Fig. 5

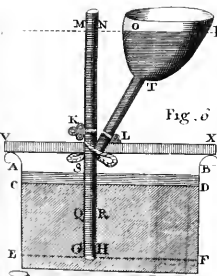


Fig. 6

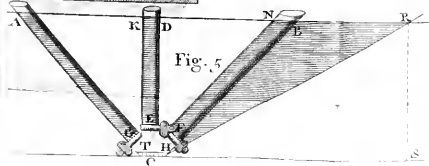
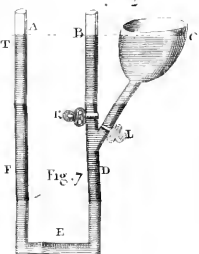


Fig. 7



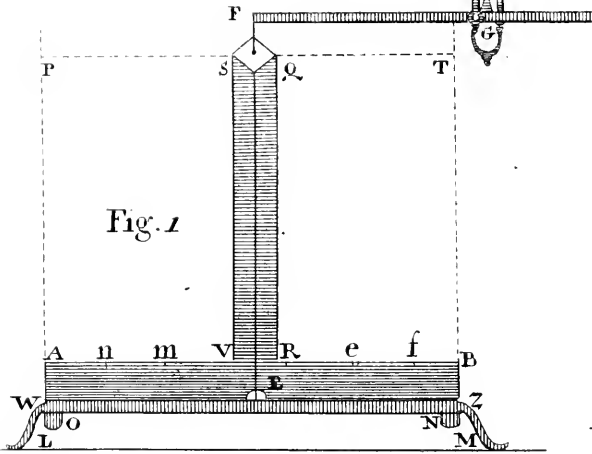
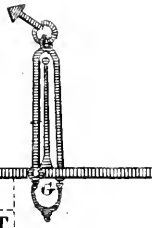
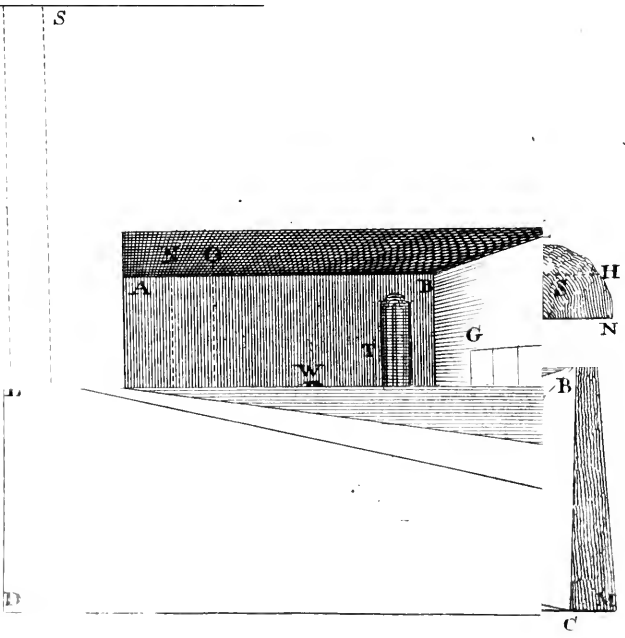
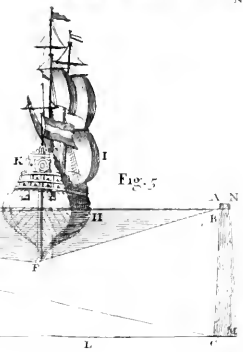
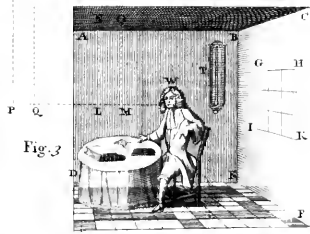
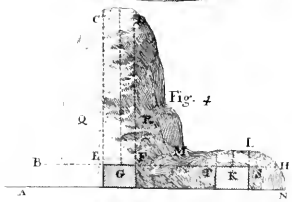
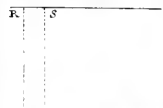
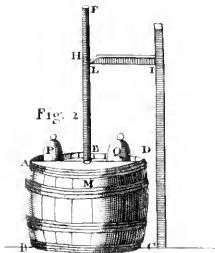
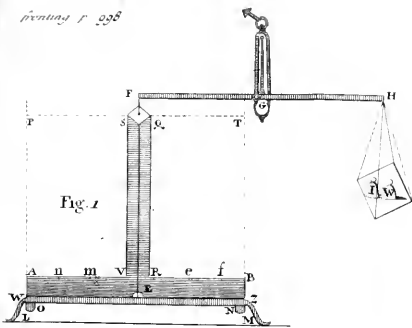


Fig. 1

R S





him the Thanks that were so justly due to him, People, should look upon him as an ignorant or foolish Fellow?

SECT. LXIII. *Even Lead it self will float upon the Water, by the Pressure thereof upwards.*

BUT if we now turn our Eyes towards that wonderful Action of the *Law of Pressure*, &c. namely, the *Pressure of Fluids upwards*; there will here likewise be visibly manifested the Glory, Power, and Goodness of the supreme Director.

Now that all Liquids which have others on the side of them, do exert a real Force, which presses upwards, has been shewn before, and may appear likewise from the Experiment of Mr. *Boyle*, which we shall represent here below, after a cheap and easy manner.

Could any Body who is unexperienced in *Hydrostatics*, easily believe that a Piece of Lead, which is so much heavier than a like Quantity of Water, should only by the Pressure thereof upwards, without being supported by any other Matter, be kept floating, and hinder'd from subsiding? And yet we see this happen, when there is no Water above the Lead, which by its Pressure might sink it down; and when the lateral Water is 13 or 14 times deeper than the Thickness of the Lead.

They who desire to make an easie Experiment thereof, may take a Tin Tube *dabf*, (*Tab. XXVI. Fig. 1.*) the lower Orifice of which, *ab*, is smooth and even; then taking a round Piece of Lead, *abmn*, the Thickness of which is about  $\frac{1}{8}$  or  $\frac{1}{4}$  of an Inch, and its Breadth *ab* such, as being laid upon the Mouth of the said Tin Tube *ab*, may stop the same; let there be likewise a little Hook *e*, fixed as near as possible in the middle of the  
Lead,

Lead, and a String *ek* tied to it. Then covering the Lead *ab* with a little piece of Leather, or a wet Bladder with a Hole in the middle of it, to the end that the Hook and String may pass through, you must draw therewith the said Lead *abmn* pretty tight against the Mouth *ab* of the Tin Tube *abdf*; then holding them thus together, let them down suddenly into the Water, the Depth *dm* (which is about thirteen or fourteen times as much as the Thickness of the Lead *am*) in a large Vessel *NTCO*, in which the Water is at the Height of *NO*; you will then find that the little String *ek*, and consequently the Piece of Lead *abnm* being free, will not sink down at that Place, but will be supported by the Force of the Water pressing upwards, and perfectly swim, according to the Experiments we have frequently made thereof.

Now that this happened only by the Pressure upwards, appears from hence, That if the Lead were not let down lower in the Water than about ten or eleven times its own Thickness, it would presently, upon loosing the little String *ek*, subside; but being placed much deeper under the Water, we found, that both the Tube and the String itself being loosened, the Lead did not only not subside, but even the whole *Apparatus* was lifted upwards, rising and sinking like a Piece of Wood.

The Reason whereof is clear enough, as well from what has been said before, as from the *Law of Pressure*, &c. for since the Lead is about twelve times as heavy as the like Quantity of Water when it is brought to be thirteen times deeper than its own Thickness *am* below the Water *NO*, and the Tube being held fast and still by the Hand, as the Lead is by the String, it is plain that the part *gb* of the horizontal Plane is pressed down by the perpendicular

perpendicular Column  $p q b g$ ; now this Column being thirteen times as high at  $p g$  as the Lead  $a m$  is thick, the Water  $m n$ , which is under the Lead, will press with the same Force upwards; and since the Lead is only able to press upon the said Water  $m n$ , with no more than twelve of the thirteen Parts, (it being but twelve times as heavy as a like Quantity of Water) it is plain enough that the said Water is pressed upwards with thirteen, and downwards with but twelve Parts; so that the Pressure of the Water upwards being greater than that of the Lead downwards, the said Lead must emerge, and cannot subside. From the said Principles it may be proved, why Lead, being let down into the Water but nine or ten times as deep as itself is thick, does on the contrary immediately subside, which is likewise always verify'd by the aforementioned Experiment.

Of the astonishing Force wherewith this Pressure of Fluids upwards and downwards is brought to pass, it will not be necessary to speak now, after what has been said above in the XIXth *Contemplation*.

And from this Experiment, and from what has been shewed before about the sinking of Wood, we may plainly enough conclude, that a Piece of Wood, and much more the smallest Ship, would sink down like a Stone to the Bottom, if it were not kept floating by the Pressure of the Water upwards.

SECT. LXIV. *Convictions from hence.*

CAN now an unhappy Atheist fancy to himself, that this Force of the Water, whereby a Ship is caused to float and sail upon the Sea (for want of which the World would be deprived of the greatest part of its Happiness) is produced by Chance?

Shall



Shall we judge those to be wise and ingenious, and to be obliged the World, who have brought Ships and all their Sackling to that Perfection in which we now see them? And can it be thought, that the causing the same to move round the whole Globe of the Earth, in a manner not to be comprehended by the greatest Mathematicians, and the making it to ride upon the back of a Matter so infinitely small, and yielding to the smallest Impulse, could ever be brought to pass, but by a Being infinitely more Wise and Good?

And the perpendicular, or downward Pressure, seems in some manner to result from the Weight of Fluids; yet could ever any Body have suspected to have found the contrary in this Law of the Pressure of fluid Matters upwards, had not the same been demonstrated visibly and experimentally? Is there not then a wise Disposition required here, and a directive Power extending itself to the smallest Particles in fluid Bodies, which ballancing them only by two equal Powers acting against each other, after a most surprizing and unconceivable Manner, even when they appear to us in an impotent Rest, and seem to be perfectly void of Action and Motion, compels them to stand still? What can one see in the Water called the *Zee* before *Amsterdam*, when it is not moved by any Wind, but has a Superficies as smooth as Glass, that can be compared with so unconceivable and violent a Force, by which whole Fleets laden with Cannon and other heavy Burdens, are hindered merely by this Pressure upwards, from sinking down a Hair's Breadth? And can any one reflect upon what has been said, and upon such an infinite Number of Millions of Millions of Particles of Water, all compelled to obey this Law without discovering therein a Wisdom and Power that far exceeds all human Understanding?

ing? In which so visibly appear the great Designs of GOD in making the Seas and other Waters capable of bearing such mighty Burthens, at the same time that they are composed of a Matter that may be separated and exhaled by the smallest Force of the Sun, or any other Warmth, and drawn up into the Air, and turned into Clouds and Vapours.

SECT. LXV. *Lateral Pressure, and the Benefit thereof.*

Now as the Wonders of the Pressure of Fluids upwards and downwards, are calculated to render Mankind happy, so likewise may this same *Law of Pressure according to Depth* (by which the lateral Pressure is also regulated) serve for a great Proof particularly; because without the same, the Sea would be unnavigable for Ships, and the Earth in a great Measure uninhabitable, so that many well peopled Countries would have nothing to expect but the utmost Destruction. Let it be supposed for Instance (*Tab. XXIX. Fig. 5.*) that the Sea BCDE stands at the Height BC against the Dyke ACMN; and first that the Water being moved by no Winds, there lies a Ship still at IFK, and at the small distance BH from the Dyke: Now 'tis plain, that if Fluids were governed by no other Laws than solid Bodies, the little Water at AHF being much less in Quantity, and therefore in Force and Gravity, the Ship would be thrust by the greater Quantity of Sea-Water EGF, towards the Dyke AB; according to which manner it would not be able to lie still in any part of the whole Sea, without being pressed by the heaviest and greatest Quantity of Water towards the side of the smallest and lightest. We don't take any notice here of the Obliquity of such Pressures.

Now what Inconveniencies would occur from the failing upon the Sea and other Waters, if the same should exert their Pressure not according to the simple Laws of Depth, but like solid Bodies, according to their Quantity and Surface also?

But that which we now have chiefly in view is, what Dykes at A C M N would Men be obliged to make, if they were to be opposed against the lateral Pressure of the whole Sea C D E B, if the Force thereof were only regulated according to the Surface and Quantity of the Water that pressed upon the Dyke, as it happens in solid Bodies, had it not pleased the Director of all Things to subject the Force of this lateral Pressure so strictly to the single Height or Depth of the Water, and not to its Breadth and Quantity; insomuch that altho' the whole Sea should press against one Dyke at B C, the said Dyke would bear no greater Burthen than the Pressure of that little Water which (supposing C L to be equal to B C) could only be contained in the Space B C L, according to what we have already shewn above?

SECT. LXVI. *Convictions from the same.*

Now can any one see exerted such a Law of so many Millions of such exceeding small Particles of which the raging Ocean is composed, and which have not the least Knowledge of what they are doing, and yet act with so much Niceness at all Times, and upon all Occasions; and cannot he therein discover an over-ruling Wisdom and Power? The rather, since this Law is the only Means by which such a dreadful Collection of Waters is hindered from overflowing the dry Land, whilst the Dykes resist their whole Force, so that neither Men nor Beasts are overwhelm'd in the lower Grounds; of all which one cannot think without

Emotion

Emotion and Horror, when one reflects upon the Weakness of the said Dykes, with respect to the unconceivable Weight and Quantity of the Water that presses against them.

If now any living Man had found out the Secret of obliging the whole Sea to submit itself to such Laws, that how vast soever it was, but a very small part of it shou'd press upon the Dykes, would not an Atheist stand astonish'd at his Wisdom? And if he had invented a Method, whereby not only all Waters, but likewise the whole Ocean of Air surrounding the Globe of the Earth, and all other fluid Matters, even to the smallest Particle of them, could be bound and subjected thereto; would not an Atheist be again obliged to confess the unconceivable Extent of his Power?



## CONTEMPLATION XXVII.

### *Of some CHYMICAL LAWS of Nature.*

#### SECT. I. *Transition to other Laws.*

**A**FTER having contemplated those Laws which have long been, and particularly of latter Years are become the Objects of Mathematicians, let us now pass on to another kind of Laws of Nature, which do not seem to be performed so much by plain Percussions or Strikings, as many of the first, but according to other Rules (we say *seem*, because we acknowledge ourselves ignorant of the manner thereof) by which Things being placed at a certain Distance from  
each

each other, are *attracted* (or at least do *move*) towards one another, without any visible Discovery of Percussion or striking of other Parts there present; or else such, as being placed in certain Circumstances by or near other Bodies, are *driven away*, or separated from one another; to which Actions the Learned have annex'd the Terms of *Attraction* and *Repulsion*; to which Laws the great Director has bound those Bodies that obey the same, after a manner hitherto more wonderful than intelligible; and as the Naturalists have discovered the former Laws by Experiments, so the Chymists in a great measure have found out these, which likewise have lately become the Objects of Mathematical Contemplations.

SECT. II. *Experiments shewing the Operation of Acids and Alcalies.*

THE great Phenomenon of Nature, and which has given a Handle to many Disputes and Argumentations of Chymists and other Philosophers, is the famous Effects produced by *Acids* and *Alcalies*. By this last is understood every thing that ferments or boils up when mingled with *soure* Bodies, and afterwards is intimately united to the same. Those who have never seen the Action resulting from the Mixture of Acids and Alcalies, would be wonderfully surprized thereat; and they may easily make the Experiment, by putting in a little beaten Crabs-Eyes, which is the Alkali, into Vinegar, which is the Acid, and they will presently see the Effects thereof.

But the Motion will be much more violent, if one mixes the Filings of Iron with the Acid Spirit of *Salt Petre* or *Aquafortis*, and attended even with a greater Heat.

To shew this Effervescence in Liquids, we may take Spirit of *Sal Armoniac* mixed with melted *Pot-Ash*, or *Salt of Tartar*, in Water, and mix it with the *Acid Spirit of Salt*, *Salt-Petre*, or *Vitriol*, and we shall presently discover a strong Effervescence between them.

SECT. III. *The aforesaid Salts are changed and united by Effervescences.*

NOW how many Effects result from these Effervescences, has been often shewn experimentally by the Chymists.

It is a common Consequence, that after these Motions both the Acids and Alcalies lose their former Properties, or at least do frequently seem to lose them, such as their Taste and Sharpness, and being closely united to each other, do thereby produce a third Constitution entirely different from each of the former, such as what the Chymists call a *Salsum*, *Enixum*, *Muriaticum*, *Neutrum* or *Mixtum*, or as we call them in our Language, a *satiated*, a *Pickle-Salt*, or a mingled Salt, all proceeding from a Mixture of Alcaline-Salts, as *Pot-Ash*, or Volatile Salts with an Acid.

SECT. IV. *Experiments, shewing that Acids and Alcalies precipitate, or are separated from each other.*

BESIDES this, when some of the said Alcalies and Acids already united with each other, and, as they term it, are so far *satiated*, that they will not act any longer upon others of the same Kind, and adhere so closely to the former, that it would be very troublesome to separate them again without the Addition of other Matter, and in some Cases even impossible to do it at all; Trials of the Operations of these Salts upon one another, have

taught Inquirers, that there were likewise among those Laws observed by the Acid and Alcaline Salts, some whereby this strict and close Union may be very easily, and yet as it were miraculously dissolved, and each of them separated from the other in such a manner, as if one of them thrust t'other Way, or at least quitted its hold, without any external Cause that we have as yet been able to discover.

Thus we find, that one Acid seems stronger than another, and that how strictly soever some Acids are joined with Alcalies, one need do no more in many Cases than to put another Acid to it, whereby to oblige the first Acid to forsake its Alkali, and then the second will unite itself to it. The same thing does likewise obtain in Alcalies, so that one of them shall immediately separate itself from its Acid, and leave the latter to be joined thereto.

Many Instances thereof may be met with in Chymistry, but we shall content ourselves with quoting one of each.

