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HALE

DIFFICILES

NUGAE

1674

By Sir Matthew Hale.

DIFFICILES NUGÆ:

OR,

OBSERVATIONS

Touching the

TORRICELLIAN Experiment,

AND

The various Solutions of the same, especially touching the Weight and Elasticity of the AIR.

LONDON,
Printed by *W. Godbid*, for *William Shrowsbury*, at the Sign of the Bible in *Duck-lane*,
M. DC. LXXIV.

THE PUBLISHER TO THE READFR.

THE *Title of this Book gives thee little incouragement to buy or to read it, and it was purposely so given. If it performs but as much as the Title promiseth, thou art not deceived; if more, thou art advantaged.*

The Subject is seemingly trivial, and suitable to the Title; yet it hath exercised the Wits and Pens of many Learned men, and makes way

to Natural Discoveries, and consequences of greater importance; at the worst it may be an innocent Divertisement, and possibly delightful to those that are pleased with Speculations and Experiments of this nature.

The Experiments therein are some new, some vulgar and common, and some borrowed from those Excellent persons, whom though the Author highly honours for their Learning and Industry, yet in some things dissents from them in their Solutions and Conclusions from those Experiments that they have most ingeniously found out and delivered.

The Author pretends not to an equality of Learning to those from whom he thus dissents, much less to Infallibility; there may possibly happen

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pen want of Exactneſs in his Tryals, there may be imperfect and miſtaken Computations. The Diagrams though but few, yet rude. The Reſolutions and Concluſions may either be imperfect, or not ſo clearly or evidently expreſſed, and inferred, or deduced.

But he that conſiders the intricacy of this Inquiry, the various complications of Cauſes, and Effects, and Appearances that occur therein, the great difficulty of arriving to exactneſs in the Experiments themſelves, will rectify or eaſily excuſe ſuch miſtakes or inadvertencies, if any ſuch occur in theſe Papers.

If the Inquiry hath not attained its full complement and perfection in theſe Papers, yet the Author hath obtained his End therein, namely, to give hints and occaſions to Ingenious

per-

persons to make farther and better Discoveries, and to rectifie (if there be occasion) the mistakes of these or other mens Solutions; and to give a little warning to men of Wit and Parts, not to be too hasty or positive in exterminating the Aristotelian *Philosophy, and entertaining new* hypotheses, *'till they have fully and maturely considered, and well looked about them. The Author's Name is not prefixed, for it would be of small advantage or use: and he is thereby the fitter to bear the correction of his Errors, and to retract them with more ease, and less observation, if any such shall occur to his discovery or notice; and therefore hath left the Book it self, and the matters therein delivered, to bear their own burthen, and to stand or fall as they deserve.*

Observations touching the Torricellian *Experiment, and the Weight and Spring of Air.*

CHAP. I.

The Introduction, containing the order of the ensuing Enquiries.

AMong the many Experiments of latter Ages, there hath been invented that Engine that commonly goes under the name of the *Torricellian* Experiment, which is but this: A Glass-Tube of three foot or more long, closed at one end, and then filled with Mercury or Quicksilver, and then the open end stopped with the finger, and inverted into a vessel of restagnant Mercury; and when the end is sufficiently immersed, then the finger nimbly removed, so that

no Air get in, the Mercury will subside in the Tube to the height of 29 Inches, and half an inch, or near thereabout; but infallibly between 27 and 30 Inches, leaving the residue of the upper end of the Tube emptied of the Mercury.

This Experiment, and the solution of it, hath exercised the Tryals and Wits, and Invention of very many excellent Persons, such as were *Helmont*, *Gassendus*, *Kircherus*, *Shottus*, Dr. *Carleton*, Mr. *Hobbs*, Mr. *Sinclere*, Monsieur *Pecquett*, Monsieur *Pascall*, *Magnanus*, Mr. *Boyle*, *Linus*, *Honeratus*, *Fabri*, and divers others; who though men of great Learning and Industry, have run into several Parties, and given Solutions, and raised Conclusions from it, extreamly contradictory the one to the other.

And although this seems but a very trifling and ludicrous Experiment, yet almost all dissenting Parties have made it to suffragate to their several preconcerned Sentiments, and Perswasions, and that in Philosophical Points of as great moment and importance perchance

chance as moſt be to be found in natural Inquiries. Some from hence confirm themſelves in their Perſwaſion, that there are both interſperſed and coacervated Vacuities or Spaces, empty of any corporeal ſubſtance in the Univerſe; others again as confidently concluding the untruth of that Opinion, and that from the ſame Experiment. Others again from hence confirming themſelves in the *Carteſian* ſuppoſition of his *Tria Principia*, and eſpecially of that *Materia Subtilis*, which cannot be excluded from pervading the moſt contumacious and ſolid body: Others attributing the ſame Power to the more ſubtil parts of the aerial conſiſtence; ſome from hence concluding an actual preſſure and gravitation of the Air upon all ſubjected bodies, and that thereby the Mercury is ſuſteined by way of Preſſure, and Truſion, and Counterpoys, and have ſubſtituted thereupon as an undoubted *Hypotheſis*, a world of admirable conſequences in natural appearances, not only in the greater World, but alſo in the leſſer World the humane

structure. Others again have hereupon maintained their opinion of Attraction as the necessary effect of Tension, and resolve this suspension of the Mercury unto the force of attraction and suction, occasioned by that Catholick Law of Nature for preservation of the continuity of the Universe, and all its parts, and the *Fuga Vacui*, and are no way satisfied with that confidence that decryes it.

From this diversity of Judgments of Learned men, we may learn, first, how little it is in natural Effects that we really and truly know and understand, when so trivial an Experiment that we have so easie an access unto, and handle with our hands, and perceive by our sight its motion, which yet so gravels, or at least divides men of great Parts, Judgment, Learning and Experience. 2. How strangely partial men are to those Sentiments that they have once entertained, and perchance taken much pains to mould and fashion, or have even publickly engaged unto or for; whereby it comes to pass that men are not willing

ling impartially to consider what makes against their opinion, and frame a thousand imaginations to evade the strength of the opposite reasons, and to construe all appearances (as melancholick persons do the sound of Bells) to speak what they fancy; And possibly all the opposite Opinators in this business are under the like partiality and unindifferency.

There is a great odds between a Matter propounded only as an Hypothesis, and propounded as a real truth. In the former there is nothing more required than a true understanding of the *Phænomena*, and a ready Wit to contrive some Model, and to dress it up so handsomly, that it may answer the *Phænomena*, and to fit up such expedients as may meet with and stop the Leaks that otherwise would happen in the Hypothesis: And such a man tells us not so much what the truth of Nature is, as what he thinks he could have made it, if he had had the handling of it; such may be the Systemes of *Ptolomy*, *Copernicus*, and *Tycho Brahe*,

which cannot be possibly all true, though possibly they may be all false. And yet every of them is so fitted and accommodated by the Wit, Invention, and Industry of the Authors, that they solve the *Phænomena* very near equally: And thus if I remember aright *des Cartes* fairly propounds his *tria Principia*'s, and some other parts of his New Philosophy.

But to propound a thing as really a truth in Nature, is another kind of business, and requires not so much a dextrous Invention, but an impartial inspection into the things themselves, and examination how all things stand one with another, as we truely find them, and not as we mind to make them: For the Laws of Nature are stable, and setled, and regular, and not like the Laws of Men, or the fashions of our Cloaths, mutable, according to new Modes, or devices of Fancy.

Therefore the bare accommodation of Hypotheses to the Solution of the most obvious *Phænomena* is not always the measure of its truth, for that may be

be but the product of Invention and Wit. For it is apparent, that though it is impossible that all the varying Solutions of this trifling Experiment can be all true, yet they are all so dressed and pieced up, that they do solve the most obvious *Phænomena* in this Experiment, well near equally each with other.

But on the other side, if any *Phænomena* happen cleerly either in this or any other instance, that do cross and thwart that which is taken up as a necessary *postulatum* in any of these Solutions; it is if not an undeniable, yet a great and possibly a clear demonstration, that the Hypothesis its self is false, and ill Founded, especially if it be the great *Basis* upon which such Hypothesis is bottomed and built.

And if the foundation of a Hypothesis, or the general *postulatum* upon which it is bottomed, be false, or only imaginary, although the Inferences and Conclusions made upon such a *Basis* be deduced with all the fineness and subtilty imaginable, and such (as were the *postulatum* it self true, upon which they are bot-

tomed) would be as necessary and consequential, as the Demonstrations of *Euclide*, yet the whole fabrique will fail when it comes to tryal, and become like the Astrological Predictions Calculated with Art enough upon a false Ephemerides.

I that come after the Labours and Scrutinies of so many Excellent Men that have gone before me upon this Subject, cannot promise my self or others that I shall say much in this Matter that hath not been said before; and the necessity of a free Discourse requires that I should take in somewhat of other mens Labours. But I shall avoid, as much as I can, the imputation of a Plagiary, by mentioning the Authors as I have occasion: But yet, though somewhat that I shall say hath been said before, especially by *Linus*, and *Fabri*, yet somewhat will be new, although the most I shall do herein will be to make the Method and manner of Explication of it as much my own as I can, which I shall do in this order.

First, I shall explain some Termes which

which I shall have occasion to use, that so I may write intelligibly according to that sense I gave my words; though it may be possibly not according to the sense wherein others have used them.

Secondly, as preliminary to what I shall say touching this Experiment, I shall set down some Statical Observations, that may be useful to me upon this inquiry, not that I shall ingage my self in the whole Theory of Statical Principles and conclusions; this hath been done already by those worthy Persons that have *ex professo* handled this Subject, as *Archimedes*, *Stevin*, Mr. *Boyl*, and others; but only shall glean up some general Observations therein necessary to this inquiry.

Thirdly, I shall set down what it is not, that may be supposed in the space dereliсted by the Mercury, namely, it is not Nothing, nor Ayre, nor *Æther*, nor any Body that comes from without.

Fourthly, I shall set down what I think it is that possesseth the place derelict by the Mercury.

Fifthly, I shall set down what I think

is

is not the cauſe that ſuſpends the Cylinder of Mercury, in the Tube to that Altitude of 29 Inches, or thereabouts; namely, not the Gravitation or preſſure of the impending Ayr, nor its Elaſtricity.

Sixth, I ſhall ſet down what I think is the cauſe, that ſuſpends the column of Mercury from ſubſiding in the Tube below Twenty nine Inches, or thereabouts.

Seventhly, I ſhall ſet down thoſe objections, that ſeem of the greateſt force againſt the laſt ſuppoſition.

Eighthly, I ſhall take a particular examination of ſome other Experiments, as touching the coheſion of Poliſhed Marbles, and the *Magdeburgh* Hemiſphere, and the riſing of Water in the common Pumps.

And this Order I ſhall as near as I can obſerve in the enſuing Chapters.

CAP.

CHAP. II.

The Explication of ſome Terms, that may be of uſe in the following Inquiry.

FIrſt, I ſhall obſerve the difference between the ſpecifical or intrinſique Weight of a heavy Body, and the extrinſique Weight or *pondus molis*.