Pour Spirit of Sea-Salt, which is an Acid, upon the Alcaline Salt of Tartar, they will effervesce, and unite themselves into a third mixed Salt, which is like the Sea-Salt: But how much Fire and Pains it will cost to separate this acid Spirit of Salt from the Alcaline Salt of Tartar, is well known to those that have made the Tryal; but if you put a little Water to it, and some of the acid Spirit of Salt-Petre, the Acid of the Sea-Salt will quit its Alkali without any Trouble, and suffer itself to be drawn off by a small Fire; whilst at the same time the said Spirit of Salt-Petre unites itself with the Alkali, or Salt of Tartar, and thereupon produces a new Matter of Burning Salt-Petre, upon which if you pour again an acid Spirit of Coperas with a little Water, there

will be another Separation between the acid Spirit of Salt-Petre and the said Alkali; which may likewise be extracted from thence with a soft Fire from Sand; and this third Acid, or Spirit of Vitriol, will unite itself to the Salt of Tartar, from which there will result another Salt, almost of the same kind with that which is commonly called *Tartarus Vitriolatus*.

To shew the same likewise in the Operation of several Alkalies, pour the said Spirit of Sea-Salt upon the Volatile Alkaline Salt of Animals, of Hartshorn, of *Sal Armoniac*, and the like, dissolved in Water; whereupon, after an Effervescence, they are united into a third, like *Sal Armoniac*, and the Volatile Salt will thereupon lose a great part of its Volatility and Scent in the Mixture. Now if you add Salt of Tartar for a second Alkali, it will separate the first, and discover itself presently by a new strong Smell, and the second Alkali, or Salt of Tartar, will unite itself with the Acid of Sea-Salt. They that have a mind to see several Kinds of Alkalies, the first of which, by the Addition of a second, will separate itself from the Acid, may be pleased to consult the following *Contemplation, Sect. VI.* besides innumerable Instances wherewith Chymistry can furnish 'em; but we shall not, nor cannot here determine any thing about the Manner used herein by the wonderful Power of GOD, reckoning it sufficient that the thing is plain enough in itself.

SECT. V. *Acid Salts dispersed in many Bodies.*

IT must not be thought that these Effervescences and Actions of Acids and Alkalies, have only place in Chymical Liquors, and that we therefore go too far in honouring them with the great Name of a Law of Nature; forasmuch as they



that is, one or other of them, are found in many Terrestrial Bodies, and that a great deal of that Matter of which many Bodies are composed, may be reduced to Acids or Alcalies.

To shew this in the Acid :

In *Animals* all the Milk and *Serum*, or Whey, is Acid ; not to enumerate any other Juices here, particularly those acid Humours which oftentimes occur in many unhealthy Creatures, or as some maintain, are always found in the Stomach of healthy ones.

We likewise meet with Acids in *Minerals*, as in Sulphur, Coppéras, Allum, Salt-Petre, Sea and Rock-Salt, in Antimony and others.

In *Plants* we likewise find some that yield an acid Spirit by Distillation ; besides all those Fruits which are soure because they are not ripe, we meet with an infinite number, which after they are come to their full Ripeness, do retain an entire acid or sourish Taste ; such as Currants, Oranges and Limons, many Apples and Pears, and the like. Besides that almost all Liquors proceeding from Plants, or other Things, by way of Fermentation, such as Beers, Wines, and the like, will turn to an Acid or Vinegar.

The *Air* itself seems to be impregnated with soure Particles, since it will corrode and cause Iron to rust.

There are likewise *Medicinal Springs* that yield sourish Waters, found in many Countries ; see *Varenius's Geography*, Part *abs Cap.* 17. *Seét.* 6. of which he makes the Number in *Germany* alone to amount to about 1000 ; so that from hence may be inferred the Quantity of Acids dispersed throughout the whole Earth.

SECT. VI. *Alcaline Salts likewise dispersed in many Bodies.*

ONE may say the same thing of the Alcaline Salts also.

From all the Parts, in a manner, of *Animals*, there are Alcaline Volatile Salts extracted in great Quantities; to say nothing here of other Alcalies, which cannot properly be named Salts, such as Crabs-Eyes, Egg Shells, the burnt Shells of Oysters and Muscles, Hartshorn and Bones.

*Plants*, when putrify'd or rotten, do likewise yield Alcaline Volatile Salts. The Smoak of burnt Wood makes a Soot, which does also afford an Alcaline Volatile Salt; and the Leaves of some Plants, such as the Palm, yield an Alcaline Spirit by Distillation. The Chymists do moreover extract from most Plants by burning a fix'd and lixivate Salt, which is likewise Alcaline, and of which the Ashes themselves will effervesce with Acids.

All sort of *Coral* is Alcaline, so are many *Minerals*, and will ferment with Acids; as also all *Metals*, Gold, Silver, Copper, Iron, Tin, Lead, Quicksilver, Antimony, Marcasites, the *Lapis Calaminaris*, Chalk, &c. Even a good fertile Earth will effervesce with Spirit of Salt-Petre. There are likewise some of the Mountain or Rock-Salts of the same Nature. Accordingly we are informed, that in the Repository of the *Royal Society of England*, there is preserved a Salt brought from the Rocky Places of the Island of *Teneriff*, the Properties of which are entirely Alcaline; and in how many Mineral Waters a like Alcaline Salt is found, may be seen in the History of the *Academie Royale des Sciences*, &c. An. 1702. p. 57 and 58, and 1708, p. 73 and 74; where an Inquiry being

made into the Waters of *Bourbon, Lancy, Bourbon à Archambaut, Bourboule, Mont d'Or, Chaudes, Aigues, Evaux, Neris* and *Vechil*, they are all found to yield a natural Alcaline Salt: So that it likewise appears from hence, that Alcaline as well as Acids, may be met with in great Quantities in many Bodies.

SECT. VII. *Convictions from the foregoing Observations.*

FROM what has been said, and from a farther Inquiry into Nature, one might produce a vast Number of Experiments and Proofs, capable of convincing a judicious Reader, that there is an infinite Number of Particles in the World, each of which are constantly moved according to particular Laws, which in some Circumstances are at Rest, and of which others being brought to a certain determinate Distance, as the Acids and Alkalies, begin a regular Motion, being sometimes *attracted*, and at other times *repelled* from each other. Do not the Parts of Diamonds adhere together very closely, tho' they have great Orifices or Pores in them, and therefore touch one another with little Superficies, as appears from their Transparency? Do not we see in Fermentations some Particles which were at first still and at Rest, and afterwards begin to move among one another, in which, always following certain Laws, they one while separate, and then again unite with each other? But they who desire to see a brief Collection thereof at one View, may consult Sir *Isaac Newton's Optics, in the Queries at the End*, and most of the Chymists; and from thence take what they think may serve for a Proof strong enough of what has been said above.

But to such as are not so well experienced in Chymistry, to give a more familiar Instance from  
whence

whence they may safely infer the foregoing Propositions, and justly conclude likewise that there is a God, who has not only Created all these Things, but does also Govern them by his Providence, according to wise Laws; let an Atheist, how great a Philosopher soever he be, reflect with himself, and consider, *First*, this Universe, as consisting of an infinite Multitude of Hundreds of Thousands of Millions of Particles, which, according to the preceding Experiments, cannot be deny'd; *Secondly*, Let him represent to himself all these Particles, as being at Rest and unmoved; which he may easily do, because Motion is not a necessary Consequence of their Existence: If now he contemplates this unconceivably great Heap of Matter, can he think it credible, first, That from thence are produced so many determinate, and such exceeding small *Stamina*, or Original Seed, and from them again so many glorious Machines, as are the Bodies of Men and Beasts, Fishes and Birds? Such wonderful Structures of Plants and Herbs, divisible into such numerous Classes? So many agreeable Liquors which Men extract from the same, making use therein of those Laws, according to which the Juice of the Grape, for Instance, and others, are wont so uniformly and constantly to operate? Finally that great and amazing Machine the World itself, with that Order and Symmetry, by which one part renders so many Services to the other, whilst not one single Particle thereof can assume any kind of Figure or Motion, but according to certain Laws prescribed to it by, and subservient to the great Designs of its Creator; nor can it separate itself from one, nor adhere to another Body, but in Subordination to the same Laws.

SECT. VIII. *The Preservation of Things proves a God.*

WE must not think that nothing but these Laws, and the infinite Wisdom by which they have been contrived, has place in the great and regular Structure of the World; for the preserving and continuing of all Things in the State and Condition in which they were first created, has likewise a Share in proving a God.

Would we see a Proof thereof, how the Great Director, from a Collection of an inexpressible Number of Particles entirely differing from each other, and which seem to us to be jumbled together in the utmost Confusion, causes only some determinate ones, and such as are subservient to his high Designs, to approach towards each other, and to unite among themselves, and with other Bodies proper to preserve, nourish and increase them according to the Laws impressed therein by his infinite Providence; let us recollect what has been said above upon this Occasion.

Is not the Air a Mixture, yea, a very *Chaos*, consisting of Hundreds of Thousands of Millions of different Particles? How many Things consumed by Fire, and dissolved by Corruption, do mingle their Effluvia, Steams, or Vapours, with the Air? How many Men and Beasts do perspire therein; yea, according to Mr. *Boyle*, almost all Bodies, not excepting Ice and Snow themselves, become lighter by Perspiration, and transmit their exhaled Particles into the Air? How many sweet-scented Flowers, how many Spices and other Things impregnate the same with fragrant Particles, insomuch that the Perfumes of them have been smelt some Leagues distance from the Islands where they grow, according to the Relations of those who have experienced the same? Every  
Body

Body knows, that in Cellars where there are fermenting Wines, the Air is full of their Vapours and Spirits; which holds true likewise in all other fermenting Matters. How many watry Vapours from Seas, Rivers, Lakes, Marshes; how many sulphureous and other corrosive and poisonous Particles ascending from burning Mountains, mingle themselves with the Air? Iron, which in all Parts of the World almost, being exposed to the naked Air, becomes rusty, furnishes us with unquestionable Proofs of the Acidity thereof. With all these there is mingled an unconceivable Quantity of Rays of Light, derived from the Sun and other Heavenly Bodies; and how much Fire is elevated and retained there, appears by Lightning and other ignite Meteors. Add to all this the proper Particles of which the Air itself is composed, and let an Atheist tell us, where he can find such another confused Heap.

Let him farther consider the Earth, and observe of what a mighty Variety of Kinds and Parts it consists. Water is turned to Earth, as we have shewn before; poisonous and wholesome Herbs, Shrubs and Trees, all the Bodies of Fishes, Beasts, and Men do likewise become Earth. In a Word, whatever proceeds from the Earth, is by Corruption or otherwise changed into the same. Let an Atheist reflect again, how many Thousands of Kinds of different Compositions all this Heap of Matter might produce, every one of which might likewise be exceedingly different from all that we now see proceeding from the Earth.

In the Water we may observe the same; How many Plants and Fishes are corrupted therein? What a great Diversity of Dews fall upon it, drawing Particles of the Air along with them? How many Salts are dissolved therein? How many subterraneous Fires fill them with the Matter that

bursts out of their Caverns? Water washes all Filthiness off, and how many Particles does it borrow from the Things in and upon which it has stood any while? Coffee and Tea, all sorts of brewed Liquors, the Off-Scourings of Apothecaries Shops and Kitchens; to say nothing of Minerals, of hot, bitter, and poisonous Liquors, nor yet of salt Sea-Waters; all these Things, I say, furnish us with Proofs that are obvious to every one.

To take notice neither of Fire, which does in a manner unite all Things with itself; let the Atheist represent to himself all these confused Collections of Water, Earth and Air; and in case there were no Laws by which each kind were particularly governed, and pursuant to which these Particles join themselves with some Bodies, and again refuse to come near others, could he himself, or any Body else think it possible, that from all this Chaos, there should not once, but even frequently, and from some of them every Year, be produced anew, so many different Things of particular Properties, and that it would have so happened as long as the World has lasted?

To give an Instance in one kind of thing only. Let any Body sow different sorts of Seeds by one another in the same Earth; they will stand in the same Air, they will be moisten'd with the same Water, warmed with the same Sun, and acquire from them all, according to what has been shewn above, an infinite Number of different Particles round about them. Now let such, who to their own Misfortune deny a Divine Providence, tell us how this can possibly happen, were it not that certain Laws obtained in all these numerous Kinds of Parts, and which are the Cause that every Particle necessary to the Growth of every individual Seed, does unite itself therewith, and to no  
other

other of different Properties, and how every Seed can always produce its own Plant of the same Kind and Virtue every Year without once failing? And why, when there are such poisonous Herbs as *Aconitum*, *Hemlock*, and the like, scattered and mingled in the same Earth with Wheat, Rye, Barley, and other Grain so useful to Mankind, there are joined only to the first, fatal and deadly Particles, and to the latter, only wholesome ones? And why an Apple-Tree never bears Pears, or a Vine, Cherries?

SECT. IX. *All Kinds of Philosophy do, or must acknowledge Laws.*

LET the most experienc'd Philosophers be called upon, and let them tell us themselves, if they will declare their Sentiments impartially, whether, without acknowledging these Laws and a directing Providence, they can make these and such like Phenomena (for there are many such in the World) the necessary Consequences of the Hypotheses upon which they found the Science of Nature.

Some have thought upon a Magnetical, and other Kind of Attractions; but these lay down one sort of Laws.

Others suppose a certain kind of *Ferment*, as the Chymists style it, in the *Stamina*, or Principles of Seeds, of which there can be no other Notion formed, than that they are Parts figured after a particular Manner, and moved according to certain particular Laws, and which unite themselves with some Bodies, and separate from others.

Finally, Since both these Hypotheses have been rejected of later Years, those that have philosophized more rationally, have laid down, that there are Pores or Orifices in Seeds of certain Figures, through which only are admitted Particles of the like



like Figure; which, according to the Opinion of others, who will not own a Direction, because that leads them to a GOD, may come to pass by Chance or Necessity, since there seems to be nothing more requisite thereto, than that these Pores should be disposed to receive those little Particles as soon as they are put into Motion. But according to this Hypothesis there might, *first*, not only all kind of Particles be admitted into the Pores of the Seed, provided they were but small enough; but likewise, *secondly*, there would hardly be one Seed capable of growing, and but very few Particles enter into the same, save only round ones, if nothing but mere Chance obtained therein, as Dr. *Pitcairn* has expressly and mathematically demonstrated in his *Dissertations*; since the same kind of Particles must always present themselves before the same Pores, and exactly after the same manner, if they would gain Admittance. But let us shew this by a more familiar Instance: Suppose any one should undertake to throw a Dye through a square Hole, through which it could but just pass; must he not stipulate, in order to have an equal Chance of winning or losing, to repeat his Throw a great many Times? So that if something like this should be the true Cause of growing of Plants, and all the Particles of the Figure of a Dye should always pass through the square Pores in a Seed; there must at least in this Case, as much as in any other, be a Rule or Law, according to which each Dye must be disposed when it comes against the Orifice or Hole.

We do not here dispute, whether any thing of all this, or somewhat else, be the real Cause, that among so many Thousands of various Particles, those only approach to, or are attracted by each Seed, which are most proper to compose the particular Plant in its kind; but our Design was only

to shew, that without acknowledging a Divine Direction, whereby all Things are moved according to the requisite Laws, whereby some Things are made to approach, and others to recede, and which are extended to every one of these unconceivably small Atoms, no other Hypothesis has hitherto been offer'd, whereby the Growth of Plants and many other Things could have been resolv'd. In short, to obviate all the Evasions of Atheists, let us recollect from what has been said above, that among the Thousands of Kinds of Animals and Plants, there is not one only to be found which was not at first formed of an exceeding small *Stamen*, containing all the Parts thereof in Miniature, and from whence, by Expansion or Unfolding, and by Covering or Cloathing with adventitious, particular and determinate Matter, all Plants, all Men, Beasts, Fishes, Fowls, and every other living Creatures are produced; as is well known by the general Experience of those that use Microscopes. Let then the Atheist or Sceptic think with himself, whether he can reconcile all this to a mere and accidental Concourse of ignorant Things; and these curious little Forms and Figures, in which all that is necessary to so many wonderful Purposes in great Bodies, are compris'd in a much smaller Quantity than a Grain of Sand: I say, let him make all these Things agree with those necessary Laws, that operate without any wise Direction or View. After so many illustrious experimental Proofs of the Wisdom of an adorable Creator, no reasonable Person can require any more; especially if it be true (as some great Men think it very probable) that in all these *Stamens*, how small soever they may be, those of all others that are to be produced to the end of Ages, are actually to be found in their determinate Figures.

SECT. X. *The Opinions of some Philosophers about Fertility.*

I DON'T know, whether it may not be thought proper by some to add to all this, one Notion more, which appears very plausible to many, but yet seems to require a farther Examination and Trial before it be entirely admitted for certain: But since the same has been entertained by several Great Men, and seems to have some Analogy with the Chymical Operations and Actions of the Parts of Matter upon one another, and especially since the thing carries along with it a great Proof of GOD'S Providence; it may perhaps be of use, if we here subjoin a few Observations that may set the same in some kind of Light; and, it may be, also excite thereby some of the Learned to look farther into a thing that is at least worth double their Pains.

It consists in the Inquiry of what may properly be the Means which the Gracious Preserver of all Things makes use of to render the Earth fertile, and to cause Plants to grow plentifully therein.

Now that which may be experimentally pronounced upon this Matter, according to the Opinions of many Naturalists, is, that the Nitre of the Air is the Cause thereof; to which perhaps one may add, that since Nitre, or Salt-Petre, is alone and of itself an unactive Matter, there must something else concur to put it into Motion; much after the same manner as it happens to the Acids and Alcalies, which, when separate, are at rest, but being put together, will effervesce and boil up with each other. The same happens by the Mixture of Salt Petre and Brimstone in Gun-powder.

SECT. XI. *The Air seems to abound with Salt-Petre: Seven Experiments shewing the Probability thereof.*

Now to prove, if not with entire Certainty, yet with great appearance of Truth, that either Salt-Petre is in the Air, or at least some other Matter, which being much of the same Nature, meets sometimes with something else in the Earth, whereby between them real Salt-Petre is produced, appears from the following Experiments.

I. That the Earth may be mixed with such Matters upon which the Air will operate; such as the Filings of Iron, the Urine, Dung, and Blood of Animals, lixiviated Chalk and Afhes, &c. and that from such Mixtures, after they have been exposed naked, by being turn'd up for several Months, to the Action of the Air, a remarkable Quantity of Salt-Petre may be extracted.

But forasmuch as great and learned Men seem to differ about this Aërial Salt-Petre, I thought fit, for greater Certainty, to make this Experiment, and found by the Event, that such an Earth after being managed properly, yielded in a Month's Time about three Pound of very good raw Salt-Petre. This has been touched upon before, so that what is here said, may be the more safely depended on, and the rather, if we add what several have affirmed to be experimentally true, namely, that the Earth from which Salt-Petre has been once extracted, will, after a while, be again impregnated by the Air with the same.