For inſtance, a pound of Mercury, and a hundred pound of Mercury, have the ſame intrinſique Weight, but yet not the ſame extrinſique Weight: A pound of Water and a pound of Mercury have the ſame extrinſique Weight, for each quantity weighs but a pound, but they have not the ſame intrinſique Weight, for quantity for quantity, Mercury is heavier then Water.

Thoſe Bodies are ſaid to have the ſame ſpecifical or intrinſique Weight, when the ſame bulk or quantity counterpoiſeth equally the other; and thoſe Bodies are ſaid to differ in intrinſique Weight, where a greater quantity of the one is required to Equiponderate a

leſs

leſs quantity of the other; as for inſtance, a Cylinder of Mercury, of an Inch long, and half an Inch Diameter, counterpoiſeth a Cylinder of Water of the ſame Diameter and 13 Inches ½ or 14 Inches long, or thereabouts. But although a Body ſpecifically or intrinſically lighter than another, may in ſome caſes have the advantage in point of ſpeed in motion of a Body of equal extrinſical Weight, becauſe it takes up leſs room, and ſo meets with leſs reſiſtance in the *medium*, yet upon the Scale they equally counterpoiſe each other.

But again, there is this difference between them; a Body of a greater intrinſique or ſpecifical Gravity of an equal extrinſique Weight, with a Body of leſs intrinſique weight, will ſometimes equally preſs upon a Fluid Body, upon its Superficies, but will preſs more than the lighter, when both have the advantage to get below the Superficies; for inſtance,

Take a pound of Lead, and a pound of Wood, whether lighter or heavier than a quantity of Water equal to it,

lay

lay them each upon a peece of Cork that will ſupport them in the Water; the pound of Lead, and the pound of Cork will both ſwim upon the Water.

But if the Cork be taken away, the Led will ſink, and the Wood will ſwim if lighter than a like quantity of Water, and if heavier than the like quantity it will ſink, but not ſo faſt as the Led.

2. There is a difference between an intrinſique Weight, and an accidental Weight, which may be various; as for inſtance:

In reſpect of the poſition of the one and the other: Water and Water are both intrinſically of the ſame Weight, yet if Water be in a Tube, open at both ends, and be ſtopt with the Finger at the lower end, and then when contiguous to the Water in a Veſſel, the lower end it is opened, all the Water in the Tube will ſubſide to an equal Superficies with the Water in the Veſſel, becauſe its higher poſition gives it an accidental Weight more than that in the Veſſel.

So again, Ayr and Ayr have the ſame

Weight,

Weight, though it be hardly measurable, but if Ayr be compressed as in a Wind-gun, it gains an accidental Gravity by its Compression of parts more than the common Ayr.

3. There is a difference in Terms between Gravitation, and pressure of heavy Bodies; for instance, A Tube stopt at the upper end, and driven down in a Vessel of Water forcibly, the pressure of the Water upon the Ayr in the Tube, will contract the Ayr as much as it can (suppose it an Inch) and the rest of the Ayr in the Tube will press upon the Water, because it will not yield more to the Water; this is properly Pressure in the Ayr upon the Water, and of the Water upwards upon the Ayr; yet neither are properly Gravitation, though possibly, I may in some passages use the words promiscuously.

4. There is a difference between Gravitation *ad motum*, which I call sometime sensible or perceptible Gravitation, and Gravitation *ad pondus*, which I sometimes call real or insensible, or Physical Gravitation: For instance,

If

If a cubical Veſſel of Water contain 56 pound weight of Water, and a piece of Cork, or parcel of Oyl of two pound weight be placed upon the top of the Water, it will not ſenſibly gravitate, but will be born up by the upper Superficies of the Water, whereunto the lower Superficies of the Cork or Oyl will be contiguous, becauſe being ſpecifically or intrinſecally lighter than Water, it is ſuſtained by it, and makes no motion in the ſubjected Water.

(*Fig.* 1.) But yet it is plain that in concretion with the water, the whole weighs 58 pound, whereas before the water alone weighed but 56 pound; ſo that here is a gravitation *ad pondus* added hereunto *in concreto* to the water. But let us ſuppoſe that the Veſſel *A*, *B*, *C*, *D*, be filled with water unto the ſuperficies *C*, *D*, and the tube *E*, open at both ends be immerſed into the water, and then a quantity of oyl, that is lighter ſpecifically than water, be poured upon the ſuperficies of the water; this will raiſe the water into the tube *E*, above the common ſuperficies of the water, to

ſuch

ſuch a proportion of height in the Tube as will countervail the weight of a like Cylinder of Oyl, which will be ſomewhat near to the ſuperficies of the Oyl, becauſe the water at *G*, is not equally preſſed with the reſt of the ſuperficies of the water by the incumbent Oyl. The diſparity of the preſſure cauſing motion or elevation of the water in the part not equally preſſed; ſo it is *gravitatio ad motum*, and not ſimply *ad pondus*. So if upon a veſſel of water there be placed a Body ſpecifically heavier than water, but not exactly commenſurate to its ſuperficies; here is *gravitatio ad motum*, as well as *ad pondus*; for the body ſinking into the water muſt needs raiſe up as much water as the ſpace it ſelf takes in ſubſiding into the veſſel of water.

And upon the ſame account it is, if the ſubſiding body be a Fluid, as *Mercury*, it will by ſinking into the water drive up as much water as the room it takes, and ſo make the ſuperficies higher; ſo that an unequal preſſure of any Fluid muſt neceſſarily make a motion upwards

upwards of the parts of it, and thereby raiſe the ſuperficies by ſo much in bulk of water as will countervail the room that the immerſed body takes up in the water. And this and the like I call ſenſible gravitation, or gravitation *ad motum*.

5. There is a difference between *Pondus*, and *Potentia*; and this is well enough evidenced in the inſtance of the Oyl and Water above given: The oyl gravitates upon all the ſuperficies of the water, except that ſubjected to the orifice of the Tube *E* there is the *pondus* of the oyl and the water driving up, and ſuſtaining the water in the Tube to that height that equiponderates a like column of oyl there is the *Potentia*.

Mr. *Sinclere* and others, that contend for the Solution of the *Torricellian* Experiment by the Gravitation of the Ayr, apply this difference unto two inſtances, which poſſibly in the event of their Examination will appear otherwiſe; namely: 1. That the Ayr equally preſſing the reſtagnated Mercury in all places thereof, but that

which is directly under the column of the suspended Mercury, and thereby Equiponderating a column of Mercury only of 29 Inches $\frac{1}{2}$ and no more, keeps it suspended at that height by the Equipondium of both, there is the Gravitation of the column of Mercury, which is the *pondus*, and the Impending column of Ayr, which is the *potentia sustinens*, that Counterpoyseth that *pondus*. I shall have occasion to use this difference of *pondus* and *potentia*, in relation to this Experiment also, but in a different way.

2. The other instance, to which he applies this difference, is in all Fluids, whether Ayr, Water, Mercury, or any else: Namely, if a Body be in any depth of Water; suppose above it were 20 foot of Water, and below it two, three, or four Foot of Water, or more, subjacent to the lower Base of the Body. The upper column of Water is supposed to press downwards, *per modum ponderis*, upon the upper Superficies of the Body, and the lower column of Water, contiguous to the lower Superficies of the Body, is supposed to press upwards,

per

per modum potentiæ. And he ſuppoſeth that the preſſure of the *potentia* upwards, is alwayes equal to the preſſing of the *pondus* downward: This is a ſuppoſition fitted principally for the accommodating of the Solution of the Coheſion of Poliſhed Marbles, by the Gravitation and *potentia* of the Ayr, preſſing upwards and downwards, and ſome other inſtances, whereunto the ſingle Gravitation of Ayr downwards will not be ſufficient: The proof whereof will be conſidered hereafter.

6. There is a difference between the reſiſtence or Renitence of a Fluid, and the Gravitation or preſſure thereof: If a man ſtrikes forcibly with the flat of his hand upon the Superficies of the Water, he ſhall find near as much pain as if he ſtruck upon a Board, although the Water doth not counter-move the hand, but receives and reſiſts its ſudden force; the like occurs frequently in Ayr: The fierce ſtriking of a wand through it, bends the wand, and the fierce Colliſian of the Bullet againſt it, is not without a reſiſtence of the Ayr,

though too weak to encounter it.

And this Renitence or resistence, without any counter-motion at all by the Water, is that which makes the Motion of the same heavy Body through the Water considerably slower than through the Ayr; and the same Weight of Led or Iron, or other heavy Body in Water, to weigh less upon the Scale, than when it is in Ayr, the retardation of its Motion, and the correction of its weight, being the same effect of the same Cause; namely, the resistence of the Water, greater than in the Ayr, without relation to any counter-motion, or counter-pressure in the Water it self.

7. There is a difference between Rarefaction and Tention, and between Condensation and Compression, though the effects be much alike in both.

Rarefaction, (for instance, of the Ayr) is the Extention of its parts, commonly by heat, or what is equivolent, the fiery Partacles that it receives, whether from the Sun, the *Æther*, or common fire, or other Calefactive nature.

Ten-

Tenſion, is when the parts of the Ayr are diſtended by virtue of ſome force or power that layes hold of its Extremes, as a Lute-ſtring is under a Tenſion to a greater length, by a conſiderable weight appended to it; only it hath this difference, a Lute-ſtring or the like, is not capable of Tenſion in length, but it muſt have a contraction in thickneſs, but Ayr as it hath a motion every way, ſo it is capable of Tenſion every way.

The effects aſwel of Tenſion as Rarefaction, are theſe, *viz.* the ſame ſubſtance holds thereby a greater and more extended ſpace. 2. The Body, thus either by heat or force, Rareſied or Tenſed beyond its true natural ſize and ſtaple, hath a Motion of reſtitution, narurally contracting it ſelf, and preſſing inward. 3. The Body thus contracting it ſelf, by the Catholick Law of Nature, to preſerve the continuity of the World, layes hold upon the Bodies next adjacent, and conterminous to it, and as much as it can draws it inward.

Again, Condenſation and Compreſſion differ in this, that the former is

commonly made by the Constipation of Cold; the latter, by any other forcible pressure, as in Wind-guns, Æolipiles, and the like.

They both agree in their effects. 1. That the Ayr Condensed or Compressed, takes up less room or space, than its natural and due size. 2. That they have each a Motion of restitution, by expanding it self to its just size.

And this Elatory or Spring, I allow to the Ayr; namely, of retraction, and expansion, when put out of its natural size or staple: But the imaginary prodigious Spring, attributed to the common Ayr, as its natural tendency, I take to be only invention.

It is hard to say to what proportion Ayr may be Rarefied or Tensed; some think to above 70 times its common extension, or to what degree it may be Condensed or Rarefied; some think to seven, nine, or ten times, less then its ordinary consistences, or more: *Quod vide apud* Morsen *in pneumaticis, et aliis.*

8. There is a difference between the common Gravitation of a Fluid of any

any kind, as it is a heavy Body, and the appropriate Gravitation of it as it is a Fluid Body: In respect of the former, it doth as all heavy Bodies, press perpendicularly downward towards the Centre; But as it is a Fluid Body, it hath an appropriate Gravitation of its own, whereby it corrects and allayes in some sort, its common Gravitation: For instance, Water in its own consistency, hath a lateral Motion, a Motion *per declivè*, an Horisontal Motion, within the compass of its own Superficies; yea, and a Vertical Motion upward, within the compass of its own Superficies: As if a Tube full of Ayr, stopt below, be immersed into Water, and then unstopped, the Water will heave as freely upward as it would otherwise downward, till it attain its own common level or Superficies; and suitable to its Motion is its Gravitation, which is nothing else but *motus*, or *conatus ad motum*.

And besides this appropriate Gravitation of Fluids, there is a certain proper and connatural Texture in Fluids,

and especially in Ayr, whereby the subjected parts do suspend, and hold up considerably the Superior parts from any considerable Gravitation, so that no Body, or portion of space less than the whole Base of the whole Fluid is considerably pressed upon by any such imaginary Column Commensurated to the Base of the subjected Fluid, as hath been elsewhere observed, and will be further Illustrated in some of the following Chapters.

9. There is a common and allowable difference beween the pure Ayr, such as may be in the upper Region, and that which is now commonly called the Atmosphere. The former is so pure and subtil, that the greatest pretenders to the Ayrs Gravitation that I have seen, do not take upon them to to determin, that it hath any Weight.

The Atmosphere, is that portion of the Ayr that is the common receptacle of Vapours, and the *Effluvia* of the Earth and Water, whereby it is less subtil than the pure Ayr.

Though some, out of the confidence they

they have of their attaining the juſt proportion of weight between Water and Ayr, and the juſt proportion of weight between Mercury and Water, and upon the high confidence they have of the juſt *Equipondium* between 29 Inches ½ of Mercury, and a Column of Atmoſphere of the ſame thickneſs with the Column of Mercury, have undertaken, to define the juſt height of the Atmoſphere; ſome determining it to be juſt 7000 Fathoms, ſome 7 Miles; yet the Doctors much differ among themſelves in their account; ſome telling us, they take it to be 22 Miles high, others 50, others above 100.

And there muſt needs be an exceeding incertainty in this way of Computing it. For firſt, Though the juſt proportion of weight between the Quickſilver and Water is eaſily and certainly diſcovered to be truly as *Merſennus*, and others, have accounted it, *viz.* that one Cubick Inch of Mercury will juſt counterpoiſe 13 Cubick Inches and ½ of Water; yet the proportion of weight that Ayr bears to Water, (if it have

have any real weight at all,) is not to be exactly Calculated, whatſoever Experiments have been made thereof by *Merſennus* and others; the former telling us, that the weight of Water to Ayr, is as one to about 1300; the others telling us it is as one to 1000, or at leaſt ſome ſmall proportion leſs. 2. Admit the proportion were juſtly known, yet thoſe that take their meaſure of the height of the Atmoſphere, or Gravitating Ayr, (if any ſuch be) by the ſuppoſed *Equipondium*, between 29 Inches $\frac{1}{2}$ of the ſuſpended Mercury; and a Column of Ayr commenſurate in thickneſs to ſuch a Mercurial Column, have bottomed themſelves, as I think, upon a falſe Foundation. 3. But if it were true, as they would have it, yet even upon their own principles, it is extremely miſtaken and convinced by their own ſuppoſitions and Experiments, as ſhall be obſerved in the enſuing Chapters.

And thus far to render my ſelf intelligible in my expreſſions in the future Inquiry.

I shall only add some Matters that will be useful as to the point of Calculation.

The weight of Water is various, according to several places; *Stevin* tells us, that in some parts of *Holland*, a Cubique Foot of Water weighs 63 pound; as I remember, Mr. *Sinclere* Computes it to 56 pound, and consequently, a Cube of Water 6 Inches square, weighs 7 pounds; and I have by tryal found, that it weighs 7 pounds wanting two Ounces; but the Standard of 56 pound and 7 pound, ordinarily sutes the proportion of weight of those two Bodies: Upon tryal, I have found the proportion very little differing, *viz.* a Cube of 6 Inches square of Water to weigh 7 pound wanting two Ounces, and consequently a Cubical Foot to weigh 55 pound 4 Ounces.

The readiest way to avoid Fractions and the long process of Arithmetical Calculations, is by immersing any regular or other Solid Body into a Vessel full of Water, and to save that which

is

is impelled over by the immersion of the Solid Body, to discover the proportion of weight between such a Solid, and a Fluid of the same Moles or Dimensions.

The measure of a Cubique or Square Body, is by Multiplying the one side into the other, to find the Area of Inches; and by Multiplying the Area by the measure of Inches in profundity.

The measure of a Cylinder is by multiplying half the Diameter into half the Circumference, which yields the Area, and Multiplying the Area (of Inches) into the number of Inches, in the depth of the Cylinder: I mention these Figures, because the most ordinary and useful in Hydrostatiques.

Mercury is thirteen times and an half and somewhat more heavier than the like quantity of Water, as I have found upon tryal: If it be taken fourteen times heavier, it will not be much out of the way, and avoids Fractions. And therefore upon that computation if a Cube of six Inches Square of Water weighs seven pound, a like

Cube

Cube of Mercury will weigh 98 pound Averdupoise.

The often use of Mercury even in the *Torricellian* Experiment, but especially, where there is occasion of frequent Superfusion or Infusion of Water in the operation, will certainly much alter its Texture, Weight, and Use, as I have Experimentally found.

It is a matter of great difficulty to avoid the immission of Ayr in the *Torricellian* Experiment, which will much disorder the operations.

CHAP.

CHAP. III.

Concerning the Gravitation of Bodyes; and first, concerning the Gravitation of Fluids, in relation to Fluids of the same kind and consistence: And therein also, first of the Gravitation of Water upon Water.

ALL heavy Bodyes have a Physical Gravitation belonging to them, as the natural effect of that Gravity; for Gravitation is either Motion, or *conatus ad motum*, which is the natural effect or action of Gravity.

And yet although the parts of all continued Homogeneal heavy Bodies participate of the same common Gravity, that is common to the whole *continuum*; Those parts are impeded in their actual or sensible Gravitation one upon another, by the support that each inferiour part gives to the superiour parts, as the upper parts of a Cube of Lead do not actually Gravitate upon the

the inferior parts, becauſe the upper are Mechanically impeded by the lower, from their actual Gravitation upon them; yet every Atom thereof contributes to the Gravitation of the whole upon the Scale.

But if the Solid Body be not all of the ſame conſiſtence, but the lower are of a lighter or more laxe Texture, or conſiſtence than the upper, there the upper parts will not only Phyſically and really, but Mechanically and ſenſibly Gravitate upon the lower, according to the meaſure of their exceſs of weight and ſolidity above the lower, as if the upper part of a concrete Cube conſiſts of Lead, and the lower parts of Clay, in proceſs of time, at leſt the upper will crumble away and decay the lower, by their more prevalent Gravitation, and the imparity of the reſiſtence and ſuſtentation of the lower.

Touching the Gravitation of Fluids upon Fluids, of the ſame kind and conſiſtence, I ſhall premiſe ſomething; and firſt, concerning the Gravitation of Water upon Water, and then of Ayr upon Ayr.

It

It ſeems clear, that the upper parts of Water do not actually or ſenſibly Gravitate or preſs upon the lower parts of Water; They do indeed Gravitate *ad pondus* and Phyſically upon the lower, ſo as to make the whole heavier, but they do not Gravitate *ad motum*, or ſenſibly: That which perſwades me hereunto is Reaſon and Experience, or Obſervation.

(*Fig.*2.)ForReaſon,I alledge,that if the upper parts, ſuppoſe the Cube of Water *C* ſhould Gravitate ſenſibly upon *D*, and conſequently upon *E*, in the Veſſel of Water *A B*, it muſt either be by diſplacing of *D* and *E* from their poſition, and ſo *C* to ſubſide in the place of *D*, and after in the place of *E*, or elſe it muſt be by Compreſſing of *D* into a ſhallower ſpace; but it can be neither of theſe, and therefore it cannot ſenſibly or *ad motum*, Gravitate upon *D*, and conſequently upon *E*.

As to the firſt Propoſition, we cannot, that I know of, think of a third; It is true, it hath a Gravitation *ad pondus*, becauſe it adds the weight of a Cube

Cube of Water to the common weight of the Water, but as to any ſenſible Gravitation, or Gravitation *ad motum* it is otherwiſe.

As to the minor Propoſition, it conſiſts of two Parts; 1. An Excluſion of the diſplacing of *D*: 2. An Excluſion of its compreſſion or contraction in height.

1. It cannot remove *D* from the place it holds, becauſe the Cube of Water *C* is of equal weight and ſolidneſs with that of *D*; and it muſt be either a Body intrinſecally or at leaſt extrinſecally heavier than *D*, that muſt make *D* give place to it.

If it be ſaid that *D* may get out of either ſide, and ſo give way to the preſſure of *C*; that cannot be, for the Collateral or Tranſverſal Column of either ſide, as ſtrongly compreſſeth *D* as the Cube *C*, becauſe each ſide is not only preſſing with its lateral preſſure againſt the ſides of *D*, But there impends upon that lateral Column a Cube or Column, of equal height with *C*, and preſſeth as hard upon it.

2. Again, if *C* should actually and sensibly Gravitate upon *D*, and consequently *C* and *D* upon *E*, and so *C* should subside, that which is driven up would possess the place of *C*, and then that should subside again, and other should succeed in its place, and so the Body should be in perpetual Motion, which is not only contrary to common Sense and Experience, but to Reason also.

3. Again, (which is but a various Explication of the first instance) it is not possible for a Body of equal weight (such as *C* is to *D*) to impel or drive out of its place a Body of the same equal weight, for the resistance is as strong as the power that should move it, which necessarily must give rest; for if the Cube *D* be driven out of its place unto a higher Superficies, it must be driven up by a greater weight than it self, otherwise it will never obey it, nor yield to it.

Some therefore finding these difficulties, have resorted to the second part, namely, That the Cube *D* is compresst into a shallower consistence: But this cannot be neither. First,

First, if it be compreſſed downwards; namely, between *C* and *E*, and alſo *E* between *D* and the Fund, then it muſt be compreſt narrower alſo, becauſe for the reaſon before given, the lateral preſſures againſt the ſides of *D* muſt be as effectual as that upon the upper Baſe of *D*; which would make ſtrange work.

Secondly, Though the quality of Ayr be ſuch, as it may be capable of Compreſſion, yet Water is utterly uncapable of it; if we lay a weight of a hundred pound upon a Veſſel of Water, indeed if it do not compreſs the whole Superficies of the Water entirely, it will drive it up where it doth not preſs; but if it ſtrictly cover the whole Superficies of the Water, it will never preſs it ſhallower.

Thirdly, It is more evident to Experience, that the lower parts of the Water are not preſſed by the upper: For firſt, If it ſhould be ſo, a Tube of Water, ſuppoſe ten Foot long, filled and cloſely ſtopped at both ends, would break the Glaſs, if it lay Horizontally,

or if a reclined Tube were exactly filled, yet being ſet up perpendicularly, it would leave a vacancy, which it will never do, notwithſtanding the pretended Acceſſion of the Gravitation of Ayr to boot. Again ſecondly, Let any man try it in a Tube of Water of conſiderable length, and put in a little button of Wax, incloſing a peece of Lead to make it ſink, it will ſink to the bottom of the Water, rather with ſome little degrees of Acceleration, the lower it deſcends; which could never be, if the Water were more compact and preſt below than above.