II. Since every Body may find, that by letting Blood run out of a Vein upon Water in which Salt-Petre is dissolved, the black or dark Colour thereof,

thereof, will be immediately turned into a bright Red; and the Serum or Whey of the Blood become as transparent as clear Water, tho' it retains its nutritious, or at least solid Parts; which by dropping a little Spirit of Salt-Petre upon it, may likewise be separated therefrom; yea it is known that black venous Blood being exposed in a Vessel or Porringer, is often red at the Place where the Air touches it; and that even upon taking off the upper red Part, the Black which was under will likewise assume a bright red Colour: I shall not here dispute, whether the Air is mingled with the Blood in the Lungs, because this is doubted by some Philosophers; but however it is plain from these two Trials, that Salt-Petre and Air do act uniformly upon the Blood; and therefore it is in some manner probable, that the Air is impregnated with Salt-Petre.

III. It is known to the Naturalists, that a great deal of Salt-Petre may be made from Blood, (See *de Stair de Nitro.*) If now it be true, that in Breathing, the Air is continually mingled with our Blood, one would be apt to imagine, that it leaves a great deal of its nitrous Quality therein, which may afterwards be extracted.

IV. Since refined Salt-Petre being held in a warm Hand, will snap and break, which perhaps might be occasioned by the Air that was in it; I took a Piece of Salt-Petre and threw it into a bright Lye, in which there is never any Air; then putting it into the Air-Pump, I observed a great Stream of Air-Bubbles coming out of the Salt-Petre, and ascending thro' the Lye.

Now whether from this Experiment it may be concluded, that the Parts of Air and Salt-Petre are easily united and adhere close together, because

cause the Salt-Petre has so much Air in it, tho' Crystallized in Water, and reduced to little Tubes, I leave to the Judgment of others: It might however in some manner lessen the Difficulty some People make, as if Salt-Petre were too heavy, and not volatile enough to keep itself up in the Air.

V. This seems however to be entirely removed thereby; forasmuch as the Observations made by the new Burning-Glasses shew, that Salt-Petre held in their Focus, entirely evaporates, and so mingles itself with the Air, *Hist. de l'Acad. &c.* 1699. p. 114.

VI. All Metals, such as Silver, Iron, Copper, Lead, which are dissolved by the Spirit of Salt-Petre, especially those upon which it acts with the greatest Force, as it does upon Iron, seem to rust in the Air; only Gold, which a simple Spirit of Salt-Petre can't touch, is not so much exposed thereto: All which gives a handle to a Conjecture, that if there be not Salt-Petre itself, there is at least some Matter of the like Nature in the Air.

VII. A yet farther Proof that there is something Nitrous in the Air, seems to result from the Pains in the Head, faintness and dispositions to Vomit, which often appear in some Women when they are in close Rooms, where a great many People and Stoves are. To be satisfy'd of this Consequence, the Reader may be pleased to recollect what we have shewn above in the VIIIth *Contemplation*, namely, that Flame and humane Respiration are maintain'd by the same kind of Air-Particles; for which reason, the Air shut up in a Room where a great many Stoves are burn-

ing, and a great many People breathing, must be very much divested of those Parts, and be the occasion that some weak Women are disorder'd thereby. Now that these Parts are properly Nitre or Salt-Petre, which being render'd, by the Warmth of the Fire and Breathing, unfit to discharge its Functions, seems to appear from hence, that Women thus disorder'd, cannot recover themselves by any better Means that I know of, especially when the fresh Air won't do, than by the use of a Nitrous Salt dissolved in Water, of which I have seen many Experiments, either by putting a little Salt-Petre or *Sal-Prunelle* in their Mouths, and letting it dissolve gently, and swallow it down.

SECT. XII. *Salt-Petre seems to come out of the North; proved by three Experiments.*

SINCE now the first of the Experiments seems to prove, and the other to make it very probable, that the Air has either Salt-Petre in it, or something of a nitrous Quality; it will appear in some manner from the following Experiments, that the same, at least on our side of the Equinoctial Line, proceeds chiefly from the *North*.

I. Not to mention that the Air is cold to a great Degree in the *Northern* Parts of the World, (as for the *South* Pole, we take no notice of it now) nor that Salt-Petre does after a particular manner produce sensible Coldness, as we see by putting Bottles of Wine in Summer-time in Water, and throwing a good Quantity of Salt-Petre into it, which chills it so much, that some have thought that one might freeze Water thereby, but that I shall not determine: From hence it may be consider'd, whether that Air which makes

makes so many Mountains of Ice in the frigid Zone, and keeps them always undissolved, must not greatly abound with Salt-Petre.

II. To render this the more probable, we shall add what the learned *Hambergorus* relates from the *Ephem. Barom.* of Mr. *Bernard Ramazzini*; that Gentleman says, that the Excrecence of Salt-Petre from old Walls made of Mortar and Stone, does mostly appear in Winter, and when the Northerly Winds blow; and that those who make it their Business to gather Salt-Petre, do at that time particularly sweep the Walls; and that they get more of that Matter from Walls that stand to the *North* than to the *South*; which seems to prove plainly enough, that besides the general Impregnation of the Air with Salt-Petre, the Northern Air does mostly abound therewith, and that it is frequently brought from those Parts to us.

III. Now whether it may be inferr'd, that upon account of nitrous Salt, the Northerly Winds make the Air heavier, and that upon the turning of the Wind to that Corner, the *Mercury* does often rise in the *Barometer*, as many who have writ upon this Matter affirm, I shall not here enquire after.

Now whether the Air be render'd heavier by the Northerly Winds (which bring along with them from the cold Regions, a thick and compos'd Air towards the *South*, as appears from the *Thermometers*, in which we may observe, that Cold compresses the Air, and as appears likewise by the Refraction of Light, which is affirmed to be greater in the *North*) or whether such Gravity of the Air proceeds from the Salt-Petre wherewith it is impregnated, or for other Reasons: They who use *Barometers* know very well, that the



heavier the Air is, and the higher the Quicksilver rises, the less rainy and the more dry Weather may be expected. See the *Act. Lips.* 1696. p. 213. from whence therefore, besides other Circumstances that may be peculiar to the Countrey of the *Jews*, the Reason in general may be assigned of that Expression in *Solomon's Proverbs*, *Chap. xxv. v. 23.* *The North Wind driveth away Rain*, since by the greater Weight of the Air, the watry Vapours remain floating therein, and cannot descend in Rain.

**SECT. XIII.** *Salt-Petre becomes active by those Particles in it that are Sulphureous, shewn by Experiments.*

**BUT** since Salt-Petre seems to be very unactive in its own Nature, insomuch as when put into a Melting-pot over the Fire, it does not exert the least active Faculty, even with great Heat; it may be necessary to examine a little more closely, what it is that renders it Active (as Acids and Alcalies working upon each other) and how it comes to produce such Wonders.

Now the Bodies which are more peculiarly proper to produce such an Effect, are all such as come under the Denomination of *Sulphur* among the Chymists; to which belongs common Sulphur itself in the first Place, and every Thing else that has Sulphur in it; such as Antimony, Turf, and Wood-Coal; and in general, all that has Fat or Oil in it, such as Tartar and the like.

Thus we see that Sulphur or sulphureous Bodies, thrown into melted and glowing Salt-Petre, or else being mingled cold with the same, and set on Fire, are put into violent Motions, and the Mixture often turned into a sudden and consuming Flame: So likewise we find that Tartar

mingled with a like quantity of Salt-Petre, will be kindled with the smallest Fire, and burn so long, till the oleaginous and other Parts of the Tartar are evaporated; after which there will remain a white Alcaline Salt, which is therefore called *Salt of Tartar*. After the same manner we see dissolved Salt-Petre mixed with beaten Charcoal, or Turf char'd, and thrown into the Fire, become active, and cast out Flames; where being continued till no more Flame is perceived, the Chymists make of it an Alcaline Salt, which they call the *fixt Salt of Nitre*: But whether it may not more justly be termed the *fixt Salt of Coals*, for the same Reason as t'other is called the Salt of Tartar, I leave to the Learned: At least, how very active Salt-Petre is render'd by Sulphur and Coals, Gun-powder furnishes us with a well-known, or rather with a wonderful and terrible Instance.

It must not be thought that these Matters cannot be kept up in the Air, as not being fine and small enough, because we have shewn before, that besides a great many other different Particles, there are likewise those of Sulphur found in the Air. Thus we see, that in the *Mediterranean*, and other Parts of the World that are more Southern than we, there is very great and frequent Thunder and Lightning, of which in *Greenland* (as I have been informed by one that has been often there) and here with us in Winter, very little is observed. Now that this is occasion'd because the Air abounds with more Sulphur in the former Regions than in the latter, (whereas in *Greenland* there seems to be more of Salt-Petre only, which passing from the Northern to the Southern Part, produces these Effects in Conjunction with the sulphureous Air) is allowed by many as a very probable Thing.

It has been likewise shewn above, that the Rays of the Sun operate upon Salt-Petre, and render the same Volatile; for, that those Rays are Corporeal, and do likewise even bring along with them a Matter that gravitates, appears from the Experiment of Mr. *Homborg* about the *Regulus* of Ifing-Glafs, as the Chymists call it. See the XXIVth *Contemplation*.

I know not whether I may not here add, that in the Year 1711, having gathered some Dew about the latter end of *May*, and kept it a while in a great Glafs Vessel, I caus'd the same to evaporate, in order to try whether there were not Salt-Petre in it, as some affirm; but found no Salt at that time, but only a little reddish Matter pretty near the Colour of the *Scoriæ* of *Regulus Antimonii*; which being sprinkled upon a glowing Coal, would not burn as Salt-Petre is wont to do; but when thrown into an earthen Vessel, in which there was glowing Salt-Petre, it flamed visibly, but however pretty faintly in comparison of common Sulphur.

I cannot here determine exactly of what Nature that Matter was, there being too little of it to bear a further Examination; but however, I judge it to be of a sulphureous Nature, by its flashing with melted Salt-Petre; at least it was plain enough that Salt-Petre acted upon this, and this upon Salt-Petre.

It likewise seem'd as if we might conclude from thence, the Operation of the Solar Matter brought to us by the South-Winds upon the Aerial Salt-Petre, since we find that a glowing Coal of Turf being placed in a hot Sun-shine (out of the Wind, which would otherwise blow it up) is extinguished, and ceases to burn, just as if it were put into a Quenching-Pot. The Reason of which seems to be, that the Salt-Petre of the  
Air,

Air, which is otherwise the principal Cause of our Turfs burning, is render'd unfit by the Action of this Matter, which proceeds from the Sun, to continue the Fire of this Turf-Coal as well as before. Now that this is true, and that Salt-Petre is a great Cause of burning of our Fires, appears from hence; because, that in the strong Frosts of Winter, when the sharp Northerly Winds reign, which have been proved before to be impregnated with a great deal of Salt-Petre, our Turf-Fire burns much brighter, and is much sooner consumed (as Coals are upon which one throws Salt-Petre) than in Summer, when the Air has not so much pure Salt-Petre in it.

SECT. XIV. *Salt-Petre in Conjunction with the Rays of the Sun, does likewise render the Earth fruitful, shewn by an Experiment.*

THUS we find also, that the Action of Salt-Petre, and the Rays of the Sun, do contribute very much to Fertility. Not to relate here, for a Proof, Mr. *Homburg's* Experiment in the *Transactions of the French Academy*, 1699. p. 75, 76. which shews the same of Salt-Petre when diluted in Water, and poured upon Earth: One may likewise make another Tryal, by steeping Grain or Seeds for some Hours in two Pints and half, for Instance, of Water, in which an Ounce of the best Pipe Salt-Petre has been dissolved, and so proportionably; and it will be found that these Seeds will be much more fruitful than any other that have not thus been infused in Water unimpregnated with Salt-Petre. I saw the Experiment thereof in the Year 1711, when some *French-Beans* that had been steep'd were observ'd to grow a third Part higher than others; and have treated some Seeds of Purslain in the same manner: it

grew so large, and so strong, that a Learned Gentleman, and one that was well versed in Plants, could not forbear asking what it was? and said, he had never seen such Purslain in his Life.

This Property of Salt-Petre was likewise known to those of the Ancients that have writ upon Agriculture: But to shew farther that which was proposed, namely, that not only Salt-Petre, but that which likewise proceeds from the Action of the Solar Matter thereupon (allow me so to name either the Sun-Beams themselves, or that which they bring along with them) does render the Earth fruitful: It will be sufficient in the first Place, to consider how much the Sun contributes to the growth of Plants, this being unknown to no Body; and it will give some Light to the Matter, to mention here that which happen'd to me about the latter end of *May*, in the Year 1712; for having sown Purslain, some of which had been steep'd in Salt-Petre Water, and other not, at the same Time and Place; some Days after which the Nights were so cold as to make Ice; and I having found by former Experiments, that in the strongest Frosts there would be found no Ice in Lye, and little or none in common Pickles; that a Water in which there was as much Salt-Petre dissolved as could be, being set within-side, or even without-side of the Window, in a little Bottle close to the others in which the Seeds were, that Water was so strongly frozen as to crack the Glass, the Parts of which were separated more than the Breadth of a Straw; it came into my Head, whether since the Salt-Petre Water froze so easily and so hard, the Purslain, the Seed of which had been steep'd in the like Water, might not be killed by this Frost, especially since the Sun had hardly appeared during all that time, which was very cold; and going to the Window to see, I found  
that

that that Seed which had been sowed after the common Manner, was green, and that which had lain in the Salt-Petre Water, much more advanc'd in those Parts that remained alive ; but that most of it was frozen and dead.

From hence I think we may infer, that in order to make Plants grow and flourish, not only Salt-Petre, but likewise something that proceeds from the Sun is requisite thereto ; to the end, that by their reciprocal Action, they may concur in the producing these Effects upon the Earth, and the Plants thereof.

Besides, that this seems to be further confirm'd by a common Experiment observed by some Husbandmen, namely, that when in the Month of *March*, and the Beginning of *April*, North and North-easterly Winds blow a long while together ; and thereupon it is apprehended, that they shall have a bad Year, and that the Grass by reason of the Cold does not spring up, there is oftentimes a very good Crop, and even an early Hay-Harvest ; for some Years I observed it, and found it always to be true, especially in the Year 1712, when by reason of the frequent Northerly Winds in the Spring, some body said to me, that he feared it would be a bad Season, and that Hay would be scarce ; to which I answer'd, that I had often found the contrary, and that if it were but followed with a good warm Sunshine, the Grass would perhaps be early ripe, and there would be a great Quantity of Hay, which likewise happen'd.

Now, they who allow the Probability of what has been advanced, may easily infer the Cause from thence, namely, that the frequent Northerly Winds might bring great Quantities of Salt-Petre to us, which being succeeded by the Southerly Winds, and the Solar Matter that accompanies them,

them, a great Quantity of those Particles which act upon each other, and contribute to Fertility, is then found in our Air; tho' on the other side it may so happen, that the Northerly Winds shall be so strong and lasting, and the Southerly so weak; and the warm Weather so little, that the Aerial Salt-Petre may be as prejudicial to the Fruits of the Earth, by reason of its too great Plenty, as the common Salt-Petre (the Experiment whereof is mentioned above) which being used in too great a Quantity, killed the Plants. With this agrees the common Proverb of the Husbandmen, confirmed by numerous Experiments, that *a Peck of March Dust is worth a King's Ransom*. That Month being commonly dry with us when the North Winds blow, by which the Air is render'd so heavy, that the watry Vapours will remain floating in them, and cannot descend in Rain; which with Southerly Winds are wont to come plentifully down at the same Season.

SECT. XV. *Conventions from the foregoing Observations.*

I HAVE dwelt the longer upon this Matter, not only because the abovementioned Experiments require to be expressed and proposed with some Clearness in their Circumstances; but particularly in order to stir up others that have Inclination and Conveniencies, to inquire more narrowly what it is properly that renders Lands fruitful, and makes Plants grow more freely; to the end that they may either corroborate what we have here said, by farther Experiments; or otherwise, if they find that the Works of Nature exert themselves after a different manner, they may communicate their Light to the World; since there still seems to be wanting Numbers of Experiments:

riments: For Instance, how to order such an Earth, or such Seeds, so as that in a few Hours a Sallad, or other Plants fit for use, may be produced; or again, that each Seed may at the same time put forth all the Seed-Plants contained in it, and make them grow equally, by which means the Fruits of the Earth might be multiplied, and such like Experiments: At least every one will readily agree, that this is a Matter, the Inquiry into which may not only much more illustrate our Knowledge of Nature, but likewise be very beneficial to Mankind.

In the mean while, since no body can be ignorant that the Air is the Magazine or Treasury, from whence that which renders the Earth fruitful is communicated thereto, as the frequent plowing and turning up the Earth, and exposing it to the Air, has shewn experimentally for many Ages; can it be thought that it comes to pass without a wise Providence, that there has never been any Want in the Air of such Particles as are fit to that Purpose? That the Waters of Rain, Dew, and Snow, falling down through the Air, are impregnated therewith, in order to carry such Particles along with them, and to insinuate them deep enough into the Earth, so as to fertilize the same, and to dispose it to furnish all living Creatures with Food and Refreshment?







## CONTEMPLATION XXVIII.

### *Of the Possibility of the RESURRECTION.*

SECT. I. *The Objection of the Sadducees answer'd by our Saviour, Matt. xxii. § 29.*

I SHOULD here have made an end of contemplating the Laws of Nature, because an Inquiry into all those, to which the Study of Nature, and particularly Chymistry, leads us, would take up too much of our time here: But since it may seem to contribute very much towards the illustrating a Matter which is of great Importance, I shall attempt to set that matter likewise in some Light, tho' it is seldom handled upon Natural Principles. To enter therefore upon it:

It is well known, that among those unhappy Persons who deny the GOD that made them, there be many who are wont not only frequently to ridicule the Confession of Christians about a Resurrection, but likewise to oppose the same after all imaginable Ways; and that others, who seem to treat this matter with more Reason and Decency, are likewise accustomed to form some Objections against it, by which they think they do sufficiently prove the Impossibility of a *Resurrection*.