As to Experiments and Obſervations, it is agreed by all perſons, that have treated of Hydroſtatiques, that I know, only one excepted, That if a Solid Body, ſuppoſe of Wood, of equal weight with the like quantity of Water, be placed in Water, it will reſt in all Poſitions under the Superficies of the Water, which could not poſſibly be, if the Water towards the bottom were more compreſſed than it is towards the Superficies: This is agreed by *Archimedes*,

medes, the Master of Hydrostatiques, in his Book, *De Insidentibus Humido*; by *Stevin*, in his *Hydrostatical Elements*, Prop. 4. By Mr. *Wallis*, Mr. *Boyl*, and others.

Only a late Author, in his *Hydrostatical Theorems*, tells us, that such a Solid will emerge so, that its upper Superficies will be contiguous to the Superficies of the Water; And this he concludes, not so much upon his Observation or Experience, for ought I can find, as upon this very supposition, that the Water below is more compressed than that above.

It is a difficult matter to find any Solid by its own specifical uniform weight, to be just equal to the weight of a bulk of Water of an equal dimension to it, without application of some subsidiary supplyes to equal it, which possibly may make the Experiment it self uneffectual; yet upon the best tryal I could make by such subsidiary applications, I rather find such an Equiponderating Solid rather to be apt to subside to the bottom, than emerge to the top.

2. Again, the next Experiment which I ſhall mention, ſhall be that of the ſame Author, in his ſeventeenth Experiment, wherein, if I underſtand him aright, he contradicts what he had delivered in his fifteenth Theorem: *viz. If a Glaſs bubble with a long ſtem turned up, heated, and then the ſtem Hermetically ſealed and depreſſed into the Water, by a convenient weight of Lead, and the Bubble tyed with a ſtring to the Beam of a Ballance, with ſo much weight as might counterpoiſe the Bubble, then the ſtem broken with a Forcept, whereby the Water entred and half filled the Bubble, the Bubble ſubſided and required an addition of a farther counterpoiſe of* 4 *Drams and* 38 *Grains, to reduce it to an* Equilibrium, *then the Bubble taken out, and the Water driven out of it, weighed* 4 *Drams and* 30 *Grains:* This inſtance being given by a worthy Perſon, to prove, that Water weighs in Water: But the Author, in anſwer thereunto, clearly evinceth, that the Water in the Bubble is ſupported by the ſubjacent Water, and concludes evidently thereupon, that

Water

Water weighs not in Water.

3. Again, if Water ſhould ſenſibly Gravitate upon Water, it muſt as ſenſibly Gravitate upon any Body ſubjected in it, eſpecially if it be at the Baſe or fund of the Water: But the Experience of divers, of the agility of Fiſh of a great breadth, lying at the bottom of the Water, and infinite more, do ſufficiently evince, that the weight of the ſuperior parts of Water Gravitate not upon the inferior parts, with any ſenſible preſſure, for if it ſhould, it muſt of neceſſity Gravitate upon the interjacent Water, lying between the uppermoſt Cube and the Body; and if it ſhould do ſo, it muſt conſiderably Gravitate upon the ſubjacent Body.

But this *Non-gravitation of Water upon Water, or upon ſubjected Bodies, and the reaſons thereof*, I have elſewhere examined.

(*Fig.* 3.) An excellent Perſon, in the firſt, ſecond, and laſt Chapters of *Hydroſtatical Paradoxes*, hath endevoured to prove the actual Gravitation of the

ſuperior parts of Water upon the inferior, by three inſtances, *viz.* If in the third Figure, the Veſſel *AB* be filled with Water unto the Superficies *c d*, and then the Tube be by ſuction filled with Oyl of Turpentine (a Body lighter than ſo much Water) be ſtopped nimbly at the top, whereby the Oyl remains ſuſpended, and then the lower open end be immerſed in the Veſſel of Water unto any depth, ſuppoſe *H*, and then the Finger be removed from *G*, the Superficies of the Tube, the Oyl will be kept up to ſuch a height as may counterpoiſe the like Column of Water in the Veſſel; and if it be immerſed lower, the Oyl will riſe in the Cube conſiderably higher, and if it be lifted up higher, nearer to the Superficies of the Water, the Oyl will ſubſide lower, and diſcharge part of it ſelf into the Water, becauſe then the like Column of Water in the Veſſel grows ſhorter, and hath a leſs counterpoiſe to the Column of Oyl in the Tube, which he concludes to be a concludent evidence of the various degrees of Gravitation

of

of the Water upon the various imaginary Superficies thereof. The second instance is like it, namely, That if the same Vessel were filled with Oyl to the Superficies *C D*, and the Tube *g* filled three or four Inches with Water by suction, and the upper end *g* nimbly stopt with the Finger, and then the lower end *H* immersed in the Oyl, the deeper it is immersed, the higher the Superficies of the Water in the Tube will remain sustained, and the nearer it is brought to the Superficies, the lower it will subside, by reason of the various degrees of Gravitation of the Oyl in several imaginary Superficies; though at the highest elevation of the Tube of Oyl, in the first instance, the Oyl, in respect of its less Gravity than Water, will sit somewhat higher in the Tube than the Superficies of the Water; and the Water in the Tube, in the second instance, will sit lower than the Superficies of the Oyl, because exceeding it, quantity for quantity in specifical Gravity. 3. The third is that of the value, which deeply immersed

in

in Water, the cover of the value will be ſuſtained by the Gravitation of the Water, with a conſiderable weight appended to it.

But it ſeems to me, that theſe Experiments concludes nothing to this buſineſs; but only evidence a reſiſtence of the Water to that Body which will raiſe its Superficies. For it is apparent, that there is required a preſſure, or force, to raiſe the Body of Water to a higher Superficies, exceeding the weight of ſo much Water as is ſo impelled higher than before, or at leaſt equal to it.

Now the preſſing down of the Tube of Oyl into the Water, or the Tube of Water into the Oyl, raiſeth the Superficies of the Water or Oyl ſo much as the Tube is impreſſed into the Water, namely, a quantity of Oyl or Water in the Veſſel, equal to the Body impreſſed and immerſed in it, is raiſed thereby, and put out of its former place, which it contends againſt, by a Renitence reſiſtence, or contrary preſſure; and as the leſs of the Tube is immerſed,

the

the leſs Liquor in the Veſſel is moved up; ſo the more of that Body is immerſed, the more is preſſed up, and conſequently, the greater preſſure is made upon the Water, the lower it is immerſed; becauſe it takes up more room in the Water, and a greater force is thereby exerciſed, to the elevation of a greater quantity of Water; and that Water, the more it is, hath the more accidental weight, or rather, reſiſtence, againſt that force which thus raiſeth it up above its common ſuperficies, which before it obtained.

And that this is the true reaſon of it, and not the various Gravitations of the ſuperior parts upon the inferior, ſeems evident by this one inſtance, which becauſe it will be uſeful hereafter, upon other occaſions, I ſhall here inſert more largely, though the thing be commonly known.

I filled a Tube of Lead of ſix Inches Diameter, and four Foot deep, and cloſe at the bottom with Water; And took a Porringer of Pewter, five Inches Diameter, and about two Inches deep,

and

and filled it with leaden Shot, and poured Water into it, to fill up the chinks, and making four holes, I suspended it with a Packthrid, like the Dish of a pair of Scales, and exactly weighing it, and the Shot, Thred, and Water, it weighed all exactly 78 Ounces, wanting $\frac{1}{8}$ of an Ounce; then suspending the Dish with a Packthrid, to the end of the beam, I set it down 40 Inches deep into the Water, below its Superficies, and it lost its weight, by the resistance and crassitude of the *medium*, *viz.* the Water 9 Ounces $\frac{1}{2}$ of its weight in Ayr; and so weighed 68 Ounces, and near about $\frac{1}{2}$ of an Ounce; and just the same weight it held, when raised 15 Inches, when raised 28 Inches, though it was then within 12 Inches of the Superficies; but at last, when I raised it 12 Inches higher, so that the Superficies of the weight was equal with it, and yet it lost not above $\frac{1}{8}$ of an Ounce; which I decrement, was, as I think, because possibly the four strings that sustained it were not now under Water.

What

What then is the reaſon why, when the Tube of Oyl or Water is ſunk lower, the preſſure of the Water is unequal? and why in this inſtance, the weight of the Diſh is no more charged with the weight of the Water, at 40 Inches, than when juſt even with the Superficies of the Water: I ſay it is not the Gravitation of the ſuperior parts of the Water upon the inferior, for then my weight of 5 Inches Diameter could never keep the ſame weight at 40 Inches depth of Water, at 12 Inches depth, and juſt at the Superficies; but the true reaſon is, becauſe in the weight of the Porringer and Shot, being the ſame bulk at 40 Inches deep, as at the very Superficies, drives up no more Water out of its place at one ſtation, than another; namely, a bulk commenſurate to the bulk of the Porringer, Shot, and included Water, which is the ſame, both at the fund of the Tube, and when its Superficies is contiguous to the Superficies of the Water: But in the inſtances of the Tube, if it were ſuppreſſed an Inch Dia-

Diameter, when it is immersed an Inch its *potentia*, lifts up but a part of Water commensurate to that Inch; and therefore the resistence, or Renitence between the Tube, and the Water, is but little; but when it is immersed ten Inches, there is ten times more Water driven up, and therefore the Renitence is the greater, and impels the Liquor included in the Tube the higher; But this concerns nothing the weight of Water in its quiet consistence: His other Experiments, in order to the proof of the Gravitation of Water upon Water, I shall consider in the fifth Chapter.

CHAP.

CHAP. IV.

Concerning the Gravitation of the Ayr upon Ayr, or any ſubjected Bodies in it.

THe Queſtion in hand concernes not Ayr put out of its ordinary texture, but touching the free Ayr, wherein Men and Animals live and breath.

And now to ſtate this Queſtion aright, we muſt conſider, 1. What the Queſtion is not, and 2. What the Queſtion is.

1. The Queſtion is not whether Ayr compreſſed and thruſt together, hath a weight in it that may put it into a conſiderable Gravitation upon other Ayr, either not compreſſed at all, or leſs compreſſed; for it ſeems very probable by the Experiments of theſe Excellent Men, *Merſennus*, *Shottus*, Mr. *Boyl*, and others, that have ſet themſelves unto tryals, in order to this inquiry,

quiry, that such a Gravitation may and doth happen by the compression of Ayr in Æolipiles and Wind-guns, that such Ayr may have a pretty evident preponderation to so much free and common Ayr.

2. Neither is it the Question, whether there may not be, or are not intersperſions of Vapours *Effluvia*, and *Effluvia*, or other *Moleculæ* even in the free and common Ayr, that considered in themselves, have a preponderation even to the Ayr it self; for although the strict intermingling, interweaving, and contiguation of some Vapours and *Effluvia*, grosser and weightyer than the Ayr it self, may enable the Ayr to sustain and bear up many of these grosser Bodies, (as Water oftentimes sustains minute Bodies, or Gravels of Sand specifically heavier than the Water) yet we every day see, that if these portions of interspersed Vapours or *Effluvia*, grow too heavy for the Ayr to sustain them, they are precipitated out of it, and discharge themselves upon the Earth, as we see in Hail, Snow, Rain,

and

and Mists. 3. Neither is the Question, whether a portion of the free Ayr, separated and disjoyned from all communication with the foreign Ayr, hath any Gravitation or no, for it seems to me, that it may have, by such a separation an actual Gravitation, which is not by reason that it acquires any new quality or accession of weight, than it had before, but by reason of such separation it doth *Removere prohibens* of its actual Gravitation; namely, the contignation that it hath with the common Ayr, into and with which it was in continuity, it was interwoven, and that little inconsiderable Gravitation that it naturally and simply considered hath, is overmatched and broken by those interveining Filaments of the rest of the Ayr, with which it is in continuity.

And therefore I do think, that if Ayr of the same consistence with the Ayr we live in, were freely let into a Bladder, which we will *per impossibile* suppose to be destitute of all weight, such a Bladder of Ayr, thus filled, (though without the help of *inflation*,

by our *longes*, which must needs carry with it some fuliginous Ingredients;) I say, such a Bladder of Ayr would subside in the same common Ayr out of which it was taken, and would Gravitate upon the Ballance, more than the like quantity of free and open Ayr incumbent upon the other Ballance.

Nay farther I dare adventure to say, That if we could suppose a Tube, open at both ends, so long, as to reach from the top of the Atmosphere, unto this Earth, such an included portion of Ayr, severed from communion with the Atmosphere, would have some Gravitation more considerable perchance, than we have ever felt from the open Ayr.

For I do much attribute the exclusion of all sensible Gravitation of the free Ayr, to that mutual interweaving of the Filaments of Ayr one into another, like a vast Net, with small Mashes or *interstitia*, filled gradually with parts more and more subtil; and this contignation sustains and keeps the parts of it from that separation, that otherwise

the

the interpoſition of a groſſer body would intercept: And although Water, in reſpect of its weight and texture, be more ſubject to disjoyn from the reſt of its body, than Ayr is, we ſhall find in the next Chapter ſomewhat Analogous to this, even in a conſiſtent Body of Water.

4. Neither is it the Queſtion, whether even the free Ayr it ſelf may have ſome intrinſique Gravity, though admirably little and inconſiderable; for if we do ſuppoſe the compreſſion of divers Particles of Ayr may render that compreſſed Body of Ayr ſenſibly heavy, we may not wholly exclude thoſe Particles from all kind of Gravity before compreſſion, for no weighty Body can ariſe from the coalition of ſuch parts as had no manner of Gravity before.

5. Nay, yet farther, the Queſtion is not, whether as the free Ayr hath ſome intrinſique Gravitation; ſo neither is it the Queſtion, whether this free Ayr hath not ſome, though very inconſiderable meaſure of actual Gravitation;

it is not impossible but it may have some, though scarce perceptible to sense, notwithstanding all the interspertions and mixtures of Vapours and *Effluvia* from the Earth and Water.

But the Question is, whether the free and common Ayr, wherein we live, which is commonly called Atmosphere, extending upwards about seven Miles or more, hath any sensible actual Gravitation upon the lower World. 2. Admit it have, whether any determinate portion of that Atmosphere, as a Column or inverted Cone, for the purpose, of six Inches square at the Base, hath any actual Gravitation upon the subjected Base, upon which it is supposed to rest. 3. Admit it hath, whether that Gravitation be of any considerable, and of what moment.

Before I come to discuss the Questions themselves, it will be necessary to repeat somewhat that I have before said, touching the proportion of Gravitation, that is alloted to a portion of, for instance of six Inches square of the Atmosphere, when it pertingeth near to the Superficies of the Earth. A

A Cube of Water, six Inches square, contains 216 square Inches, and upon the exact Calculation of those that have tryed it, weighs just seven Pounds, and a Cube of twelve Inches square of Water weighs 56 Pounds.

A Cube of Quicksilver weighs fourteen times as much as the like quantity of Water, though *Mersennus*, and some others, nearer to the truth, compute it to be thirteen and ½; but I will make my Calculation by fourteen, to avoid Fractions.

The consequence whereof will be, that a Cube of six Inches square of Mercury, will weigh 98 Pounds, which is fourteen times as much as the like Cube of Water.

The consequence whereof is, that fourteen such Tubes of Mercury weighs 1372 pound.

In the *Torricellian* Experiment, the Mercury is sustained to the height of 29 Inches ½; to avoid Fractions, let us reckon it 30 Inches, be the Column never so large.

If the Column of Mercury be six

Inches square at the Base, then there will be five such square Cubes of Mercury in that Column will weigh 490 Pounds: According to the late Philosophy, this Column of Mercury is counterpoised with a Column of the Atmosphere of six Inches square, and extending from the restagnant Mercury to the upper surface of the Atmosphere.

And consequently, this Column of Ayr or Atmosphere, doth actually gravitate with a weight of 490 Pounds, upon the restagnant Mercury, and really and actually weighs as much as that comes to; and consequently, when I hold a Trencher in my hand of six Inches square, there is incumbent upon it 490 Pound weight of Ayr, though there be found a help in that case to support it, by the recoyling Column of Ayr, commensurate to it; whereof in its due place.

And this is the supposition I contend against in this paper, *viz.* that 1. The whole Body of the Atmosphere hath no considerable Gravitation either upon its

own

own parts, or upon the ſubjected Body of the Terreſtrial Globe, much leſs ſuch a prodigious Gravitation as is here ſuppoſed. 2. If it had, yet any given portion or Column of the Atmoſphere, hath no ſuch Gravitation.

Touching the Gravitation of the whole Atmoſphere in general, upon the Terreſtrial Globe entirely, I ſhall not ſay much, becauſe it is not capable of Experiment, only my reaſon and ſenſe ſuggeſts it to me, that it is neither evident nor likely to be of ſo vaſt a Gravitation as the late Philoſophers affirm.

Firſt, I confeſs I am none of thoſe Adepts in Philoſophy, that can tell us how to ſolve all the effects in Nature, without recourſe to the infinite Wiſdom, Power, and Goodneſs of the Glorious God, who certainly knew better how to frame the World, and fix the Laws of Nature, than the wiſeſt of Men or Angels. I muſt confeſs, I know not how to reſolve the reaſon of the Motion of weighty Bodies downward nor why or how either the Sun holds his regular Motion, if the Hypotheſis

of *Ptolemy* be true, or why the Earth, as other Planetary Bodies, holds its regular Motion, if the Syſteme of *Copernicus*, and *Galilæus*, be true, and a thouſand ſuch inſtances; but into the primitive diſpoſition and ordination of the Moſt Wiſe, Powerful, and Soveraign Lord and Maker of the World, who hath fixed the Order and Law of Nature, by his Soveraign *Fiat*, with the moſt exact accommodation of it to the concerns of the Univerſe, and all the parts thereof, and with moſt incomparable Congruity. This Soveraign Architect, that hath made all the parts of this *Mundus aſpectabilis* in Order, Weight, and Meaſure, and deſigned the Earth and Ayr, for the habitation and uſe of Men, and all other breathing Animals, and likewiſe for Vegetables, hath ſo ordered and digeſted the texture of the Ayr, that the inferior part is more groſs than the ſuperior, and fitted for nouriſhment and reſpiration; the upper parts more ſubtil, and pure, and light, and deſtined to other uſes, hath ballanced the Ayr, ſo that the more

light

light and ſubtil parts are inclinable perchance, more to aſcend; and the lower parts gradually more laden with Particles of a groſſer allay, and ſo poſſibly thereby inclinable to ſubſide; and he hath connected the more ſubtile, and the more Feculent parts thereof, ſo together, that they hold an *Equilibrium* as a ſtate and poſture more ſerviceable to the ends and uſes he deſigned for it, and for which they ſerve: The proceeding of this Soveraign Architect in the Frame of this great Building of the Univerſe, not being like to the Architecture of men, who begin at the bottom; but he began at the Roof, and Builded downwards, and in that proceſs, ſuſpended the inferior parts of the World upon the ſuperior. But this kind of reaſoning, I know, is not grateful to the palate of the preſent Philoſophers; I therefore proceed.

Secondly, Therefore I ſay, that the common appearances of the World, ſo far as they are obvious to our common ſenſes, contradicts this immenſe, nay, or any conſiderable Gravitation of the Atmo-

Atmoſphere upon ſubjected Bodies; It is hardly conceptible, how Birds could raiſe themſelves upon their wings, and keep themſelves in free Ayr, if a burthen perchance of above 1000 pound weight ſhould lie upon their Wings and Bodies; it were not poſſible for me to breath, to walk, to ſtand upon my Feet, if at every time I open my Mouth, a Column of Ayr of three hundred pounds weight were preſſing into it, it would tare open the valves of my *Larinx*, and blow up my Stomach and Intrals, like a Bladder, and break my Ribs, if it had an admiſſion; and if it had not the circumjacent preſſure of the Ayr, would preſs me to death: Theſe and the like inſtances render this prodigious Gravitation of the Ayr incredible to us vulgar Souls, that are apt to credit our ſenſes.

But I very well know, that theſe will be ſaid to be vulgar common places, and that they have many handſome Solutions of theſe common difficulties.

And it is true, I very well know, they

they have colourable Solutions for those sensible occurrences, as the supposed counterpoise of included Ayr, and of the recoyling Columns of Ayr; which I shall in due time consider.

But I do reply, that though these common instances perchance amount not to demonstrations of the untruth of the Hypothesis, yet they do require a very great and very clear evidence to encounter even those vulgar experiences; and therefore, if any Solutions offred of them, are not perfectly concludent, but strained, and the instances they give in their favour, are capable of any other Solution, than this which is so visibly and apparently contrary to our sense; such Solutions and such instances are too weak and impotent to build such uncouth conclusions upon.

Thirdly, Therefore I say, there is not any one instance or experiment, that ever I yet heard of, for the evincing of this imaginary Gravitation of the free Ayr, but is readily capable of a more sutable Solution more adequately fitted

fitted to the *Phænomenon*, and less incumbred with difficulties than this new Solution, by the Gravitation and Elatory of the Ayr. I shall refer my self herein to Mr. *Linus* his Tract *De Inseperabilitate Corporum*: And *Honoraly Fabri*, in the 6th of his late *Philosophical Conferences*, wherein all the instances given from the *Magdeburg* Engin, and the *English* Ayr Pump, and particularly the *Torricellian* Experiment, are sufficiently and much more satisfactory and naturally solved, without recourse to this imaginary Weight or Spring of Ayr.

And there are above an hundred Experiments of this kind and nature, which can never by this solution be explicated (without intolerable torture of them) some instances whereof we shall in due time remember.

But omitting more that may be replyed in general to the common Gravitation of the Ayr; I shall more particularly and closely apply my self to the second.