I know very well, that in order to cut off all Difficulties and Cavillings raised against this Article of our Creed, by those who acknowledge a GOD; and believe the Holy Scriptures, nothing can be more strongly returned, than what our Lord  
was

was pleased to answer to the *Sadducees* who deny'd a Resurrection: *Ye do err, not knowing the Scriptures, nor the Power of God,* Matt. xxii. v̄ 29. That is to say, the Word which you admit to be Divine, says so; and no body ought to doubt, whether the Power of GOD be great enough to perform what he has said.

SECT. II. *It is not a greater Miracle to Raise a Body, than to Create it.*

BUT since we have here to do with a sort of deplorable Disputers who have no Reverence either for GOD or the Scriptures, and who think that they are able to prove from their Philosophy, the Improbability, if not the Impossibility thereof, I have been of Opinion, that altho' the Certainty of a future Resurrection can only be deduced from the Word of that GOD who never deceives any one, and that the Manner of it must likewise be referred to his Wonder-working Power; yet that it might be perhaps useful to some, to shew here, that all the Objections which they can raise against it, are far from having any Strength in them; but on the contrary, that the few as yet known Laws of Nature and Appearances are more than sufficient to answer them all, at least all that have ever occurred to me, and to put the Possibility of the Resurrection, the Proof of which is our present View only, quite out of a doubt.

To begin therefore: Let one that denies or doubts of the Resurrection, tell us whether he is not forced to allow, that all the Food of which his Body consists, as well as the Bodies of all his Progenitors, does proceed from the Earth, or rather is nothing more than a metamorphos'd, or transformed Earth: (If he denies this, let him read what we have said thereupon in the first and following

lowing *Contemplations.*) 'Tis a plain Consequence then, that his Body likewise proceeds from Earth.

And this being so, it is no more strange that his Body which was once Earth, should be raised again from the same, than that it had acquired or received its first Figure from thence. What Impossibility is there, that so wonderful and dreadful a Power, which made use of the Earth to form a humane Body before there was any such Being in the World, without its Knowledge, without its Concurrence, and after such a manner as is unconceivable to him and all other created Beings, should now again think fit to make use of the same Earth to the same Purpose, and raise him up again from the Dead? Let this Philosopher suppose with us, that a Man were born and brought up in a Place where he should be entirely ignorant of the Nature of his Food: If now another Person came and shewed him a Lump of Earth, out of which Rye and Wheat, or what else he might have used for Food, were produced; and if he told him, that his Body did not only proceed from, but was likewise maintained by this Earth; would not this Denier of the Resurrection think, as we do, that such a Man would make as many Scruples in admitting the same for Truth, as others now do when we tell them, that their Body shall once again proceed out of the Earth into which it is turned after Death? And would not likewise, even the most learned Enquirer of what happens in the World, be as much amazed at the Manner after which his Body is formed out of, and sustain'd by Earth, were it not that the Custom of seeing frequently how a humane Creature is born and nourished, but never how he rises from the Dead, would seem to make this Matter more intelligible to him, and, as it happens with  
customary

customary Things, make him look upon the former with no Wonder?

SECT. III. *Even the common Formation of Bodies is less credible than the Resurrection.*

LET one that denies the Resurrection tell us, whether the Parts of which his visible Body is compos'd (for as for the exceeding small *Stamina*, we shall take no notice of them here) were not as much scattered over the whole Earth about 5000 Years ago, as they will be many Years after his Death, or at the End of the World? (See concerning this Matter more largely in the following *Contemplation*, *Seët. V.*) And whether it be more impossible in this last Case, than in the first, to collect the Parts so dispers'd, and to bring them into Order.

Again, if he were ignorant of the Manner by which the Procreation of Animals is performed, and had had no Opportunities of seeing the same, let him ask himself whether he should admit it as a Truth, that a human Creature, for Instance, lying so many Months in a Liquid Matter, like a Fish in the Water could be able to live; whereas now the same Creature, if kept but a few Minutes under Water, would perish? And would not he think, that from hence he might alledge many Reasons, why 'tis more probable that a Man should be produced, like a Plant, out of a Seed, or at least after some other Manner that does not so directly contradict Experience? And yet he sees this comes to pass constantly, and always after the same manner, without any Variation. Can now the Resurrection of the Dead appear to him more wonderful, or even so much? Since in this last Case it is only required, that a Body should be produced from the same united Parts;

Parts; and the Manner after which a Man is now formed does besides this seem likewise to run counter to several plain Experiments, by which it appears necessary that we should breathe in order to live; whereas we have nevertheless sufficient Cause to affirm, that a Child can live several Months in his Mother's Body without Respiration.

This seems to be sufficiently proved, forasmuch as the Lungs of a Child that is *still-born* will sink in Water. *Bergerus*, p. 481. gives an Experiment thereof, and tells us, that the Lungs of a Child born dead, being put into an Air-Pump, will not swell, and when thrown into the Water, will subside; the quite contrary of which must have happened, if the Child had been born alive, and had remained any time in the Air, since such Air is never perfectly discharged again from the Lungs, but there will always remain a sufficient Quantity thereof to cause the same to swell, and to hinder the sinking. Accordingly we find, that a Piece of the Lungs of a Beast newly killed, being emptied of Part of its Air by the Pump, will contract itself and sink deeper into the Water than before; but however, it will not subside to the Bottom till, after much Pumping and a good deal of Trouble, the Air be quite exhausted.

SECT. IV. *The first Objection answer'd, namely, That we have no Parents in the Resurrection.*

BUT to proceed; we must not stop at this Objection, which to understanding Persons is too Vulgar, *viz.* That the Resurrection does therefore seem incredible, because when we came into the World, we had Parents to whom we owed our Birth, and that there were so many proper Means at hand upon that Occasion, but that the same  
will

will all be wanting at our second Birth or Resurrection.

Since all that a good Logician can prove from thence is, that there is a Power and Wisdom capable of providing Means for the Generating of human Creatures after this manner; now what Reason can be given, that the same Power which has been able to do this after one manner, cannot make use of other means for the same Purpose? The rather, since we see that God, to manifest his Wisdom likewise to those that hate it, is wont to execute the same Purposes in numberless Ways and Methods. It would be unnecessary to repeat Instances here of all kinds of Animals, having done the same largely in the beginning of the *XXIII* *Contemplation*, where we have given an Account of their Motion, Nourishment and Production, in respect to which the Instruments of each kind of *Fishes*, *Birds* and *Beasts* are almost all differing from each other, and yet they are all procreated, nourish'd, and do move themselves from one Place to another.

So likewise when we contemplate the *Plants*, how various are the Ways of putting forth and growing among them! Some grow in Earth, and that oftentimes in one only determinate and particular Sort; others require another kind of Soil; some grow upon the Water, and some even under Water; one in a warm Climate, and another in a cold; some are propagated by the Seed; some by a Branch taken off from the main Plant; a third by Setting; a fourth by Grafting; a fifth by many of these, and perhaps yet different Methods: And thus are the Views of the Great Creator, of causing Plants to continue in their Kinds, executed after so many different Ways.

This being so, what Impossibility is there that the same Power which produced the Bodies of

Men once before by the Means of their Parents, may not perform the same again by other Means? And if we only suppose, that this Great Maker can use as many Ways as all Men can invent, (wherein nevertheless his Power does far exceed all human Inventions; as is plain to those that are wont to inquire into his Works, where they daily learn something new, that perhaps never before entered into their Thoughts) no Body will easily deny the same; forasmuch as he would pass but for a poor Philosopher among the Atheists, who should not imagine himself capable of forming an Hypothesis, whereby human Bodies, by a different Disposition and Motion of Parts might be produced after a different manner than now they are.

SECT. V. *The Second Objection, from the Smallness of the Parts after Corruption, answer'd.*

THOSE that deny the Resurrection do again think the same impossible, because our Bodies being dissolved by Corruption into so many and so small Particles, it does not appear credible to them, that they can be all again replaced in their necessary Order, nor the *proper* Body thereby restored to its former Figure. But will they therefore doubt, whether a good Anatomist can put all the Bones of a Skeleton, or a good Clock-maker all the Wheels and Pieces of a Watch, tho' jumbled together without any Order, into the same Structure again, so as to compose the very same Skeleton and Watch? If therefore we do but suppose that the Great Creator of the Universe is endowed with only so much more Wisdom and Power than an Anatomist and Clock-maker, as the Structure of a human Body is more noble and curious than a Skeleton or a Watch, what Difficulty

culty can there yet remain? For that we do not herein ascribe too much to that Adorable Being, but on the contrary think of him much too meanly, and below his great Perfections, by such a Supposition, may appear from hence; that if all the best Workmen in the World should lay their Heads together, there would not be Wisdom enough in them, (to say nothing of their Power) to put in order the Body of a Flea, or any other Insect, or even any little Seed of the smallest Plant, so as to compare for Excellence and Contrivance with any one of those which we daily observe to proceed by Millions out of the Hand of this Great Artificer: the rather, because, as has been shewn before, the more minute Particles, even those of Light itself, are governed by a Power which extends itself to all Things, and they are subject to certain and fixed Laws, even when they appear to be in the greatest Disorder. Having often seen the Picture of a Man so accurately formed upon a white Cloth, or Paper, in a dark Chamber, it occurred to my Mind as an agreeable Type of the Resurrection; at least it appeared from thence, that the Rays of Light reflected from the real Body of a Man standing out of the Chamber, pass through the Air mingled among numberless others that proceeded from circumjacent Objects, and yet, after entering into the Chamber, were separated from all the foreign ones, and collected into the exact Image of the same Man, according to the Laws of *Dioptrics*.

If now all these Particles of Light, after so many Mixtures with, or Percussions against other Particles, can be oblig'd so strictly to obey certain Laws, that when receiv'd upon a white Paper, and regularly collected, they will paint and express the just Form of that Person from whom they proceed; what Impossibility is there, that the Parts



of a putrified Body, tho' mingled and dispersed among an infinite Number of others, should be brought together again, and compose the same Body, any more than that the Particles of Light do the Figure of it?

If this be not sufficient, our Reader may recollect what has been said in the two preceding Contemplations, *viz.* that not only the smallest *Animalcula*, or Particles of Bodies, cannot escape the Direction of the Glorious Maker and Ruler of all Things; but also and chiefly, that before all greater Bodies do become Instruments of his Power, he has thought fit, for the displaying of his own Glory, that they should be first divided and separated into Particles of the extremest Smallness, and such as can be scarce conceived by Men. If then it be proved by undeniable Experiments, that there is a Power which has framed all Things upon the Earth round about us, yea, even the great and glorious Body of the Sun itself, of such small Particles, and has disposed them in so wonderful an Order; how can the most unhappy Sceptic, or Doubter of the Resurrection, pretend with Reason to deduce any Argument from the unconceivable Smallness of the Particles into which a human Body after Death may be dissolved by Corruption or otherwise, against the Possibility of the Resurrection of such a Body?

SECT. VI. *The Third Objection, from the Attrition of the Particles, answer'd.*

BUT as the Fancies of some, who wish that all their Notions may be true, are rich in finding out plausible Arguments in Favour thereof; so they endeavour to amuse themselves with the Opinions of some famous Philosophers, who maintain that every thing, especially the smallest, and consequently

quently the weakest Particles, wear away with Motion; and therefore change both their Figure and Properties, so that after a great many Years, and the passing away of Ages, we do in vain seek throughout the whole Universe for those Parts of which a Body was compos'd, and of which, if they were to be found, it might be again compos'd after the same manner.

But he who contemplates the Operations and Laws that have already obtained in the World, will be convinced;

*First*, That by the Art and Invention of Men, whereby they apply the Laws of Nature to their own Purposes, even the whole Frame of the Bodies of Men and Beasts may be preserved, unchanged, and uncorrupted; it is therefore much more possible, and likely too, that incomparably smaller Particles may by an unconceivably greater Wisdom and Power be continued in their present State and Condition. Now that the aforesaid is true, will appear from the known Manner, after which so many exotic Plants and Animals are secured from Corruption in Spirits of Wine, refin'd from all their Water, with the Addition of a little Camphire; as likewise from the embalming of Dead Bodies, as well by the Ancients, as particularly by the Moderns, who can much better secure Bodies from Putrefaction. So likewise *Simon de Vries*, in his Description of *Old Greenland*, says, that the Air is so sharp, as to preserve dead Bodies from Corruption; and the famous Geographer *Sarson* relates, that when a *Spanish* Colonel marched from *Peru* to *Cbili*, over a high Mountain, some of his People were frozen to Death; and that several Years after, he found them in the same Condition, that is to say, sitting upon their dead Horses, and holding their Bridle fast, their Bodies remaining uncorrupted.

Secondly, That all Things do not wear away and change their Figures indifferently, has been already shewn in the XXVIth *Contemplation, Sect. V.* since if it were so, Water, Air, and the whole World in all its Parts would be changed as to their Nature and Properties, just contrary to what Experience teaches us.

And if any one desires to be convinced thereof, by an Experiment, which I had made with another View, in order to shew, that the Tempering of Acids (as it is called in the Language of the Physicians) does not consist so much according to some, in the obtunding or blunting the acute Parts of the Acids themselves, as in their strict Union with Alcalies, either watry or other Parts; let him first dissolve Silver in the Acid Spirit of Salt-Petre, or otherwise in *Aqua fortis*, and then after having put a little Water to it, lay a Plate of Copper in the said Liquor, whereupon the Acid will let the Silver go, and dissolve the Copper. But if you throw in some Iron, the Copper is precipitated, and the Iron dissolved by the Spirit, which being filtrated again by the Addition of some *Lapis Calaminaris*, the *Aqua fortis* quits the former, and dissolves the said Stone. If then you should pour off this Liquor from all that has subsided in it by Filtration, and then put some Lixivate Salt of Tartar to it, this last will be dissolved and precipitated, and the Salt be united with this *Mensivuum*; so that this Mixture being Crystaliz'd, (which is a Sign that the Parts of the Nitrous Spirit remain unchanged) will yield a burning Salt-Petre.

And to shew farther, that it preserves its Acidity, I put fresh Water and Oil of Vitriol to the aforesaid Salt-Petre; from whence by Distillation, I produced again the same *Aqua fortis*, or Spirit of Nitre, which, upon Trial, discovered its

its Acid Qualities; for when we threw into it some unruſted Filings of Iron, I obſerved the Iron to be diſſolved, with a great and violent Efferveſcency, and a very red Vapour to aſcend, which is peculiar to a Nitrous Spirit. This was yet more ſtrongly confirmed, by putting ſome Salt of Tartar to it again, by which means there reſulted the ſecond Time a good Salt-Petre from the ſaid Spirit. From which Experiments it does appear at leaſt, that this Nitrous Spirit, after ſo many and ſuch different Unions with Silver, Copper, Iron, Calamine-ſtone, and Salt of Tartar, and after having twice reſiſted ſome of them, ſtill remained in its former Condition, the Particulars thereof being neither changed, nor worn by all theſe Motions; which ſhews it is by no means impoſſible, that the ſame Power which preſerves to the Spirit of Salt-Petre its Figure and Properties, after ſo many Unions, Mixtures and Efferveſcences, may likewise do as much in the Parts of other Bodies. Thus we alſo ſee Quick-ſilver and Gold handled numberleſs Ways by the Chymiſts, and yet continue the ſame, after having undergone ſo many Changes.

SECT. VII. *The Fourth Objection, from the Union of theſe Particles with other Bodies, answer'd.*

ANOTHER Objection is wont to be made by ſome, againſt the Poſſibility of a Reſurrection, becauſe, that not only all Bodies are divided into ſuch ſmall Particles by Corruption and other Means, but chiefly becauſe theſe Particles become united, or rather changed into other Bodies; and the Earth, which for Inſtance, proceeds from a putrify'd Carcaſe of Man or Beaſt, is oftentimes tranſmitted into many kinds of fluid and ſolid Bodies, ſuch as Water, Air, Trees, Plants and Herbs; ſo that there

seems to be necessary here, not only a bare Union of these divided Particles, but likewise, *First*, A Separation from those Bodies wherewith they were united ; which to these Objectors seems incredible, and hardly possible in so many Millions of Cases, in which all this would be requisite towards the raising of one only Body again.

But those Gentlemen would easily be of another Mind if they were reasonable, upon our shewing them what they look upon as incredible, is brought about many Ways in Chymistry, both in respect to solid, as well as fluid Bodies.

If one put Silver into *Aquafortis*, it will be dissolved therein, and turned into a fluid Matter ; add a little Copper, and the Silver will be separated and sink to the Bottom, as we have shewn before.

Melt Gold and Silver together, and when they are cold, they will become a hard mixed Metal ; but throw that Mixture into *Aquafortis*, and they will be immediately separated, the Silver incorporating itself with that Liquor, and the Gold subsiding like a Powder to the Bottom ; as is well known to all that deal in those Metals.

The Oil or Salt of Tartar being dissolved in Water, and boiled with Sulphur, will unite itself therewith ; but pour a little Vinegar into it, the Salt of Tartar will mix itself with the same, but the Sulphur will be separated.

Mingle Spirit of Sea Salt with some Volatile Salt, for Instance with that of Hartshorn, and they will unite themselves closely to each other ; but add some Pot-Ash or Chalk thereto, and they will presently quit each other, and the Spirit of Salt will join itself to its new Guest. It would not be difficult for those that are well vers'd in Chymistry, to produce innumerable other Examples of Matters that adhere and unite closely with  
one

one another, which yet are easily separated by the Addition of the Third. And if it happens so in these Cases, where is the Impossibility in any other Matters?

SECT. VIII. *The Fifth Objection, that in the Particles of Bodies, we cannot observe any such Union, answered.*

BUT it may be, our unbelieving Philosophers will reply, that we cannot observe any such uniting Properties in the Parts of human Bodies, and that therefore there is no such Thing.

But if they would please to attend to other Chymical Experiments, they might see that Water and Oil being put together, will not unite, but remain unmixed; but if you should join the same Oil with Pot-Ash, and Salt of Tartar, or any other good Lixivate Salt, (or even some Oils with Sugar) and make it into Soap, it will easily unite with Water.

Copper is likewise indissoluble, and will hardly be touched by common Water; but if you add thereto some Volatile Salt of Sal-Armoniac, the Copper will be entirely dissolved, and turned into a blue Liquor.