2. Therefore, admitting it were possible

poſſible to ſuppoſe the whole Body of the Atmoſphere might Gravitate upon the Earth in general, yet no one particular portion of the free and common Ayr, impending upon any one determinate Superficies, can at all or at leaſt can ſenſibly or conſiderably Gravitate upon any determinate *Baſis*.

And the reaſon ſeems to me to be this, becauſe although we ſhould admit a conſiderable Gravity of a portion of Ayr taken, divided and ſeparated as one intire ſeparate Groſs Body (as in a Bladder, a Glaſs Bubble, or the like) ſo that it partakes of the common quality of heavy Bodies, yet there is a peculiar preſſure or Gravitation belonging to this ſubtile Fluid Body, which hath its lines of direction every way within the compaſs of its own extream Superficies, whereby that perpendicular Gravitation, which is common to all Bodies, is corrected, abated, and in a great meaſure ſuſpended. 2. Becauſe that if there were no ſuch allay given to its common perpendicular Gravitation, by its proper Motion or Gravitation of its

own;

own; yet the Ayr being one continued Body, and so interwoven and mortaised as it were, one part in another, the other parts of the Ayr that are contiguous every where to the Earth, do sustain and bear it up, like the sides of an Arch, from any sensible pressure or Gravitation upon any determinate or particular Body, that is within the compass of its pressure; as I have elsewhere inforced the Argument in relation to the Gravitation of Water upon subjected Bodies, narrower than the common Base that supports such Water.

And although the Ayr hath an intermingling with it of Vapours and Terrestrial and Aqueous *Effluvia* heavier than it self; yet they are so interwoven in the very Webb and texture of the Ayr, that it supports many of them, and those that are too heavy for it, or much disunited and separate from it, are precipitated upon the Superficies of the Earth, and the Ayr discharged of them, as in Rain, Snow, Hail, subsiding Gravel Sand, *&c.*

And although the instance that

an

am now giving, is more proper for the next Section, yet it is in some kind suitable for the explication of what I intend.

Of all hands it is agreed, that the Water, though a Fluid Body, is, some say, thirteen hundred times heavier than the like portion of Ayr; others, that it is a thousand times heavier; they that speak least, say it is above nine hundred times heavier than Ayr: And it is obvious to any that attends it, that there is not the same strict Cohesion of one part of Water with another, as is of one part of Ayr with another, unless divided by a more firm and stable Body then it self: And therefore there is far more reason, that one part or Column of Water in its consistency should Gravitate upon a subjected Body, than there is, that a Column of Ayr should in the free and open Ayr, Gravitate upon a body subjected to it; And yet it will be found, that in *libera aqua*, that Gravitation that it exerciseth upon a Body subjected to it, and capable of it, is not above one half so much

as

as the weight of such a Column of Water, divided and separated from the common consistent Water.

It is true, I had not so dextrous a Messenger, to make the Experiment in the bottom of the Sea, or 20 Fathom within Water, as *Dromo* is Poetically related to have done, though I believe he never made that tryal: But I will give an account of what I have tryed and found.

(*Fig.* 4) I took a Glass Siphan of a quarter of an Inch Diameter, the longer legg 32 Inches, the shorter 8 Inches long, open at both ends.

I filled the short legg with Mercury, which, accordingly as it must rose to 8 Inches high in the longer legg, and then stopping the shorter legg with my Finger to avoid any violent pressure by the fall of the Water upon the Mercury, I then filled the longer legg to the top with Water, and gently removing my Finger from the shorter legg, to avoid too violent an Exsilition of the Mercury, I found the Mercury to subside in the longer legg two Inches and a quarter,

and

and as much driven out of the ſhorter legg, by the acceſſion of the weight of 24 Inches of Water in the longer legg, (which I confeſs is ſomewhat leſs than the proportion of weight between Water and Mercury; wherein, according to an exact calculation, 28 inches of Water counterpoiſeth 2 Inches of Mercury. But then emptying the Water and Mercury out of the Tube, I again filled up the Tube with Mercury, to 8 Inches in both leggs, namely to the top of the ſhort legg.

And then filling a glaſs Tube, of about three Inches diameter, and 32 Inches long, with Water, I immerſed the Syphon with the Quick-ſilver to the bottom of the greater Tube full of Water. And although the column of Water in the great Tube, impending upon the orifice of the ſhorter legg, was full 24 Inches, yet it drew down the Mercury in the ſhort legg, and raiſed it in the longer legg, empty of Water, only one Inch, and no more; whereby it did riſe in the longer legg to 9 Inches, and ſubſided in the ſhorter to 7 Inches,

as I could easily perceive through the great Tube, by a Scale of Inches, and quarters, fitted to each leg of the Syphon.

I then tried it doubly, *viz.* pouring in the Water into the longer legg of the the Syphon, whereby the subjacent Mercury subsided in the longer legg two Inches, and as much thereof driven out of the shorter legg, and then immersed the Syphon into a glass-vessel, 32 Inches deep, filled with Water; the Mercury thereupon subsided in the short legg somewhat neer an Inch, and no more, and accordingly impelled up the Mercury and incumbent Water in the longer legg neer an Inch: whereby it appears, that there was no *Æquipondium* between the pillar of Water included in the Tube, and the imaginary pillar of Water in the open vessel.

And in this experiment I must remember, that the orifice of the shorter legg of the Tube, and the legg it self, was of somewhat a larger diameter than the longer legg; and that might give some advantage to the pressure of the Water in the vessel upon the shorter

legg

legg. But notwithstanding that advantage, the gravitation of the external Water, or any imaginary column thereof was not half so much as the gravitation of the Cylinder of Water included in the Tube; which is sufficient to convince the mistake of those, that assign an equal pressure to an imaginary column of free Air or Water, with an equal column of Air or Water that entirely presseth upon the Mercury, and hath no other circumjacent base to lean upon.

And it is to be noted, that although, as I have said, a Cylinder of two Inches of Mercury doth really counterpoise a Cylinder of 28 Inches of Water, of the same diameter, yet in this instance of the Syphon, 24 Inches of Water drew down two Inches of Mercury, and raised as much out of the shorter legg. And the reason seems to be, because the Mercury being *in æquilibrio*, was more capable of a sensible pressure by a less quantity of Water in this *libra naturalis*, than it would be, if both were weighed in their gross consistence in an artificial Scale.

And the reaſons why the preſſure through the Tube, is ſtronger than the preſſure by the open veſſel of Water, are theſe: 1. Becauſe in the Tube the Water included had no communion with any open or free Water, nor had any ſuſtentation thereby, but in the common Water there is a communication and mutual ſuſtentation of one part by another. 2. And principally becauſe when in the Tube the Water had no other Baſe but the Mercury, to which it was commenſurate, and therefore ſingly, and entirely, and adequatly preſſed it. But the Water in the veſſel had another Baſe circumjacent to it, namely the bottom of the veſſel, from which it was built like an Arch over the ſhort legg of the Mercury, whereby the weight, preſſing upon the Mercury, was broken, abated, and intercepted. For Water will find the loweſt Baſe for its reſt.

And ſurely if this be true in Water, as upon more than one tryal I found it, it will be much more ſo in the open Air, which will much diſorder the whole *hy-*

potheſis

potheſis of the Gravitation of the Air, and thoſe very ſubtle and fine Concluſions that are ſpun out of it, and built upon it.

But I would not be miſtaken, as if I meant that the Column of 24 Inches of free Water did gravitate upon the orifice of the ſhorter legg of the Syphon, to the weight of neer an Inch of Mercury, for That is wholly contrary to my Suppoſition: but only I hereby ſhew the great diſproportion of the appearing Gravitation of Water, where it hath no lower nor other Baſe upon which it leans, but only the body of the Mercury, and where it hath another or lower Baſe upon which it leans.

For in this inſtance of the Syphon, there is another reaſon of the Gravitation of the free Water upon the cavity of the ſhorter legg of the Syphon: for here the preſſing or keeping down of the body of the Syphon into the free Water, diſplaceth and raiſeth up a portion of Water anſwerable to the bulk of the whole convex Superficies of the Syphon, which is far greater than its

cavity; and that Water so diplaced doth indeed press upon the Tube that displaceth it; and because it can find no part yeilding to its pressure but the orifice of the shorter Tube, it presseth there in such proportion, as the whole bulk of the Water, so lifted up by the immersion of the Syphon, bears to about an Inch of included Mercury, and 24 Inches of the Water included in the Tube. But of this more distinctly and exactly, when I come to examin the reason of the Valve.

2. But having thus offered my reasons against this prodigious Gravitation of the imaginary Aery Cylinders, I shall proceed to some plain and homely Experiments and Reasons, which seem to me very much to encounter the Supposition.

I shall begin with that whereunto I am sure they are furnished with an Answer, but such an Answer as will give me the opportunity of a Reply, which possibly may be of more moment, than if the Experiment it self were without an Answer.

Take a pair of Scales, the one Dish of 12 Inches

Inches of diameter, the other of 3 Inches diameter, yet of that thickneſs, that it may be juſt of the ſame weight with the other, each diſh weighing for the purpoſe three Pounds. Theſe two Diſhes will yet exactly equiponderate, yet the one ſuſtains a Column of Air of above twelve times the weight of the other, yea and according to the proportion above computed, poſſibly the greater Column impending upon the greater Diſh, may weigh above 4000l weight.

But there is a common Anſwer ſingularly fitted to this difficulty. For it is ſaid, there is a Column of Air below each Diſh, that hath a Superficies commenſurate to the lower Baſe of each Diſh, which though it be but 3 or 2 or 1 foot, nay but an Inch above the Earth, bears up each Diſh as ſtrongly as the Column of Air of 7 miles high bears them down, and ſo there is an *æquipondium* between the *pondus deprimens* upon the upper ſide of the Scale, and the *patientia ſuſtinens* of the lower ſide, and the Pillar of a Foot of length, between the Earth and the greater Scale, is of a

Foot diameter, and ſuſtains it as forcibly as the *pondus deprimens* of a Foot diameter depreſſeth it, and ſo it is ſupported by an equal force impelling it upward, as it is depreſſed by the weight of Air incumbent upon it. And the caſe is the ſame with the leſſer Scale, and ſo the greater Scale, though it hath a greater weight than the leſſer impendent upon it; ſo it is recompenſed with a more forcible power than the leſs hath to ſuſtain it, and ſo there is an *æquipondium*.

But although this ſeems marvellous, that the *potentia* of a Pillar of Air from the Earth to the Baſe of the Scale ſhould counterpoiſe ſo vaſt a weight, as what is incumbent upon it, yet to ſerve the turn, and to give a Solution by the weight and power of the Air to maintain the coheſion of two poliſhed Marbles *(de quo infra)* this reaſon is given, that as there is a vaſt weight of Atmoſphere upon the Scale, ſo there is the ſame Gravitation of Air round about it all, but what is juſt under the Scale; and this impending Air round about the ſides of the Scale, as it is ſo much, ſo it

is somewhat weightier than that which impends upon the Scale; for this reaches only to the Scale, and that reacheth somewhat farther in length, even by so much as the distance is between the Earth and the Scale; and this doth so gird and help in that short Column of Air subjacent to the Scale, that it is as firm a Pedestal or *potentia* to sustain the Scale, and to press it up by the auxiliary Columns of Air, that supply and support it, as the impending Column is to depress it, and so between both there is an *æquipondium*. So that in all cases, as well in Air as Water, the subjected Column sustaining and impelling upwards, and the *potentia* thereof is of equal force to the *pondus* of the superior Column, depressing the upper Superficies of the intermediate Body.