Resin made of Drugs, such as *Fallop*, *Scammony*, &c. cannot be separated in simple Water; but add to them Yolk of Eggs, or pounded Almonds, and they will be easily mixed together; from whence, as also from a great Number of other Experiments which we might borrow from the Chymist, it is plain, that tho' two Matters will not unite, the same may be brought about by the Addition of a Third: And having shewn this in so many Cases, what Impossibility is there again, that the Material Particles of our Body, according to the same, or other Analogous Laws of  
Plants

Plants and Animals wherewith they have been united, may after a Separation be joined again as they were once before?

SECT. IX. *The Sixth Objection, That these Particles are scatter'd too far from each other, answer'd.*

IF any Body that seeks for farther Evasions, should hereupon reply, that these Particles before they can be united to others, must first be brought very near together; but that between those of our Body, there are oftentimes found very great Distances, and that their Union is thereby prevented; let him consider, that tho' Acids and Alcalies must come very near, before they can lay hold on each other, yet Amber, Wax, Glass, will attract Straws, and other light Matters at a much greater Distance, only by being a little rubbed; that the Load-Stone draws Iron, tho' it be yet farther off, and that whatever is counted heavy upon the Earth, moves, or is attracted towards the Centre thereof; not to repeat here that which must be supposed, according to the Opinion of Sir *Isaac Newton*, and whereof we have given a Proof above in the XXVIth *Contemplation*, viz. that even the heavenly Bodies at their great and almost immeasurable Distances, are subject to a Law that brings them towards each other. If then it appears from hence, that such great Bodies gravitate or move towards each other, according to the present Laws of Nature, tho' at such great Distances, and as far as their Motion will permit, do unite with one another; why should it be impossible for the same Power to do this in human Bodies?

SECT. X. *The Seventh Objection, That the Particles of Matter would act with Choice or Knowledge, answer'd.*

THERE is another Objection, namely, that the Particles of our Body might seem to act with Judgment and Election, if among so many Millions of others they should just meet at the same Places of the Body to which they belong, and concur with them in forming a new Structure.

Yet this is no greater a Wonder, than that among so many other Places where the Particles of the Earth, Water, Light and Air might fix themselves, those that are proper to produce Grapes, do only unite themselves to Vines; those of Apples, to Apple-Trees; such as belong to wholesome or unwholesome Plants, are united after the same Manner; and notwithstanding that the most poisonous Herbs grow near, or in the midst of a great Quantity of Corn, this last will not be affected thereby.

The like may be observed even in our own Bodies, where from a mixed Chyle consisting of so many Kinds of Meats and Drinks, those Particles are only join'd to each Part of the Body where they are wanting for the Support of the same; by which Direction it comes to pass, that Flesh, Bones, Membranes, &c. do all remain unmingled, and in order; without which they would otherwise be soon incapable of discharging their Functions.

And to give other Instances, of which we may find a great many in Chymistry; mix Iron, Lead, Salt and Stone, all of 'em reduced to a Powder, together; then hold a Load-Stone near it, it will draw the Iron only, and as it were by free Choice out of this Composition, leaving all the rest of the  
Bodies



Bodies untouched: Pour Quick-silver upon this Powder, it will only embrace and unite itself to the Lead, neglecting the rest; put some Water to it, that will only imbibe the Salt, and let all the rest alone. The Doctrine of the *Menstrua* or dissolving Liquors, will furnish us with a great Number of other Instances, wherein each acts upon its proper Object, as it were by free Choice and Knowledge.

Now there is not more required to the Renovation of our Bodies from their Atoms or Particles, than what we see in these Matters.

SECT. XI. *The Eighth Objection, Concerning Canibals or Men-eaters, answer'd.*

BUT the Histories which we read of Men-eaters, seem to be of some Weight with those who would insinuate this Notion of the Impossibility of the Resurrection into the Minds of weak Men: Since when one Man is devoured by another, the Consequence would seem to be, that as one is turned into the Food of the other, his Body would likewise be changed into the Body of the other; and forasmuch as it is an Article of the Christian Faith, that each one shall rise with his own Body, they think they can prove it to be impossible in this Case; because, tho' the Body of the *Canibal* should be raised in all its Parts, yet that of him who was devoured, will be deprived of several.

Now to remove this Difficulty; these Objectors must be forced to own, that two Cases may come to pass therein. The *First* is, when the Canibal lives some Years after the Person he has devoured; for in this Case it is clear, that the Objection will fall to the Ground, because, according to the common working of Nature observable in all Bodies, that which now tends to Food, and

to compose a part of the Body, may be separated therefrom long before its Death; for if in the Body of any one who daily makes use of Food, the Substance did not lessen; and if only one Ounce of that Food which a Man takes each Day at every Meal, should be converted into the Substance of his Body, there would be added every Year 20 Pound to the Weight thereof, and consequently in 53 Years, it will amount to above 1000 Weight; whereas we find it otherwise by Experience. From whence we may conclude, that as the Body becomes heavier and bigger by Food, it does at the same time grow lighter and less by Perspiration, and other Motions of the Fluids, as *Sanctorius* has first observed.

If now we suppose *the second Case*, and in order to make all the Concessions that are reasonable, allow that this Canibal, or Man-eater, does die at such a time as the Objector himself thinks fit; and that the Flesh of the Person devoured is united to the Body of him that eats it: This Objection may seem at first Sight to those that have not much contemplated the Manner of God's working in Nature, to carry some Force with it.

But let these Objectors consider, that altho' the Maker of a human Body permits so many Things to come to pass therein with our Knowledge, and at the Command of our Will, yet he excepts the Nourishment of the Body out of it, that being performed not only without any Power of the Will, but even without our Perception or Knowledge: Since after that the Food has passed thro' the Stomach and Bowels (where indeed sometimes we have some Perception thereof) no Body knows what becomes of it afterwards, nor with what Parts, nor at what Time it is united: Shewing thereby, that this Benefit which is procured to us by the taking of Food, depends perfectly  
and

and only upon his Will. We see likewise that some sickly Dispositions, as also too great Heat, too violent a Motion, too great a Passion, which last are not wont wholly to deprive us of Health, like bodily Distempers, are oftentimes the Occasion that our Bodies are not nourished by the Food that is used, so well as at other Times.

From whence it is probable, that if the Design of the great Creator of all Things, be that every Man should rise with his own Body, as he has declared to us in his holy Word; 'tis likewise in his Power to hinder, that no one Particle should essentially belong to two Bodies, and that, even after a natural Manner, there is no Impossibility in it.

But if this Argument should not appear sufficiently convincing to some, they may be assured thereof by numberless Chymical Experiments; by which it will appear, that tho' a Body has the Property of uniting itself to another, yet it can be hinder'd by the Addition of a third, and by other Ways too from doing the same.

Thus Spirit of Salt-Petre will unite with Steel; but if one first puts into it a fixed Alcaline Salt, such as that of Tartar, the aforesaid Effect will be prevented.

A Lixivate Salt will mix with Oil, and turn it into Soap; but put a little Vinegar to it, or any other Acid first, and the Salt will not incorporate with the Oil; and even when the Mixture is actually made, they will be divided and separated thereby.

Iron will join itself to the Load-Stone, or rather they will move towards each other; but turn them only the wrong Way, and they will fly from, or drive one another away. But to Instance in no more Cases, as one might easily do from Chymistry, who can give any Reason why  
the

the same Power that does all these Things, cannot bring about the same Effects in the Parts of a Man, whose Body has been united as Food to the Body of a Canibal?

SECT. XII. *Conviction and Possibility of a Resurrection.*

I KNOW very well, that some ingenious and acute Philosophers may not be at a loss to fancy Hypotheses, in order to solve the Causes of all those Experiments we have produced, and it may be such as may seem to have some Analogy therewith; and that even all the Chymical Phænomena are accounted for, by one this way, by another, that; but it is not necessary either to admit or to reject the whole: *First*, because we do not here undertake to inquire into the Truth of those Principles upon which each Man builds his System of natural Knowledge. *Secondly*, Because it is sufficient to our Purpose if the Experiments be only true, let People deduce them from such Causes, as they shall judge most consistent with their own Hypothesis: Forasmuch as no Body can pretend to prove from such Pores, such a Figure, such a Determination of Motion, such an attractive Force in the Parts of Matter (from which Principles most Causes are derived in this Age) whether it be possible that each of these are likewise to be found in others; and that the same Power which has adapted the first to these Properties, does likewise do the same in others, by changing them every time according as it shall judge it to be most serviceable to its great Ends and Purposes.

SECT. XIII. *Transition to another kind of Threefold Objections.*

I MIGHT have made an end here of the Proof of the Possibility of the Resurrection in the same *proper* Bodies, were it not that some Atheists pretend to defeat the same after other Manners: Namely, *First*, by unadmittable Consequences, which they think they can draw from thence. *Secondly*, By the Supposition of Things that are possible, which notwithstanding the Resurrection of the same Bodies, makes impossible according to their Notions. *Thirdly*, By comparing the Bible with itself (from whence all Christians prove the Certainty of their Resurrection) and by quoting such Texts out of it, which, as they would make us believe, seem to have very little Agreement with a Resurrection in the same Body. And I hope we shall not appear tedious to the Learned, if we still add something here to obviate these Difficulties, especially if we use no other Proofs therein, than such as are founded upon daily Experiments.

SECT. XIV. *Three Objections of the first Kind.*

THE *First* Consequence then, which they think must appear absurd and unadmittable to every one, is, That in case the Resurrection be made in the same *proper* Body, a Child dying soon after its Birth, will rise again likewise as a Child, and with an imperfect Body.

The *Second* is, That if any one whilst he is yet a Child, loses a Leg or an Arm, and lives afterwards some Years, and grows bigger, he must believe that when he dies, he shall rise again maim'd, and without Arm or Leg; or in case his Body be supply'd with those Limbs that are  
wanting,

wanting, they will be wholly disproportional to the rest.

The *Third* is, That if a Man is to rise with his *own* Body, it seems to them a necessary Consequence, that almost all Bodies will be entirely spent and wasted, and much smaller and lighter than they ought to be naturally at the Resurrection: Since most Men before they die, fall away so much through Sickness, and some are so exceedingly wasted by Consumptions, as to fall far short of that Weight and Size which belong to their Bodies in Health.

SECT. XV. *Objections of the second Kind.*

THE *Fourth* Thing which they Object, and which, tho' possible in itself, they think the Belief of Christians renders impossible, is the following: If a Canibal or Man-eater should live a Number of Years, and in all that time should use no other Food than human Flesh, it seems impossible to them that both the Canibal himself, and at the same time all that have been devoured by him, can rise again with their own perfect and proper Bodies.

SECT. XVI. *Objections of the third Sort from the Holy Scriptures.*

THE Objections which they themselves produce from the Holy Scriptures, are first, such Texts where express mention is made of a Resurrection in the same Body; as *Job* xix.  $\psi$  26, and 27. *Tho' after my Skin Worms destroy this Body, yet in my Flesh shall I see God, whom I shall see for my self, and mine Eyes shall behold, and not another.* And *Paul*, Rom. viii.  $\psi$  11. *He that raised up Christ from the Dead, shall also quicken your mortal Bodies;* as

also *Phil.* iii.  $\text{v}$  21. *Who shall change our vile Body, that it may be fashioned like unto his glorious Body.* We shall not repeat all the rest that are of the same Tenour.

Against these Texts they oppose some Expressions of the said Apostle, *1 Cor.* xv.  $\text{v}$  35, 36, 37, 38. which they think cannot be understood consistent with the former; for when before, he introduced an Objector using these Words,  $\text{v}$  35. *But some Men will say, how are the Dead raised up? and with what Body do they come?* He answered the same by a Comparison of a Grain of Corn,  $\text{v}$  36. *Thou Fool, that which thou sowest, is not quickened except it die,*  $\text{v}$  37. *And that which thou sowest, thou sowest not that Body that shall be, but bare Grain, it may chance of Wheat, or some other Grain,*  $\text{v}$  38. *But God giveth it a Body as it hath pleased him, and to every Seed his own Body.* From which Words therefore they conclude, that we shall not assume at the Resurrection the same Bodies which are put off at Death; but that they will be other, and different, and such as God gives according to his Pleasure. So that according to them, this Text seems to contradict the former, and likewise itself, because if a Man sows any Thing else than the Body that shall be, and that God gives to the thing sown, *a Body as it hath pleased him,* 'tis impossible in their Opinion to be the same Body of that Seed.

Besides this, some of 'em urge other Difficulties against *a Spiritual Body,*  $\text{v}$  44, and 46. and especially because in  $\text{v}$  50, it is said, *that Flesh and Blood cannot inherit the Kingdom of God.* This seems to them contradictory to the former Passages quoted from *Job.*

SECT. XVII. *Our Design here is not to describe the manner of the Resurrection, which we must leave to God.*

BEFORE I pass on to answer these Difficulties, I find myself obliged, for the Instruction of such Christians as may happen to read this, to premise :

I. THAT our View here is not to account for the manner of the Resurrection of the same Body, which great Mystery we must leave to the Wisdom and Power of GOD only; nor have we undertaken any Thing more, than to shew that such a Resurrection involves no Impossibility in it; and that the foregoing Objections raised by some Atheists, even from the Holy Scriptures, in order to sooth and quiet their own Consciences against the Terrors of this Resurrection, may be easily cleared up and removed, from what we find daily passing in the World by our own Experience.

SECT. XVIII. *A General Answer to all the Objections against a Resurrection, taken out of Scripture.*

II. To return a general Answer to all that these unhappy Cavillers, and deplorable Bible-readers (I mean such as only sift the Scriptures to discover Absurdities therein, as I have known some such) fancy they have found in that Holy Word, which they can neither reconcile with their own Notion, nor with other Texts that treat of this Resurrection. I say, nothing more is required to answer these People, than what we find to be expressly affirmed in the said Scriptures; namely, that in order to understand the true How, and other Circumstances of the Resurrection, we must according to the before-quoted Reply of our Lord to the *Saducees*, not only *know the Scriptures,*



but likewise the *Power of God*, if we would not *Err*.

SECT. XIX. *A bare Hypothesis is sufficient to shew the Possibility of any Thing.*

TO disarm the Atheists as much as possible of all their Evasions, it is necessary to add, that tho' what we should hereafter produce from natural Observations, could not be demonstrated to be strictly true, but were only a simple and naked Hypothesis; it would carry with it perfectly the same Weight and Force in this Matter. Since to prove the Possibility of any Thing, there ought not to be more required from him that asserts it, than only to find out an Hypothesis containing the Manner how it may come to pass, and which includes no Contradiction in it. I don't think that any Atheist will deny this, since it is own'd by the chiefest of their Sect. To begin then :

SECT. XX. *There is a Proper or Own, and a Visible Body.*

I. EVERY Man has besides his Soul, a *Body*, which for so far as it can be seen by all, we shall express by the Name of a *visible Body*.

II. THIS Body may be termed, in respect to those of other Men, one's *peculiar* or *particular Body*, since a Man is thereby distinguish'd from others, and it is the Composition of this particular Person, and no other.

III. BUT since this *visible* and *particular Body* does undergo very many Changes, and according to the Difference of Years, and to the good or bad Constitution of a Man; and otherwise, becomes

comes smaller and greater, leaner and fatter, lighter and heavier; and that it is even possible that one and the same Matter may now belong to the visible Body of one Man, and afterwards to that of another; as for Instance, if the Blood of one Man, by a Wound or otherwise, should be spilt upon the Earth, the Matter of it might serve to feed some Plant or Fruit, which being afterwards eaten by another, contributes to the Increase of his *visible* Body: And since, notwithstanding all these Changes, every *visible* Body does still remain the Body of the same Person, it is apparent that there must be something in the *visible* Body which undergoes so many Changes, from whence it has a Right to be always denominated the *own* Body of the same Person; which Term we shall likewise make use of in the following Discourse, in order to make a Distinction between the *own* and *visible* Body of every Person.

IV. AND thus it is plain, from what has been said, that there is an essential Difference between the *own* and *visible* Body of a Person; since many Parts of the last can be joined to, and separated from it, and even belong to more visible Bodies than one; but the *own* Body remains fix'd and determined to one and the same Person only.

SECT. XXI. *This Distinction is acknowledged by all.*

V. AND that none may think that this Distinction between a *visible* and an *own* Body is invented by us, and has no Foundation in Truth; it is known that if one says of a Man, *that he weighs 200 lb.* nothing else is understood thereby, than that it is his *visible* Body which is of that Weight; but if one says, *that such a Man is 80 Years old*, it can only be meant of the *own* Body, since all the

Food that he has used in the last 10, 20, or 30 Years of his Life cannot be said to have appertained to his *visible* Body the whole Space of 80 Years.

SECT. XXII. *The visible Body consists of Fluid and of Solid Parts, and of Laws.*

VI. NOW to inquire wherein this *own* and *visible* Body does determinately consist, it must be confess'd, first, that this *own* Body which helps to compose the Person, is not the *visible* Body wholly and solely; See [Numb. IV.] it must therefore be contained within the *visible* Body.

VII. THIS *visible* Body consists:

*First*, Of *Fluid Substances*, as Blood, Whey, *Lympha*, Chyle, and Milk in Women that give suck, and Water in which the Embryo lies in those that are pregnant; various Kinds of Glandular Juices from the *Pancreas*, the Glands of the Stomach and Intestines, Gall, Spittle, Sweat and perspiring Matter, Tears, Snot, Nervous Juice, and others, that have yet no particular Name; to which some add Fat, the bitter Matter in the Ears, that in the Seminal Vessels, and the like, tho' they are something thicker than Liquors or Fluids.

*Secondly*, Of *Solid Matters*, Flesh, Bones, Nerves, Membranes, the Teeth, &c. The modern Inquirers reduce them all to Bones and Nerves, as we have observed already in *Contemplation XI. Sect. 17.*

*Thirdly*, Each *visible* Body, whilst it is alive, has its particular Laws; thus there are Laws in human Bodies, according to which are regulated the Consumption or Digestion of the Food in the Stomach, the Separation of the Chyle from the grosser or excrementitious Matters, the Sanguification

cation or Conversion into Blood, the Separation of the Humours, the Motion and Nutrition whereby the said Blood is turned here into Bones, there into Nerves and Tendons, in another Place into Membranes, &c. besides Generation and Production. According to these Laws, we see, that when a Piece of Bread is eaten by a Man, a Dog, a Fowl and a Carp; in the three first it is turned into different kinds of Flesh, in the last it becomes Fish; and the same Food makes a white Skin in an *European*, and a black one in a *Moor*, as it makes one Man fat and another Man lean; and we find that Children using the same Food, are subject to the same Laws; that the Stomach of one digests with Ease and Pleasure one kind of Food, as the Stomach of others does another.

SECT. XXIII. *The own Body consists, in a manner, of no Fluid Parts, nor of Laws, but almost only of solid Parts.*

VIII. So then the *own* Body of a Man must consist of one or more of these three, *Fluids, Solids* and *Laws*.

It does not seem to consist of the *Fluids*, since many of them are changed, become more or less, and may be entirely separated from the Body, whilst at the same Time it shall remain the proper and *own* Body of the same Person: Thus the Blood daily diminishes by the Separation of Humours, and by Perspiration, and is as daily increased by a new Chyle; not to mention great Effusions of Blood both in Men and Women; of the last of whom, I knew one who in a few Years had lost much more Blood than the Weight of her whole Body was equal to; now whether it was a Blood consisting of this or that Matter that

flowed thro' her Veins, her Body remained unquestionably the same proper Body.

Now since the Blood does not belong essentially to the *proper* Body, neither can all the Humours that are separated from it, be counted to belong to the same, forasmuch as they are daily changed; thus Fat is diminished by Leanness, and other Fluids by other Means, from thence we may conclude, that hardly any, at least very little of the Fluids, are necessary to the Composition of what we call the *own* Body.

IX. Now that the Laws likewise do not belong essentially to the *own* Body, is apparent; *First*, Because the same are frequently changed in the same Men, whilst they remain in the same Persons: Thus Experience teaches us, that sick and healthy People, young and old, are not subject to the same Laws, which holds true both in Men and Women. *Secondly*, The same may be infer'd, not only because the Body is material, and the Laws do only consist in certain Motions and Properties, but particularly (which puts the thing past all doubt) because a dead *visible* Body, in which it cannot be said, that these Laws do any longer prevail, is as much esteemed to comprehend the *own* Body of the deceased Person, as when it was living.

X. LASTLY, Since it plainly appears, from all that has been said, that a Body may still continue the *own* proper Body of the Person, tho' filled with Humours and Juices quite different from those it once had, and that such Fluids may be likewise moved by quite different Laws, but even those Laws may also entirely cease when the Body is dead; we must therefore only seek for this  
proper

proper *own* Body in the simple and naked *solid* Parts thereof.

SECT. XXIV. *The own Body consists either of a Stamen or Principle unfolded only; or else of a Stamen, that grows and increases by the Addition of Foreign Particles.*

VIII. Now to treat more closely of these *solid* Parts.

It is very well known to those that are versed in the Inquiries of the present Age, that as the Plants and Animals, so likewise Man does consist of a first Principle or *Stamen*, which may therefore be denominated the *own* Body, or at least something that contains the same; as has been already shewn in the XVIth *Contemplation*.

The Parts of this *Stamen* are in the Growth of it, and from time to time expanded, or unfolded, and cloathed as it were, and filled up with other Particles continually, till the visible Body of a bigger, and at least of a full grown Creature, results from it.

Now since this *Stamen*, during the Growth of a Body, is clad and stuffed with other Matter in and about it, and since it contains all the solid Parts of the Body in Proportion to its Bigness, either this simple expanded *Stamen*, without any other adventitious Matter, must be admitted and allowed to be the *own* Body, or else the same *Stamen* filled and cloathed with that Matter, which afterwards becomes Bones, Flesh, Ligaments, Membranes, &c. so far as those compose the solid Parts of a Body, must be reckon'd the *own* Body; one of these is certainly true.

We shall therefore, in both these Cases, one of which must needs be admitted, endeavour to solve the Objections of Atheists; and first, those which they

they are used to bring from Nature, and next from the Holy Scriptures.

**SECT. XXV.** *How a Man may be said to rise again with his own proper Body, in the first Case.*

**IX.** IF it be supposed that the bare *Stamen*, expanded according to the Bigness of the Body, without the Accession of any other Matter to fill and cloath the same, be the *own Body*, and which is to continue so in all Men from their Birth to their Death; there will be nothing more required, that such a Person should rise with his *own Body*, than that only this *Stamen*, separately from the Particles that cloath and fill the Body, should remain, and be continued in its own little Substance, and that the great Author of our Resurrection, should, after Death, unfold, fill and cloath the same into a visible Body, with the same Matter that belonged to it before, and in its Lifetime, when it was a visible Body; or else with such other Matter as he shall be pleased to use. We shall not speak of the altered or changed Properties and Faculties, since they do not affect the Matter thereof, nor do change the *own Body* as to its Essence; but refer it to the Word of God, touching the same.

**SECT. XXVI.** *The own Body, tho' filled with other Matters, remains the own proper Body of the same Person.*

**X.** BEFORE we proceed any farther, let me add two Things that may obviate all Objections against what has been lately said.

*First*, That an *own Body*, tho' filled and cloathed into a *visible Body* with other Matter that never belonged to it, does nevertheless remain the

*own proper* Body of the same Person; nor does this want much Proof, since any one that has fallen away by Sicknefs or Pain, if after his Recovery he becomes bigger and fatter, and for that Purpose has used Food that was never any part of his own Body, will always be reckon'd to have been the same Person, and consequently to have been alter'd by becoming fo much more *visibly* bigger and fatter.

SECT. XXVII. *When any one dies, a great deal of that Matter which belonged to the visible Body, will be separated therefrom.*

XI. *Secondly*, That when a Man has lived some Years, a great Quantity of that Matter which belonged to his *visible* Body, may be separated from it, and he still remain the same Person; inso- much that the *own* Body undergoes no Change by the Loss or Accession of such Matter that helpt to make it a *visible* Body.

To prove this, Let us again suppose a Man that is 80 Years old, and that weighs 160 Pounds, and who, reckoning one Day with another, after Breakfast, Dinner, and Supper, unites but one Ounce every Day of the Food he uses, to the fluid and solid Parts of his Body, in order to repair what he loses by Perspiration, and other Ways; according to which, without reckoning the Weight of his whole Body as soon as he was born, there would be 80 times 365, which is 29,200 Ounces, or 1825 Pounds of nutritious Matter, that has gone towards the Composition of his *visible* Body in the Space of 80 Years; from which if we substract those 160 Pounds, there will still remain 1665 Pounds, which during his Life-time, when they were at first nothing but Wheat, Rye, Fish, Flesh, &c. did not belong to  
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his Body, but were quite foreign to it, and might have as well have gone towards the Composition of any other Man's *visible* Body, as of his; and which afterwards have served to nourish his *visible* Body for some Time, and finally have been separated again from it; in all which Cases none can deny that it has been the same Person, and therefore always preserved his own Body, from which, what has been said before is sufficiently demonstrated.

SECT. XXVIII. *The three Objections of Sect. XIV. answer'd, in case the own Body consists of a bare Stamen.*

XII. Now to return a particular Answer to the particular Objections started by the Atheists, *Sect. XIV. and XV.* and which they pretend to raise from Nature, upon this Foundation, that the bare *Stamen* does only remain the *own* Body, and is only expanded or unfolded from itself into a larger Size, by extending the Parts of it farther from each other (of which an Example may be seen in the *XVIIth Contemplation*) there is no need of any other Argument than the following:

If a Child were to rise again as a Child in its *own* Body, the Matter of its *Stamen* need only be preserved and be again filled up at the Resurrection by other or by the same Particles by which it had been increased before.

If a Person is to be raised as full grown, the aforesaid *Stamen* needs only to be expanded after the same manner as it would have been in the Life-time, and then filled up and cloathed with Matter, which, when it remained alive, and increased in Bulk, would have served for filling up the same; in which Case, every one must acknowledge, that the same Person would have risen again in his *own proper* Body.

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The same may likewise be said, if any one that is now a Man, and had lost a Leg or an Arm in his Childhood, should die; for here it is only requisite, that that Part of the *Stamen* which was to compose the Arm or Leg, should be expanded, filled up, and cloathed, in Proportion to the bigger Body, as has been shewn before concerning the smaller.

Moreover, if any one dies lean and wasted, and at the *Resurrection* his Body is filled with Matter, which did either never belong to him, or otherwise, with such as had before filled up his *own* to a *visible* Body, why should he, at the *Resurrection*, be less accounted the same Person, and be reckoned less to enjoy his *own* Body, than *Job* is said to remain the same *Job*, and to have retained his *own* Body, as well, when by the Goodness of GOD he was restored to his former Strength and Health, as when he was so wasted, as to be able to say of himself, *Chap. xix. v. 20. My Bone cleaveth to my Skin and to my Flesh, and I am escaped with the Skin of my Teeth?* Now it is very probable, that that which render'd his *visible* Body bigger and heavier after his Recovery, consisted of such Food and Matter as did not before belong to the same.

SECT. XXIX. *The Objection in Sect. XV. answer'd upon the same Foundation.*

XIII. FINALLY, if now even a *Canibal* had, during his whole Life, fed upon nothing but the Matter of the *visible* Bodies of Men, and it had only pleased GOD to hinder that the *Stamina* of all those whom he had devoured should have been converted into Food, but that they should have passed thro' his Body, with other excrementitious Matter; what Impossibility is there that the particular

ticular *Stamen* of each Person (which we here suppose to be the *own proper* Body) should be separated from thence, and filled up again by other proper Matter, or, it may be, by some that had served the same Purposes before, as well as other dead Bodies. For it has been already shewn, in *Numb. XIV.* that when a Person dies after some Years, there are always a great Number of Particles separated from his Body, at the Time of Death, which had served before to the filling up of a *visible* Body.

Thus likewise may the *Stamen* of the *Canibal* himself remain alone, without any of its expanding Fluids, and be filled up with others at the *Resurrection*, and he accordingly may rise likewise in his *own* Body. For who can deny that any Man, for Instance, that has lived twenty Years upon human Flesh, and after that, fifty Years more upon Bread, does not, in both these Cases, retain his *own* Body? For which Reason the proper Body of any Person does remain the same *proper* and *own* Body, tho' filled up with other Fluids. See *Sect. XXVI.*

**SECT. XXX.** *The visible Body of a Man may be very much emaciated, and yet remain his visible and own Body.*

XIV. Now to pass on to the second Thing mention'd in *Sect. XXIV.* and to solve the Objections of the Atheists by this other Principle, that the *own* Body of a Man does not only consist of the simple *Stamen*, but does moreover always comprehend some of the filling and cloathing Matters which adhere to the said *Stamen*, altho' what has been already mention'd be sufficient to demonstrate the Possibility of a Resurrection in  
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the *own* Body, against all Atheistical Evasions whatsoever.

Let me here premise, that it is experimentally known to many, that the *visible* Body of a Man may be extremely emaciated, or become very lean, and yet remain his *own*, and likewise his *visible* Body. Accordingly two Instances, among many others, do particularly recur to my Mind; the first was of a Person who had before been very Musculous and Fleshy, but was, without any visible Fever, so exceedingly reduc'd by a *Marasmus* or *Leanness*, that his Legs and Arms, and all his Body besides, appear'd to them that saw and felt him, to be nothing but Bones, or a living Skeleton; his Skin was all over blackish, and very hard, cleaving almost inseparably to the Bones; nor could we externally discover the least Softness of any Muscles, of which, notwithstanding, the solid Parts remained under the Skin.

The Second, who was likewise before a very corpulent and fat Man, upon the bursting of three Vessels in the Lungs, call'd by the Anatomists *Vomicæ Pulmonum* (from the least of which, there proceeded by Coughing and Retching as much Matter as would fill half a common Basin, and from the biggest much more, in less than an Hour's time) was in a little while reduced to such a Leanness, that his Flesh was quite wasted; and the same was attended likewise with a continual Cough, which lasted even a great while after he was asleep. Notwithstanding which, both these Persons afterwards recovered their Health to such a Degree, that the first of 'em was again plump and fleshy, and the other grew extremely fat. I have related both these Histories, because no Body ever question'd, nor can it at all be doubted, that these Men, in both these so different Cases, were the same Persons, and that  
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their Fat as well as their lean Bodies might and ought to be denominated their *visible* and *own* Bodies.

SECT. XXXI. *The own Body, tho' allowed to be a Stamen, with an Accretion of foreign Matter, consists of nothing else but of solid Particles, and chiefly of Bones.*

XV. BEFORE we proceed, it must be here again observ'd, that the *own* Body of a Man, tho' consisting of a *Stamen*, increased with other Matters, is, as has been already hinted, only composed of *Solid* Parts; forasmuch as the *Fluids* and the *Laws* are daily changed, and the last of 'em do entirely cease at the Time of our Death.

Moreover, since a *visible* Body, tho' reduced to such a Leanness as we have just now shewn, may continue to be the *visible* Body, having never been entirely deprived of its *Fluids* during its Leanness, the *own* Body must be still less in Matter than the emaciated *visible* Body.

Finally, that this *own* Body does consequently consist of nothing else but Bones and Nerves, of which likewise the Membranes, and of them the Tubes of the Flesh are composed, (*See Contemplation XI. Sect. XVII.*) and the said Flesh, when the Blood and Humours are separated from it, is so very small a Part of the *visible* Body, that it can hardly be seen, nor even felt externally in the greatest Leanness; so that from hence it appears, that the real *own* Body does chiefly consist of mere Bones.

SECT. XXXII. *The three Objections mentioned in Sect. XIV. solved upon the Supposition, that the own Body does consist of a Stamen increased to a certain Bigness.*

XVI. Now in order to solve the former Objections likewise from this Second Principle, of which mention has been made in Sect. XXIV. Suppose a Child to die, if it be to be raised again as a Child, it is unquestionable that it puts off by Death its *own* Body in the *visible* one.

If it be to rise as a full grown Person, it is certain that no Atheist can deny, but that this *own* Body of the Child would have been filled up and cloathed with other Matter that never belonged to the same, if the Child had lived to Man's Estate, and yet it would have remain'd the *own* Body of this Person. Now in case the Body of such a Child should at its Resurrection be increased with the same Matter which would have been made use of if it had remain'd living; what Reason can there be to affirm, that such a grown Body would not have been the Child's *own* Body in the one Case as much as in the other?

The same Thing may likewise be apply'd to a Person, that in his Youth has lost a Leg, or an Arm, or any other Member; as likewise to those Objections, that most Men must rise again with meagre and wasted Bodies. Forasmuch as we have shewn above, Sect. XXX. that not only a Body almost utterly emaciated, but also in the Case of *Job*, the same Body fill'd with other Fluids (such as never belonged to it before) may remain the *visible* Body of the same Person; and no Reason can be given, why that which happens at the Resurrection to a Body emaciated by Sickness, may not likewise be apply'd to a Body

fill'd with Parts that render it much more beautiful, and denominate it the *own* and *visible* Body of the same Person; the rather, since such a Repletion or Increase may likewise be made with such a Matter, which even had served before to the filling up of the same Body in its Life-time; of which, at the Resurrection, there will be at hand a great Quantity, and more than is necessary. See *Seçt.* XXVII.

SECT. XXXIII. *The Objections of Seçt. XV. answer'd from the said Principles.*

XVII. FINALLY, to return an Answer to the Difficulty which these deplorable Philosophers think impossible to be solv'd, and which they fetch from the Example of a *Canibal*, who was supposed to have devour'd a great many Men, and to have used no other Food: These Gentlemen are desired to observe in the first Place, that the Foundation of their Mistake consists herein, *viz.* That the Body of such a Man-eater can be nourish'd as well by the *own* as *visible* Body of one or more Persons, the contrary whereof is true.

To prove this, can a *Canibal* support his Life (not to speak of his Health) wherewith, if nothing but such emaciated Bodies as we have described above, were allowed him for Food? Can he likewise eat Bones that are withered to a greater Degree even than those that are dried in the Sun? Can he be nourished with Nerves and Membranes entirely and perfectly divested of all their Juices? For a *visible* Body, though never so much emaciated, can yet be in no Sense esteemed an *own* Body, as long as there are any Fluids therein, as we have shewn above, *Seçt.* XXII. and XXIII.

On the contrary, daily Experience teaches us, that what we make use of for Food does belong only to the *visible* Body of an Animal, and the Fluids that are therein. Thus we know that the Gravy of Roast Meat, and the Soup of that which is down boiled, yields a very hearty Nourishment, but that the solid Particles belonging to those Bodies upon which we feed, are separated from the Nutritious Juices, and pass off through the Body.

To conclude; Since now the *own* Body must be considered abstractly from any Humours and Juices, and since all that serves for the Food and Nourishment of a Man-eater, must only be divided from the *visible* Body of the Person devoured; it is plain, that altho' a *Canibal* had devoured hundreds of *visible* Bodies of other Men, it would likewise happen, according to the common Course of Nature, that the solid Particles divested of all their Juices, or the *own* Bodies of the devoured Person, would be discharged, or cast out unmingled with those of the Devourer; and consequently that each of them might appear separate and entire at the Time of its *Resurrection*.

SECT. XXXIV. *Convictions from all the foregoing Objections.*

XVIII. Now let an unhappy Atheist ask himself seriously, and in his Retirement, whether all these Objections which he is wont to fetch from Nature, can secure him against the Possibility of a *Resurrection* so much dreaded by him? And if he argues without a Resolution of not believing the same, whether these studied Evasions can free his Mind from the continual Terrors that must unavoidably follow the least Reflections of an



approaching Resurrection, and the Considerations of appearing before the Judgment-Seat of that Just and Almighty GOD, whom he has so frequently, and so unworthily Blasphemed?



## CONTEMPLATION XXIX.

### *Of Unknown Things.*

#### SECT. I. *Transition to Unknown Things.*

SINCE we have endeavoured in the foregoing Contemplations, to shew from a very small part of what is known to us both in the great and little World (and we hope likewise with unquestionable Success) that there is such a Being as a Wise, Mighty, and Gracious GOD; we might here put an end to this Work, were it not that even in those Things which are still unknown, and which, perhaps, will remain for ever unknown to all Men, there did not seem to remain some Proofs great and strong enough to bring unhappy Atheists to a better Mind.