And the same they suppose in Water, the instances whereof is the Valve, and some other instances; but of these in the former Chapter.

And now upon this Supposition of the *potentia sustinens* of the recoiling Pillar, as I may call it, sustaining and impelling

pelling up the lower Superficies of the body, they have raised most marvellous Paradoxes and Consequences, namely, that if a Milstone were by some art suspended in the Air, if it were possible that the Pillar of Air incumbent upon it were either wholly taken away, or deprived of all Gravitation, this Milstone would be sustained by the subjected Column of Air, and possibly carried up much higher; yea, and if a long Column of Brass were let down deep enough into the Ocean, they assign a depth, at which the Column of Brass would sink no lower, but be sustained by that marvellous *potentia* of the recoiling or subjected Column of Water: things that I confess are wittily deduced, and consequential enough upon their *postulata* admitted, but such as are warily enough propounded, because impossible to be tried.

But in answer to this Question likewise, I say this will be found untrue, and therefore although the Consequences are Logically enough inferred upon such premises; yet the thing proving

false

false in the event, the Premises, Principles, and *Postulata* themselves must needs be fictitious and vain.

Suppose therefore two small Cylinders of Brass, each of 4l weight, but the one of two Inches diameter, the other of one Inch diameter, and therefore about double the length of the other, were weighed in a vessel of Water by a pair of Scales, with the Superficies of each just even with the Superficies of the Water in the vessel, they will each lose a just equal portion of their weight by the thickness of the *medium*, and will still hold their *æquipondium*, yet the imaginary column of Air impending upon the two-Inches Cylinder above treble the weight to that impending upon the one Inch diameter, and here is no recoiling Column of Air to sustain them.

But I easily foresee the Answer to this Instance, and therefore I gave it to let in what I have to say; for it will be said, that the Gravitation of the Air upon the residue of the Water, gives a greater concrete weight to the Water, by so much as the Column of Air, commen-

surate

surate to the Superficies of the Water, adds to it, and so both Air and Water make one common pressure, and consequently the recoiling or sustaining Column of Water, hath as great a *potentia sustinens* as the weight of both put together can contribute. But to avoid this *Effugium*, first I took two Brass Cylinders, weighing each four pound, but one of double the others diameter, I took then two Laton-Tubes of 6 Inches diameter, and about two foot in length, closed at both ends, only in the centre of the close Cover of the one I caused a hole to be made, commensurate to the Superficies of the Cylinder of Brass of 2 inches diam. & a like hole in the other, commensurate to the cylinder of Brass, of 1 Inch diameter, so that they might just play upon them without any considerable distance between the weights, and the concavity of the holes. I then filled the vessels brim full of water, & weighed the Cylinders with their Superficies just equal with the Water and Cover. Here could be no Gravitation of the Air upon any part of the Water, but only upon the

the Weights, so that the Column of Air, pressing upon the greater Weight, being, as is supposed, above treble to what presseth upon the less, must needs drive it down, because the recoyling Pillar of Water, could not countervail such a disparity of *pondus* of Air.

And yet I found not above one Grain odds in their Weights, the broader weighing about a thin Groat more than the narrower.

But because I would have no evasion, by supposing that that small distance between the Weights and the Hole, might give some more help and strength to the sustaining Pillar of Water by letting in some Air to lean upon the Water, thereby to enable it to keep the *Equipondium*. I took a very flat peece of Lead, with a hole in the Centre, no bigger than would let through freely that small Packthrid that suspended the Weight, and letting the Thrid through the hole, and pressing the Lead so exactly close, that no Air can pass to press upon the Water and Weight, but just that little passage for the

the Thrid which impended also in the very middle of the Weight, and thereby covering the Orifice, fitted to the one Inch weight; yet the *Equipondium* between both, continued exactly the same, as when both holes were left open, one of two Inches, the other of one Inch Diameter, at both times, the Vessels being perfectly full of Water.

And yet according to the supposition, the supposed Weight of the Pillar of Atmosphere impendent upon the two Inch Weight, could not be so little as 200 pound, and the weight of Air, pressing upon the Centre of the lesser Weight, and no where else, being not a quarter of an Inch Diameter, could not in proportion, weigh the 100th part of 200 pound, according to the supposition of this new Philosophy: And all this while the entire Superficies of the Water, discharged of all manner of Gravitation of superior Air, by the close cover that every where covered its Superficies.

I do not understand what evasion can be made, unless they will suppose that the

the little hole for the Thrid, might by a ſtrange Contagion, infect the entire Body of Water, with a new Gravitation, which nevertheleſs is ſo impoſſible, that it deſerves no other anſwer than what our common ſenſe allows; for this little pertuſe, letting in that little Column of Ayr of a quarter of an Inch Diameter, impends not upon the Water, but is wholly received by the Braſs Weights, upon whoſe Centres it leans.

So that the imaginary repercuſſive Column bearing up the Body into an Equilibrium, with the impendent Column of Air (admitting the Air ſhould have ſuch a Gravitation downward) muſt needs be a fiction upon a fiction, and therefore upon the whole matter laid together, both are fictions, and neither true.

2. But yet farther, if ſuch a preſſure upward of the inferior, or (as I have called it) the recoyling Column of Air ſhould be admitted, it doth wholly deſtroy the ſuppoſition of Gravitation of the ſuperior Column of Air, becauſe

in

in truth it renders the ſuperior and inferior Columns of Air in a perfect *æquilibrium*, every lower portion of Air checking and counterpreſſing the ſuperior, with the ſame ſtrength or *potentia ſuſtinens*, that the ſuperior portion chargeth the inferior with a *pondus deprimens*.

(*Fig.* 5.) For ſuppoſe in the 5th Figure *A B* were a Cylinder or Column of Air, reaching from *A* the Superficies of the Atmoſphere, to *B* the Superficies of the Earth, and of 12 Inches diameter. If the portion *B E F* preſs with an equal *potentia* upward to the portion *A E F*, preſſing with an equal weight downward; then theſe two portions of Air muſt be at reſt, and *in æquilibrio*, and ſo far every diviſible part of every other portion of the entire Column. And if the ſuperior and inferior parts of the Air be by this means *in æquilibrio*, there can be no more Gravitation downward than upward; for all motion muſt ariſe from a diſparity of weight and weight, or power and power, or power and weight. And therefore it is that although

although one Scale be charged with a hundred pounds weight, and the other Scale be charged with as much, the Scales will be at reſt, becauſe *in æquilibrio*; and by the advantage though but of a Grain of weight, added to one Scale, they will be put into motion, but not 'till then.

But then it will be required to make out that, upon the Suppoſition, that in our firſt Inſtance the greater Scale is kept *in æquilibrio* by the *pondus* of the ſuperior, and the *potentia* of the inferior Air; that there will be the ſame *æquilibrium* between the *pondus AEF*, and the *potentia EFB*, upon or in every imaginary Superficies of the Column of the Atmoſphere; as *EFCD*, or any other imaginary ſuperficient, interjacent between the top of the Atmoſphere *A*, and the Superficies of the Earth at *B*.

And ſurely there need not be much pains taken to prove this: for it is not the interpoſition of the Scale that makes the *æquilibrium*, but it is the counterpreſſure of the ſuperior and inferior

part of the aerial Cylinder, which must needs be as effectual, and of the same kind and strength, if that Scale were removed out of the way; for though the interposition of the Scale hinder the contiguity of the upper and lower Cylinder, yet it contributes nothing to the Gravitation of the one, or pressure upward of the other.

Upon all which large digression, it seems to me that their very answer given, that the equal Gravitation of each Scale, the greater and the lesser, is by the equal pressure, *viz.* by reason the greater Scale as it is pressed by a greater aerial Cylinder, is also supported by a reversed or recoiling Cylinder of Air of equal sustaining force, though not of equal length with the superior, destroys totally their whole Supposition of the Gravitation of the Air, and renders their contrivance of the investigation of the weight of the Atmosphere, by the *æquipondium* thereof, to a Cylinder of 29 Inches of Mercury, utterly ineffectual.

And this it seems to me must be admitted,

mitted, namely that the inferior Cylinder of Air recoiling and returning from the Earth, or any other ſolid Baſe, doth in truth ſuſtain the impending *pondus* of the ſame Cylinder, and ſo there is an *æquipondium* in any given or imaginary Superficies of Air between the *pondus deprimens* and the *potentia ſuſtinens*, in the ſame perpendicular Pillar or Column: and ſo the Air becomes not heavy in it ſelf, but yet that it gravitates entirely upon the Baſe, which is as it were the common *hypomoclian* that receives the impreſſion of the impendent Air, and remits the *potentia* upward in counterpoiſe to it.

But then they ſay, that where in that Pillar of Atmoſphere the Contiguity between the ſuperior and inferior Columnn is interrupted by ſome intervenient body: as in the firſt inſtance, by the intervention of the Scale the *æquipondium* between the *pondus deprimens*, and the *potentia ſuſtinens* of the aerial Pillar, is wrought by another means, namely the imaginary Pillars of Atmoſphere circumjacent to that intercep-

ting body: as ſuppoſe the three Columns of Atmoſphere *AMBNCO*, and the Column *B* were cut off at *D* by any ſolid body (ſuppoſe the Scales, in the firſt inſtance;) yet the two adjoining Columns gravitate upon the inferior Pillar of Air (ſuppoſe it tranſverſe,) and ſo give it as vigorous a repercuſſion as if it were in the ſame perpendicular Column: as in the figure,

Suppoſe *BH* be a Column of Air, impending upon the cube *H*, of ſix Inches ſquare; *H* to be (for inſtance) a cube of Braſs, ſome way there ſuſtained; *EN* be the ſubjected Column of the ſame baſe, reſting upon the Superficies of the Earth at N. Suppoſe alſo *ADm*, and *CFo*, be two lateral Columns of Air, preſſing *g* upon a lateral or tranſverſal Pedeſtal of Air *GIKL*, upon an imaginary Superficies, contiguous to the lower Baſe of the cube H, namely *GDFI*; here the Cylinders *HD* and *CF* preſs ſo ſtrongly upon the entire tranſverſal Baſe *GDEFGKLMNO*, that the portion thereof *EN* is ſo ſtrongly bound together, compreſſed, and fortified by

the

the columns *A D* and *C F*, that it ſuſtains the cube *H* as forcibly as it would have ſuſtained *B H* an entire Column of Air, and ſo makes an *æquipondium* and ſuſtentation of the cube *H*.