#### SECT. II. *That there are many Things still unknown.*

IT will not be very necessary to use many Arguments to prove, that there are an unexpressible Number of Things in the Visible World, as yet unknown to all Men. The different Opinions which prevail among the greatest and most learned Men, about the Causes of the same Appearances, prove this Assertion plain enough; and one might

might well judge a Man very uncharitable, who when any one among those Learned Men had proved properly and experimentally the Truth of his Opinions, should think of all the rest, that they could be so unreasonable as to refuse to comprehend, or so stupid as not to be able to comprehend this Truth: At least this is certain, that if there be three Persons of different Opinions, two of them, and it may be all three, know nothing of the Matter. And, not to repeat here the Confessions which great and famous Mathematicians have made of their Ignorance of many Things, with a generous Self-Denial (of which one may see one Example in the thirteenth *Hydrostatical Proposition* of Dr. Wallis, and another in the eighteenth *Optical Lecture* of Dr. Barrow, *See* Sect. 13.) let the proudest and most self-conceited Atheist tell us, whether there is any real particular thing, such as *the smallest Leaf of Grass*, or *the most contemptible Insect*, that are perfectly known to him; and concerning which numberless Questions might be proposed to him, whereof he would be scarce able to answer any; at least, could he tell us concerning one of those, or any other material Being, how the smallest and original Particles thereof are formed, how disposed, how moved, and what sort of Pores or Interstices they make with one another? And even, not to go so far, could he with all his Wisdom be able to say, how a thing would appear through a good Microscope, unless he had taken the Pains before to examine the same? And after all, since there are so many Things which are quite out of the reach of the nicest Inquiry, one may easily conclude, that in each of them there is a great deal that is wholly unknown to him. But this may suffice here, since I cannot imagine that there is any Body who would pass for wise or reasonable, that

will not readily own, *there are many Things of which he is entirely ignorant.*

SECT. III. *Atheistical Objections answered.*

I KNOW very well, that among these unhappy Men there are some, who to elude the Proofs of a Wise GOD (the very Thoughts of which are dreadful to them) endeavour to screen themselves against the Reproaches of their convinced Minds behind these unknown Things, saying, That if there be still so much unknown, how can we extol the Wisdom of a Great Creator, which can only manifest itself in the Things that are known? To answer which, before we proceed any farther, and for the Satisfaction of such as may stumble thereat, we affirm, *First*, That the Wisdom and Skill of an Artificer is not so much displayed by the Number of Things he has made, as by the Contrivance and Workmanship that appears in each of them. For Instance, need we desire to see any more than one Watch well made and skilfully put together, to judge of the Knowledge of the Maker? And if we see but one compleat Picture of a Painter, will it not be sufficient to acknowledge him to be a great Master? Now if this be true, as it cannot be contradicted, I leave it even to the Atheist himself, whether he must not own, that in the foregoing Discourses not one, but very many Instances have been produced, of a Wisdom that governs the World; and consequently, altho' there be an infinite Number of Things still unknown, whether those which we now know are not abundantly sufficient to demonstrate the Wisdom of their Maker: The rather, since that in knowing all these Things, we know a great deal in respect of others that have never inquired into, nor read the Discoveries in Natural  
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Philosophy ; which, however, is very little, in Comparison of what remains to be still known.

*Secondly,* These Objectors must be told, that a Man may be entirely ignorant of the Structure of a Machine, and of the Manner how it is put together, and yet not be the less satisfied of the Art and Wisdom of him that framed it ; especially when one sees that it is accurately and nicely adapted to perform some great and useful Design. For can any Body observe a good Microscope, consisting of two or three Glasses, so wonderfully contrived for viewing the very smallest Objects ; or a noble Telescope, made use of for the clear and distinct contemplating the Heavenly Bodies, so vastly distant from us, and consequently invisible to our naked Eyes ; or a fine Clock, shewing the Days, Hours and Minutes, and endued with several other Motions, and yet persuade himself, that all these were made without any Skill or Contrivance, only because the Structure and Disposition of them are unknown to him ?

SECT. IV. *Unknown Things, tho' in themselves not conceivable, do yet prove the Greatness of God.*

IF now it be obvious to every one, that from what has been said about Unknown Things, even Reason will teach us that God may be magnified thereby ; the Wisdom of his Holy Word, tho' it were not allowed to be Divine, does likewise appear as plain from thence ; not only because it does not make use of any Philosophical or Mathematical Demonstrations to prove the Power, Wisdom and Goodness of God ; but particularly, because it makes use of Things that are unknown to Men, and even unscrutable, in order to convince us of the infinite Perfections of God, of the Mean-

ness and Vileness of Man, and to shew the Reasons that we all have to praise Him and admire his Glory.

To give an Instance thereof, Whether we suppose the World and all material Beings in it, to have been produced in the Beginning by the commanding Word of an Adorable Creator, as is confessed by Christians; or whether, according to the Hypotheses of unhappy Atheists (for higher than an Hypothesis they cannot pretend to go) it should be admitted, that if not the Form, yet the Matter of the World is Eternal: This at least will unquestionably result from each of those Hypotheses, that all the Particles of which all human Bodies are composed, have existed as long as the World, or as long as all Matter itself.

Now then no Body can deny (because it appears too plain by Experience) that all the Parts of our Bodies did at first exist in the Food that has been made use of for the Growth and Increase thereof, and consequently in Wheat, Rye, Barley, Rice, as also in the Flesh of Oxen, Sheep, all kind of Fowls and Fishes, in the Fruits of all Trees and Plants, and, in one Word, in everything that serves to support the Life of Man. Consequently that they were likewise to be found in every thing from whence such Plants and Animals have been produced, that is to say, in Earth, Water and Air; and thus tracing them still backwards, we meet with them in every thing whereof this very Earth, Water and Air consists, namely of corrupted and putrified, burnt and consumed Bodies. So that if we go back from one thing to another, and follow this Thread to the Beginning of the visible World, must not every one that seriously considers the same, be convinced, that his Body, and all the Parts of which it at present consists, have incessantly passed from one  
Mixture

Mixture and Composition to another, for as many Ages as the World has lasted; so that these our Hands and Feet, and all the Limbs we now possess, have, with respect to their original constituent Particles, been dispersed and scattered thro' infinitely different Places for Thousands of Years past, growing in Plants upon the Ground, walking with Cattle in Meadows, flying with Birds in the Air, swimming with Fishes in the Water, and plowed up in the Furrows of the Earth. And since Water and Air likewise do bear a part in the Composition of our Bodies, the Particles thereof which are now mixed with our own Flesh, have been exhaled out of Rivers, have ascended in Vapours, and descended in Rain, Hail and Snow, have been kindled in Lightning, and other Meteors, have been scatter'd in Storms, and waded backwards and forwards to all Parts of the World by the Winds; and thus in numberless Places, at numberless Times, and after numberless Manners, have undergone numberless Compositions and Mixtures, till they have been finally collected and become the constituent Parts of these our Bodies.

Now tho' nothing of all this implies any Infinity, or any Incomprehensibility; yet the most self-conceited Atheist must acknowledge, that neither he, nor any one else can ever be able to trace this his Genealogy or Pedigree; nor to say in what Figure, in what Structure, or in what Places the Parts of his present Body have resided from the Beginning of the World; and that a greater Knowledge than that of all Men living, is requisite to return a proper Answer to this Question.

And the Almighty seems to have proposed much the like Question to *Job*, to convince him in the strongest manner of the Divine Glory and Greatness,

Greatness, and of his own Vileness and Nothingness, in the following Words: *Where wast thou when I laid the Foundations of the Earth? Declare, if thou hast Understanding,* Ch. xxxviii. *vs* 4.

After the same Manner we find King *David* taking an Occasion to praise God, and to acknowledge his Works to be wonderful, from the Things that were unknown to him, but manifest to God alone. For after having confessed his own Ignorance, and extolled the infinite Knowledge of God in these Words of the CXXXIXth Psalm, *vs* 6. *Such Knowledge is too wonderful for me; it is high, I cannot attain unto it;* he continues to say, in the 14th and following Verses, *I will praise thee, for I am fearfully and wonderfully made.* And, as if he did not thereby sufficiently acknowledge his own Ignorance, he adds, *Marvellous are thy Works, and that my Soul knoweth right well. My Substance (otherwise my Bones or Strength) was not hid from thee when I was made in secret, and curiously wrought in the lowest Parts of the Earth. Thine Eyes did see my Substance, yet being imperfect, and in thy Book all my Members were written, which in Continuance were fashioned, when as yet there was none of them.*

I should not have repeated these Things here, having had occasion to speak of them more than once already, were it not that we find much the same Expressions about the Existence of a human Body, as are analogous and uniform to the various Observations and Discoveries of the greatest Naturalists of our Age: And that an Infidel may be fully convinced thereof, let him only read what the great *Harvey* writes thereupon, *Exerc. 56. de Ord. Part. in Gen.*

We shall find in the aforesaid Treatise, that even in the second Month, the whole Frame of the little Embryo is of such a sort of inconsistent Substance, that it cannot be touched without it be laid in Water. Let then the Atheist consider, whether

whether King *David* had not Reason to say, that *he was fearfully made*? And would he not be frightened, in seeing how easily his precious Body, and the tender Limbs thereof may be squeez'd to Pieces, or turned to a mishapen Creature, even by the Motion of the Mother's Bowels, and other Causes?

*Secondly*, The aforesaid Prophet says also, that he is *wonderfully made*; and after the same manner we hear the famous Philosopher *Harvey* expressing himself with Amazement, *Mirum dictu*, or, 'tis wonderful to say it, how far the *Embryo* or Fruit is in the fourth Month advanced in Bigness, being grown from the length of an Inch to a Span.

*Thirdly*, The Psalmist of *Israel*, who names his first Beginning *an imperfect Substance*, could hardly express this with more emphatical Words than the abovementioned Author, when he tells us, that in the third Month the little Limbs begin to appear; but he adds, *Rudi tamen formâ*; that is, in a rough or irregular Form; in-somuch that even the Muscles could not be then distinguished, tho' the Flesh, or greatest part of the Body be compos'd thereof. And when he proceeds to describe an *Embryo* four Months old, he says, that the Head of it was very large, the Face without Lips, Cheeks, or Nose: that the Mouth was likewise very large, and the Tongue visible therein, but the Eyes were small but without Eyelids; that the Flesh of the Forehead, which covered the whole Crown was not yet cartilaginous, far short of having acquired the Consistence of Bones. Now what Atheist can say, that the Holy Scriptures do without Reason compare the Origine of all Men to an *imperfect Substance*? The rather, if we add thereto what Mr. *Dodart* says in the *History of the Academy of Sciences*, 1701, p. 26. *It is plain, that a Fœtus has*  
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very different Proportions from those of a grown Person; and that if the Limbs of a Man were made accordingly, they would be quite monstrous, and hardly pass for human.

Lastly, These Expressions, *In thy Book all my Members were written, which in continuance were fashioned, when as yet there was none them*, Ps. cxxxix. v 16. do shew how well known to him that inspired the Holy Penmen, were these daily Changes of a *Fœtus*, after the same manner as they have been observed in our Ages by the aforesaid *Harvey* and *Malpighi*, and as they have been described in *Birds* by the latter from Day to Day.

To conclude then; Let an Atheist consider, from the few Passages here quoted, and from a great deal more, that he will find in the above-mentioned Authors, how much is unknown to him of his own Formation, and how exceedingly he is beholden to that great Wisdom and Power which expanded him from the little *Stamen* and *Clew* in which he was roll'd, first to an imperfect Substance, and afterwards to such a noble and well-contrived Body, without the least Knowledge or Concurrence on his own Part.

After these two Instances, we should pass on to something else, did we not think it might be of some use to those Philosophers who mean well, and do even read their Bibles with Reverence, to shew them a Mistake into which they fall, by depending more upon the Hypotheses they have learnt from their Masters, than upon true Experiments, and are accordingly persuaded, that many of those Things which the Holy Writ, to represent the Praise and Glory of the great Creator and Governour of the World, places among those that are *unknown*, are now discover'd and thoroughly known in our Days; and consequently, that some at least of the Questions proposed by *Job*, which  
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by Reason of the slender Knowledge of the Naturalists who lived in those Ages, were really great Mysteries and Secrets then, are yet easily accounted for by the Moderns.

Thus the Question of *Elibu* to *Job*, Ch. xxxvii. v 17. (*How thy Garments are worn, when he quieteth the Earth by the South Wind?*) did not appear proper to a serious and learned Divine of my Acquaintance, because he thought with most of the Philosophers of this Age, he was able to prove, that the Warmth of the Air (which, as several other great Commentators, he understood to be here meant) was only to be ascribed to the Operations and perpendicular Descent of the Sun-Beams.

But to convince all those who are of the same Opinion, as indeed it is the common Opinion of many Naturalists, of the great Wisdom of the Author of this Expression, and to let them see how much there remains still *unknown* in this Phenomenon, let them only take the Trouble of perusing what that eminent Inquirer into the Secrets of Nature, Dr. *Halley*, (as we find it in the Transactions of the *Royal Society*) writes very accurately and mathematically, about the Warmth which is produced by the Sun only in several Parts of the World; and how justly he says, that he knows no Reason why the Day, which is 24 Hours long under the North-Pole, at the time when the Sun is in the Tropic of *Cancer*, should not be as hot there as it is to the People who live under the Equinox, when the Sun is directly over their Heads? Forasmuch as by an exact Calculation, which he there makes, p. 333. he finds, that the Heat of each Day being reckon'd together, the Day under the *Pole* does as much exceed that of the *Equinox*, as 5 does 4.

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They who please, may read the said Calculation demonstrated by him. It is sufficient for us to have proved, that principal Philosophers are likewise convinced, that a greater or lesser Heat is not to be imputed to a greater or lesser Height or Proximity of the Sun only.

And that the most famous Mathematicians, and greatest Genius's, have not been ashamed freely to acknowledge their Ignorance of the true Causes of this Heat, may appear from *the History of the French Academy of Sciences*, An. 1705. p. 49, and 50, where we meet with a circumstantial Account, that the People of *Montpelier* felt so violent a Heat on the 30<sup>th</sup> of *July*, that none of 'em ever remembered the like: The Air was as warm as if it came out of the Furnace of a Glass-House, nor could they be cool any where but in their Cellars. All the Thermometers or Weather-Glasses which had been made by Mr. *Hubin*, burst in Pieces, and others represented such a Degree of Heat as was sufficient for melting Fat or Suet. Most of the Vines were set on Fire that Day, which was never known before in that Countrey. That on the 30<sup>th</sup> of *August* the Heat was yet greater at *Paris*, and the Thermometer of *Monf. Cassini* broke about Two o'Clock, tho' it had lasted 36 Years; an Argument that the Air of *Paris* had never been so heated in all that Time. After all which, the Historian goes on in these emphatical Words: *Who would not have imagined that in the great Heat of this Summer, the Burning-Glass of the Palace-Royal should have produced greater Effects than at any other Time? And yet it fell out quite contrary; and certainly (which is well worth observing) one would not have judged so, by any System of Philosophy.* *Monf. Homberg* did likewise observe, that the Sun-Beams being collected by the said Burning-Glass, exerted little or no extraordinary Strength

Strength, at the very Time when those which came directly down from the Sun, dispersed as they were, did in a Manner inflame the whole Region of Air.

Now I leave every Man to judge whether any plainer Confession is to be expected from such learned Men, from whence to conclude, that the just and perfect Cause of the Warmth of the Air is as yet unknown to us.

I shall not here repeat the Opinions of the said *Monf. Homberg*, which he himself does not pretend to be more than Conjectures. And the very Experiment that is there subjoin'd, and which seems to have some Analogy with this *surprizing Phenomenon* (as it is there expressly named) is not even less wonderful hitherto. For it shews that a Chafing-Dish filled with burning Coals, and placed between the *Focus* and the Glass, in such a manner that the reflected Rays are obliged to pass thro' the Evaporations of those glowing Coals, the Action of the said Glass were notably weaken'd thereby.

They who are desirous to see more of the amazing Properties of the Augmentation and Diminution of the Force of this Burning-Glass, and such as the best Naturalist would be unable, perhaps, to deduce from his own Principles, if his Observations did not verify the same, may consult the above-mention'd Place.

We might produce several other Experiments in further Confirmation of what we have advanced. To be inform'd of one of them, we need only consult the 2d and 11th Proposition of the XXVIth Chapter of the 2d Book of *Varennius's* Geography, where he says, That in the *Torrid Zone*, which lies between the Tropicks, the Seasons of the Year are entirely different from what we should expect from the Course of the Sun ;

Sun; so that in some Places 'tis *Winter* when the Sun is vertical, or just over their Heads, and *Summer*, when it is at its greatest Distance; for which Reason that Author is forced to distinguish the Seasons of those Countries into *Cælestes* and *Terrestres*; that is, such as are conformable to the Influences of the Heaven, or Earth.

SECT. V. *It is unknown, whether the Earth or the Sun moves.*

IF now (passing by a great Number of Things that are still unknown) we proceed in the last Place to give a famous Instance of one more unknown Thing, namely, whether the Sun or the Earth moves, and consequently to which of them we owe the Days and Nights, and the Seasons of the Year: I doubt not but it may appear very surprizing to many, and especially to those who without having taken the Pains, or had an Occasion experimentally to enquire into Astronomy themselves, do found the whole Structure of Natural Philosophy upon this or that Hypothesis; tho' otherwise the greatest Mathematicians are fully convinced, that altho' there has been perhaps no other Thing examined into with more Pains, Charge and Application, in order to know the same with Certainty, yet nothing entirely positive can be advanced concerning it.

SECT. VI. *Such Ignorance proceeds, First, from the Disagreement of great Astronomers.*

Now to satisfy every unprejudiced Person of the Truth of what we have asserted, we shall endeavour to 'prove it, *First*, from the Disagreement of the greatest Inquirers into this Matter. Accordingly we find among the Ancients, that

*Philolaus*

*Philolaus* held one side of the Question, and *Ptolemy* the other; and among the Moderns *Tycho Brabé* maintains that the Earth stands still, but *Kepler* that it moves, and both these were famous Astronomers. It may be the Reader will be surpris'd that I have not mentioned the Great *Copernicus*; but the Reason why I have omitted him is, because we find that he himself was convinced, that nothing could be certainly laid down concerning this matter in his Time, as we shall shew more fully by and by. Others again suppose the Diurnal Motion of the Earth about its own Axis, but an Annual Motion of the Sun, who are therefore called *Semi-Tychonics*; and they likewise do thereby account for all the present known Phenomena, as well as *Copernicus* and *Tycho Brabé*.

To see this proved, we may consult *Dr. Gregory's Astronomy*, at the Eleventh Part of the First Book, together with many more Authors, who have with great Skill and Judgment shewn the Laws and Directions of the Motions whereby each of these three Hypotheses may be supported.

Since then these great Men, from whom only one might expect a Determination of these Disagreements, since they who have inquired into the Matter with so much more Care and Application than others, do still differ so much among themselves about the same, can any one believe that they would not long since have agreed in one and the same Opinion, if ever it had been fully and rightly proved? The rather, forasmuch as we find that they do not make the least Difficulty to depart from the Opinions of *Ptolemy*, concerning the Ways, or rather the Revolutions of *Venus* and *Mercury* (which he supposes to revolve about the Earth) as soon as ever the Experiments

and Observations made by Telescopes had taught them, that these Planets moved only about the Sun, and by no means about the Earth; wherefore, as long as this Disagreement lasts between the greatest Mathematicians, we may be pretty sure that no Body has been able to see a solid Foundation of Truth in the Proofs produced by others; and consequently that other Arguments which only depend on the Observations of those, have not hitherto been able to prove any thing certain thereof.

SECT. VIII. Secondly, *Because great Astronomers do themselves own that they are uncertain about this Matter.*

*Secondly,* This may likewise be inferr'd from hence, that the most famous and most skilful Astronomers, after having employed so much Pains in this Inquiry, do freely and honestly confess, that they are still entirely uncertain, concerning the Motion or Rest of the Earth; which Confession is yet stronger for this Purpose, than their Disagreement.

And to the end that this may not seem incredible to those who have a higher Opinion of these Mathematicians than they have of themselves, we will quote some of 'em, to witness the Truth of what is here advanced: Thus I remember, that having had the Honour to discourse with the great Mr. *Huygens* about other Matters, and asking him whether he could affirm any thing, with Certainty, about the Earth's Motion; he was pleased to answer, *That it was his Opinion, that as long as we were upon this Earth, no Body could be able fully to prove the same.*

Thus

Thus likewise we see Sir *Isaac Newton*, tho' with Mr. *Huygens* he commonly supposes the Earth to move, yet he mentions the Matter with great Caution, and without advancing any thing positively; See *Princip. Philos.* p. 375, of the second Edition, where it being affirmed, among the Hypotheses, that the *Centre of the World is at rest, and not moved*; this Reason is added, *this is allowed on of all Hands, whilst at the same time some make the Earth, others the Sun, to be at Rest in the Centre of the World.* We likewise find in the fourth *Phænomenon*, this Expression; *Of the five Principal Planets, and (of the Sun about the Earth or) of the Earth about the Sun, the Times of the Revolution are, &c.* and in the fourth Proposition of the said third Book, towards the End, we see these Words, *This Calculation (which is of some Moment) is founded on the Hypothesis of the Immobility of the Earth.*

And can any one speak out more plainly hereupon, than the famous and so highly esteemed Mathematician, *P. Herigonus*? who in his *Cursus Mathem. de Sphæra Mundi*, p. 53. uses these positive Words: *Whether the Earth is in the Centre of the Firmament, or out of it: Or, whether it is moved or not moved, cannot be proved by any Mathematical Demonstration.*

And that we may know that other great Men do likewise speak doubtfully of the *Earth's Motion*, we need only read the last Lines in p. 273, of Dr. *Gregory's Astronomy*; where speaking of the *Parallax* of the fixed Stars, with respect to the Earth's Way, he thus concludes: *For after this Manner they might put the Motion of the Earth out of doubt, which every one would own is well worth the while.* By which he shews how uncertain that Matter still is.



The Opinion of Mr. *de la Hire*, in the Preface to his Astronomy, is likewise declared upon this Matter; that great Astronomer saying, *But after I had compos'd some Tables of the daily and yearly Motion of the Sun, or of the Earth, &c.* from whence it plainly appears, that he durst by no means determine the Matter.

Thus we find in *the Memoirs of the French Academy*, 1707, p. 14. That Mr. *Varignon* having said, that *Ricciolus* had given several Reasons for the *Immobility* of the Earth, and that *de Angelis* had returned an Answer to it, he the said Mr. *Varignon*, far from determining which of 'em was in the right, contented himself with declaring only, that *he did not undertake to inquire into their Arguments*; but suggested another Difficulty, which seems to render the *Earth's Motion* yet more uncertain.

If now down to this present Time, in which most of these Things have been written, one only solid Proof, to determine whether the Earth moved or stood still, had been known to these great Men; can it be supposed that Persons of their Learning, most of whom form their Computations upon the Hypothesis of a *moving Earth*, would have spoken so doubtfully and uncertainly thereof.

SECT. VIII. Thirdly, *Because the Parallax from the Annual Motion is still uncertain.*

Thirdly, It is true, that Mr. *Flamsteed* is of Opinion, that he is able to prove, from his Observations, a *Parallax* of the fixed Stars, and consequently that the Earth moves; but with how little Certainty, may appear from the Place that we lately quoted out of Dr. *Gregory's Astronomy*,

nomy, to which Mr. *Whiston* has replied in Defence of Mr. *Flamsteed*: But this whole Discovery seems to be but of little Use for this Purpose, chiefly from what we read of Mr. *Cassini*, the younger, in the *Transactions of the French Academy for the Year 1696.* to which Mr. *Whiston* answering in his *Prælect. Physf. Mathem.* p. 202. (as much as he seems inclined to maintain the Certainty of the Earth's Motion from the above-mention'd Observations, for nothing certain can be concluded upon any other Principle) does confess, *that Mr. Flamsteed does not argue right in every thing, as the French have lately observed; and that he often deduces the Parallax of the fix'd Stars from the Phænomena, that do by no means prove the same; which in so great an Astronomer as he was, appeared very strange to him:* Concluding with the following Words, after he had said something which did not imply much Certainty; *but this must be left to the farther Diligence and Wisdom of the Astronomers.* So that this Gentleman, who is otherwise wont to declare himself with very strong Expressions against those that maintain the Immobility of the Earth, does nevertheless in this Case, as it appears from his own Words, finally leave the Matter undetermined.

Now how little Hopes remain to find a *Parallax* of the fix'd Stars, whereupon to build with any Certainty, may be seen by *Seçt. XI.* of the 3d Book of Dr. *Gregory's Astronomy*, and from the *Cosmotheoros* of Mr. *Huygens*, p. 134, &c. so likewise Sir *Isaac Newton* says, *Princip. Philos. Lib. 3. Sect. 14. That the Stars have no remarkable Parallax proceeding from the Annual Motion of the Earth.*

SECT. IX. *Nothing can be inferr'd from the Expressions used by great Astronomers, about the Earth's Motion.*

Now tho' the greatest Mathematicians of this Age are not ashamed freely to own their Uncertainty, as to the *Motion* or *Rest* of the *Earth*; yet there is another Sort of Philosophers, who being but little skilled in Astronomy, or Mathematicks, do confidently and positively maintain, that *the Earth moves*; because they cannot imagine that so many, and so great Men, should in their Writing and Calculations, suppose the same, if they were not fully assured thereof.

Now to convince them, that the Mathematicians themselves do not always give Credit to their own Hypotheses, there needs no more to be said, but that it is sufficient for Mathematicians, that they can most conveniently deduce from thence the hitherto known Phænomena, without considering, in the least, whether they be true or no: A great Proof thereof may be found in a certain kind of Preamble to the Book of the famous *Copernicus*, the whole of which were worthy to be transcribed by us, had it not been too large. It is there said, that *it is not necessary that the Hypotheses should be even probable, and that it is enough if the Calculations may be thereby made to agree with the Experiments.* And afterwards, *and since various Hypotheses are often adapted to one Motion, (as in the Course of the Sun, an Excentricity and a Motion about the Center) an Astronomer may chuse that which is most easily comprehended: A greater Probability may, perhaps, be required from a Philosopher, yet neither of them can be able to discover any thing with Certainty, unless God reveals it to them.* Whereupon,  
 finally,

finally, these emphatical Words follow: *Let no Body, so far as it concerns an Hypothesis, expect any thing certain from Astronomy; since it won't afford any Thing like that, least by admitting for Truth that which is dress'd up for other Purposes, he should leave this Science with greater Folly than he engaged in it.* I don't know whether any one could more strongly confirm what has been said before; and I think that the foregoing Objections are sufficiently answered hitherto, by referring our Readers to the Authors of these several Books.

Thus we find in the Text of *Copernicus* himself, *Lib. I. Cap. X. p. 20.* That this great Astronomer, instead of producing Reasons to support the Truth of his Hypothesis, contents himself with saying, *Which I think we ought to admit more readily, than to puzzle and confound our Minds with an infinite Number of Circles.*

After the same manner, says *S. Stevin*, in the 5th Proposition of the *Celestial Appearances*, with respect to a moving Earth; *That it does not appear necessarily, that the Sun should be in the Center of the fix'd Stars, but that it is allowed to be so for good Reasons.* And would you know his Reasons? They are the following: After having said, that it may be supposed, but, according to his Opinion, not fully proved; he concludes thus: *But it is more convenient to allow the Sun to be in the Center of the World, because other Phænomena may be more easily and rationally solv'd thereby.*

Thus we hear the famous *Kepler* speaking in his *Epitom. Astronom.* p. 448. and again 673. *When these Causes are understood, tho' they be not believed, but only supposed, the Use thereof will be very easy.*

But the same is very plainly made out by the *Transactions of the Royal French Academy*, 1709. where *Mr. Cassini*, after having spoken of the

Uses, Properties and Advantages of old and new Hypotheses with great Learning, (but without maintaining the Truth of any of them) describes very curious Planetary Machines, all of which are founded upon the Supposition of the Earth's Im-mobility. For which Reason likewise he places the same immoveably, in the middle of those El-lipses, which the Planets seem to revolve in, in the Space of several Years, with regard to the Earth itself; and he even marks the appearing Re-volution of the Sun about the Earth with a prick-ed Circle. Now every Body knows, that altho' this great Astronomer does here use the Hypothe-sis of an immoveable Earth, yet he does by no means assert the Truth thereof; nay, he some-times uses a different one.

From all which it appears, that these so highly esteemed Mathematicians do more consider the Conveniency than the Truth of their Hypotheses in very many Cases. But since some do pay such a blind Deference to their Science, that when they see an Hypothesis used by Men of a great Name, they take it only upon their Credit; there-fore to convince these Gentlemen likewise, that we don't speak at random, when we affirm, that such a Mathematician does for the foregoing Rea-sons of Conveniency advance an Hypothesis, which is not only absolutely false, but even al-lowed to be so by himself, we shall present our Reader with a few Examples thereof.

Thus the Mathematicians do suppose imagina-ry Lines and Circles for the Construction of those so useful Tables of Sines and Tangents, &c. and in those of *Logarithms*, that all Numbers are the true ones; whereas among Hundreds of them, there be very few that are really so: For which Reason also, and that the Difference between  
true

true and false may be the less, their Way is to use such great Numbers.

So likewise Surveyors, or those that measure Land, tho' they find some Lines to be a little crooked, and sometimes go in and out in small Angles, yet they take them for strait ones; provided only that from the Supposition of such a known Falsity a greater Convenience results, and the Difference be not very considerable.

Who does not know, that making the Degrees of Latitude larger and larger in *Navigation*, is nothing but a mere Fiction, and only that one may with more Conveniency make good the real Decrease of each Degree of *Longitude*, though such useful and necessary Tables are calculated upon the same Foundation?

Though it be known to such as understand *Optics*, that Spherical Glasses never collect the Rays into a Point, (excepting in one or two Cases) as Glasses of some other Figures do: Yet how common a Thing is it in the making of Telescopes or Microscopes, to suppose the same, contrary to Truth; and the Demonstration of the *Practical* Part is founded thereupon, even by such as know that this is a manifest Falsity in the *Theory*?

What is more common than to suppose in *Statics*, that two Plumets fall down in strait Lines parallel to each other, whereas they would notwithstanding both meet at the Center of the Earth?

In like manner, and upon the same Foundations, 'tis supposed by *Gunners*, and even by those famous Mathematicians that write upon the Art of throwing Bombs, that their Balls by the Force of the Powder, and their own Gravity, do describe a Line, which they call a *Parabola*; whereas if they considered the Resistance of the Air,  
and

and other Causes aforementioned, they would know that the Properties thereof were very different.

In *Dialling*, we suppose the Center of the Earth, or rather of the Sun's Course, to be always at the Top of the Perpendicular Style (when the Shadow of it, as a *Nodus*, shews the Hour) wherefoever the Dial be plac'd upon the whole Earth, though every Body knows it to be contrary to the Truth.

Thus all the ancient and modern Astronomers have always taken it for a Foundation of their Calculations, that the true or apparent daily Motion of the Sun is in a Circle parallel or equally distant from the Equinoctial, notwithstanding that this Line, by the intermixing of the Sun's or Earth's Annual Course, comes nearer to a *Screw* or *Spiral Line*, than a Circle, as is well known to the Astronomers.

After having shewn all this in so many Branches of the Mathematicks, I don't think that a more express Demonstration will be required, to make appear, that altho' some of the chiefest among the Astronomers do suppose either the Motion or Rest of the Sun, and found their Calculations thereupon, yet this does not in the least shake either the one Hypothesis or the other: Since, provided the Mistakes be not of too great Importance, they frequently make use of Hypotheses for Convenience sake, which they themselves know to be false.

SECT. XI. *The Simplicity of an Hypothesis is not always an Argument of its Truth.*

THERE is yet one Argument from whence some People do conclude a little too hastily, that the Hypothesis of the Earth's Motion is true; namely, because it appears to them the *more simple* of all: And for farther Proof, say, that it is most becoming the Wisdom of the great Creator, to bring about the greatest Matters after the most *simple* Manner.

We shall not here enter into a large Discussion about the Weakness of this Characteristic; since no Body can know, when a Machine is shewed to him, whether it be the most simple or no, unless all the Views and Ends of him that invented it were at the same time disclosed to him, which none will presume to affirm concerning the Structure of the visible World: For upon this Foundation, those who maintain the Sun's or the Earth's Way to be Circular, contrary to Experience, might justly alledge, that their Opinion had more Truth in it than that of those who maintained the same to move in an Ellipse or oval Figure: Forasmuch as beyond all Dispute the Figure of a *Circle* is more simple than that of an *Ellipsis*.

But to come a little closer; let such as maintain this, tell us what is the Reason why all Astronomers, at least all that I know, and among whom there are likewise many that zealously contend for the Earth's moving, and the Sun's standing still, as *Copernicus* himself, and since him *Kepler*, *Lantsberg*, and in our time, the North-Hollander, *Richard Rembransen van Nierop*; tho' all of them do in the *Theory*, or annual Course from East to West, maintain the Hypothesis of a moving  
ing



ing Earth, (forasmuch as the Calculations are much more convenient according to them in this Case) yet in every Thing that belongs to the *Spherics*, or daily Revolution from East to West, they are wont to make their Figures and Calculations directly contrary to their own Notions, upon the Foot of a moving Sun and a resting Earth, tho' they commonly start the greatest Objections against this last.

Of what has been said, there is no farther Proof necessary, since this is apparent to every Body in almost all Figures that are used by them to this Purpose; in which they are even wont to express the *Parallels*, in which the Sun daily moves, and to call them by that Name. It seems to me likewise to be particularly remarkable, that Mr. *Whiston* himself, who is otherwise so great a Champion for a moving Earth, does transcribe the Demonstration of the Manner after which Mr. *Cassini* has so ingeniously observed the *Parallax* of the *Planets*, into his *Prælect. Astron.* p. 75, &c. with so great respect from the *Act. Lips.* 1685, almost in the Words of Mr. *Blanchini*; notwithstanding that the same is formed upon the Hypothesis of a fix'd Earth, and the daily Revolution of the fix'd Stars and Planets, shewing what he himself terms it, *The daily Revolution of Mars in a Circle*, and often using this Expression, *That Mars and the fix'd Stars are moved and carried round about by the Diurnal Motion.*

We might produce many more Instances here, to shew how little Account is made of all Hypotheses; but having dwelt so long upon this Matter already, we choose rather to refer our Reader to the Preface of Mr. *de la Hire's Astronomy*; there is likewise something said about the same in our *Introduction*, Sect. XVI.

SECT. XII. *A Conclusion from the Whole, that neither the Sun's nor the Earth's Motion has ever been rightly proved.*

NOW to come to a Conclusion from what has been hitherto said of the Motion or Rest of the Earth.

I. Since the greatest Men do still differ upon this Point, and no Body has yet been ever able to produce a fix'd and solid Proof of the Truth on one Side or the other. (*See*. VI.)

II. Since such famous Mathematicians and principal Astronomers as *Huygens*, *Newton*, *la Hire*, *Varignon*, (to whom few will dare to compare themselves in the Knowledge of Astronomy, without being thought very presumptuous and conceited) and so many other have ingenuously confessed their Uncertainty in this Matter, tho' they are of the most modern, some of them being still alive, and all till lately; and consequently have had the best Opportunities that can be yet procured of examining into every Thing that has been discovered concerning the same. (*See*. VIII.)

III. Since the Hopes of finding out the *Parallax*, and Distance of the fix'd Stars from the Earth, are very small, by which otherwise the Matter might be determined after a good, if not the best Manner. (*See*. IX.)

IV. Since we cannot find any Demonstration of the Proof upon it, because very learned Men have indifferently made use of the one or the other Hypothesis; forasmuch as in almost all the Branches of Mathematicks, Hypotheses are used not to shew how the Thing is really in itself, but only in order to deduce from thence the known *Phænomena* with the greatest Convenience, and  
with

with the least sensible Difference; so that even Things that are known to be entirely disagreeing with Truth, are frequently supposed, for the afore-said Reasons, even by the greatest Men that treat of Mathematical Matters. (*Señ. X.*)

V. And lastly, since the same Mathematicians do one while make use of this Hypothesis, another while of that, according to their Convenience in present Cases, or for the ease of their Calculation, or for the better Conception thereof; or Description of them by Figures in the most plain and simple Manner. (*Señ. XI.*)

Let every Body consider with himself, whether he can be persuaded, that there will ever be discovered any solid or proper Proof, such as may be sufficient experimentally to convince Men, that the Motion or Rest of this Globe of the Earth is demonstrable, clearly and plainly, and to the Satisfaction of true Mathematicians: At least if any one should pretend to assert this, it would be the same Thing as if he should declare, that all those great and learned Astronomers above-named, have been either so ignorant as not to be able, or so malicious as not to be willing to understand such a Proof; which any Man who is just and reasonable, must think to be the greatest Absurdity.

*The End of the Third and Last Volume.*





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