(*Fig.* 6.) To examine the truth of this Suppoſition, let us ſuppoſe in this, *A* to be the baſe of the cube *B C D*, and *E* to be the baſes of four Pillars or Columns of Air, contiguous to the four ſides of this cube, equal in Baſe to it, and all theſe Baſes, both of the cube *A* and of the four collateral Pillars of Air, to be upon the Superficies of the Earth. If *A* be removed higher, as to *H* in the former figure, the intermediate ſpace between *H* (in the former figure) and the Superficies of the Earth, *viz.* the ſpace *H N*, muſt be furniſhed with Air; now the Air, that muſt ſupply that ſpace, cannot be immediately thruſt in from the Pillar ſuperior to the cube, *viz.* *H B*, becauſe the deſcent of that Pillar of Air is obſtructed by the interpoſition of the cube *H*, whereupon it is bottomed. Therefore of neceſſity each of the collateral Pillars of Air, *B C D E*, muſt

must thrust in an equal portion of their stock of Air, to supply the *interstitium* of *Hn* in the former figure; and then they will want so much of their Pillar, as will make good what they have thus contributed to fill that space. And this they are to borrow from the Pillar *HB*, that lay perpendicular to the cube, which now at this Elevation is *BH*: for as the cube it gradually raiseth from *N* towards *H*, the Pillar of Air incumbent upon it must be displaced, and what is so displaced, must be thrust into the lateral Pillars *BCDE*, to supply what they contribute to the relicted space *HN*: and so in every Elevation higher of the cube *H*, so much space as it leaves, must be immediately thrust in from the collateral Pillars adjacent to the Tube, and must be made good in the same moment from the Air, thrust out of the perpendicular Pillar *BH*, by the gradual Elevation of the cube to supply the collateral Pillars. By this process of one part of the Air into another, to accommodate the motion of its parts, it seems evident, that there is not

that preſſure of one part of the Air upon another, nor of all upon the common Baſe, that ſhould be like ſo many Wedges to keep every portion of Air juſt in that place it hath; or by Gravitation of one part upon another, to keep all the parts ſo tight one to another, as the *Suppoſition* imports. For then certainly there could be no motion or tranſmigration of one part of the Air into another, as we ſee there is not only in the Inſtance above given, but in a thouſand more. The moſt forcible Winds could no more remove one portion of Air out of its place, then they could remove a Pyramid of *Memphis*, if this Suppoſition were true.

Therefore there ſeems to be very little ground for the late Maſters of Experiments, to lay any weight of proof for their ſuppoſed Gravitation of the Air, upon the *Torricellian* Experiment; which, by what I have ſaid, and ſhall hereafter ſay more at large, depends upon a clear other Solution.

And thus far in general, touching the Gravitation of Air in Air, or upon

any other Bodies; wherein I have been the longer, becauſe I ſhall perchance hereafter have recourſe to ſome of the things ſaid in this Chapter.

CHAP. V.

Concerning the Gravitation of heavier Fluids upon thoſe that are lighter.

THere be thoſe that contend, that there is no Body poſitively light, but only comparatively; and that the Aſcenſion of any Bodies is not from the intrinſick nature or quality of the Bodies themſelves, but becauſe others that are more heavy than thoſe are, and more vigorous in their deſcent, do drive up thoſe that are leſs heavy, by taking their places, and ſo force them to mount higher.

Whatever may be ſaid in this reſpect, in relation to Air, yet ſurely it holds true in other groſſer Fluids, and ſometimes in ſolid Bodies alſo: Oyl is truly heavy, and yet driven higher by Wa-

er,

ter, which is ordinarily heavier than Oyl. And the same is true in relation to Water and Mercury, the latter driving up the former though a heavy Body, because not so heavy as Mercury. As I have before said, there is a double Disparity or *æquipondium* of heavy Bodies; one in relation to their intrinsick or specifical weight, another in relation to the external or quantitative weight. Water is specifically heavier than Oyl, and Mercury than Water; whence it comes to pass, that a bulk of Mercury weighs more than a bulk of Water equal to the bulk of Mercury; one square Inch of Mercury, counterpoising neer 14 square Inches of Water. But yet the bulk or quantity of Water may be so much, or so great, that it may overpoise the Mercury, two ounces of Water necessarily being more, and weighing double to an ounce of Mercury, though specifically heavier than Water.

And therefore in the consideration of the Gravitation of heavy Fluids upon lighter, we are to take these two parts into consideration. *viz.*

1. The

1. The Gravitation of a Body, ſpecifically heavier, upon or in a Body ſpecifically lighter; as the Gravitation of Mercury upon Water, or Water upon Oyl or Air.

2. The Gravitation of a Body ſpecifically lighter, yet in quantity or extrinſically heavier than the Fluid it preſſeth; as two pound of Oyl upon a pound of Water, and the like.

As to the former of theſe, there ſeem to be four ways, wherein the Gravitation or preſſure of a Fluid upon a Fluid, ſpecifically lighter, ſenſibly is exerciſed. *viz.* 1. By way of Penetration, 2. by way of perpendicular, or other deſcending Depreſſion, 3. by way of lateral Preſſure, 4. by way of Elevation of the lighter Body.

For the firſt, if a cube of 12 Inches ſquare be filled 9 Inches with Oyl, and the other three be filled up with Water; though for the preſent the Water gently poured on will flote upon the Oyl, yet in a little time it will penetrate through it, and get under it, and the 9 Inches of Oyl will ſwim upon it, preſſing

ſing its Superficies equally every where.

And ſo if a *lumen* be at the bottom of the cube, the Water firſt, and then the Oyl, will gravitate upon the Air, and preſs through it.

But if the top of the cube be cloſely covered, ſo that Air cannot get in above the Water, the Oyl will not deſcend through the *lumen*, the reaſon whereof is hereafter explained.

For the ſecond, it is very plain, that the heavier Fluid will in ſome Inſtances preſs upon all the lighter, by a depreſſion where it can have way; ſometimes immediately, ſometimes mediately, *viz.* notwitſtanding the interpoſition of another body. For inſtance,

If an empty Bottle or Glaſs-bubble be placed in a veſſel of Water, at a ſmall depth, the Air included in the Bottle or Bubble, being a Body lighter than Water, will mount up to the top, if it be not kept down: for a ſmall preſſure of Water, though it preſs upon the included Air as much as it can, yet it cannot compreſs the Air ſo much, as to drive into it a quantity of Water, that may

make

make the Bottle and included Water equal in weight, or more in weight than the like bulk of simple Water; but if more Water be poured into the vessel, whereby a weight of Water incumbent upon the narrow mouth of the Bottle or Bubble, is sufficient to compress the included Air, to such a contraction, as may admit Water enough to make the Bottle, with the admitted Water, to counterpoise more than a like quantity of simple Water, the Bottle or Bubble will subside, and sink to the bottom again; if the vessel be unladen considerably of its Water, whereby the Air included in the vessel being under a less pressure, can expand it self to its natural dimension, and thereby thrust out of the Bottle so much of the included Water, as may render the Bottle, with the included Water, lighter than a like quantity or bulk of simple Water, equal to the bulk of the Bottle, the Bottle will emerge again.

This is the Experiment mentioned by *Schottus*, in his *Magia hydraulica, parte* 3, *l.* 5, *problem.* 3. and the excellent Author

Author of *Hydroſtatical Paradoxes*, *pag.* 16, 53, 153. and elſewhere. The Experiment is certainly true, but the Solution thereof, and the Concluſion deduced from it, of the Gravitation of the upper parts of the Water upon the lower, is as I think wholly miſtaken; for the reaſon of it is not from the imaginary Gravitation of Water upon Water, but of Water upon Air, which being a lighter body than Water, and capable of compreſſion into a narrower compaſs, by the Gravitation of Water upon it, ſuſtains that weight of the Water, and is compreſſed by it, and under it: it is not an effect of Gravitation of Water upon Water, which is of equal intrinſick or Specifical Gravity, but of Water upon Air, which is a lighter Fluid, and compreſſible. Again, this Gravitation of heavier Fluids upon lighter, though not immediately contiguous, is plain by this inſtance.

If a Cylindrical veſſel of Water be of 6 Inches diameter, and there be a Rundle of Wood ſpecifically lighter than Water of five Inches $\frac{3}{4}$ diameter placed

placed at the very bottom of it, the Water will drive it up to the Superficies of it, because it is a Body specifically lighter than the Water. But if there be a hole of five Inches diameter in the bottom of that vessel, and the Rundle be placed upon that hole, so that it somewhat overlaps the hole, so that the Water cannot pass out of it, and then it be filled up with Water; the Rundle will gravitate upon that hole, and the incumbent Cylinder of Water, commensurate in Base to that Rundle, so hard and close, that it requires a weight in a pair of Scales, neer commensurate to the weight of the impending Cylinder of Water, to raise it from the bottom; and the reason is, because the Rundle being the *Operculum* of that hole, through which the Water should pass into the lighter Fluid, the Air, and so is the impediment of the Waters passage, it gravitates upon it, because it hath mediately a lighter Element upon which it gravitates, namely the Air. It is *Stevinus* his Experiment, in his *practical Hydrostaticks*, upon his 10. Proposition. And

And upon the ſame reaſon it is, that if a Glaſs-bottle filled with Sea-water, and ſtopped, be let down twenty fathoms into the Sea, it will not break, for it is filled with a Fluid of an equal weight, and ſo the external Water doth not ſenſibly gravitate upon it, for it hath within a ſufficient power to reſiſt the external preſſure. But if it be full only of Air, and ſtopt, and let down as deep by a weight appended to it, (as it muſt) it will be broken by the preſſure and weight of the Water immediately upon the included Air, which is lighter than ſo much Water, and ſo it preſſeth upon it, to drive it up, and cruſheth the glaſs into it.

And this I take to be one reaſon, though not the only reaſon of the Experiment of the Valve, and likewiſe of Oyl thruſting up Water into a Tube, though of a ſpecifically heavier conſiſtence; and poſſibly may contribute ſomething to the inſtance in the fourth Chapter, whereby a Syphon filled up with Mercury to the hight of the ſhorter leg, and immerſed in Water, the Mercury in the ſhorter legg will ſubſide a little, and aſcend in the lon-

ger

ger leg, although the Mercury be a Body 14 times heavier than Water; for in theſe inſtances; though the immediate contiguity be of the heavier Body to the lighter, as Oyl to Water, and Water to Mercury, yet in as much as the Mercury in both leggs is in *æquilibrio*, and the Air is behind the Mercury in the longer legg of the Syphon, and behind the Water in the Tube, the Water in the one caſe, and the Oyl in the other, doth in truth gravitate upon that Air mediately and effectively, rather than upon the intermediate heavier Fluid, eſpecially if the body of the Air be any whit lower than the Superficies of the Water.

And thus far touching the Gravitation or preſſure of a Fluid ſpecifically heavier, upon a Fluid ſpecifically lighter. I ſhould now come to conſider the preſſure of a Fluid ſpecifically lighter, yet with an exceſs of extrinſick or quantitative weight upon a Fluid ſpecifically heavier; as two pound of Water upon a pound of Mercury, or two pound of Oyl upon a pound of Water: but be-

cauſe

cauſe this and ſome other conſiderations, for the better clearing of the matters contained in this Chapter, may occur in the next, I ſhall remit it thither.

CHAP. VI.

Concerning the Preſſure or Gravitation of lighter Fluids, upon thoſe that are ſpecifically heavier.

IT is certain, that every Body, whether fluid, or ſolid, incumbent upon another, though that Other be a thouſand times intrinſically and alſo extrinſically heavier than the incumbent Body doth gravitate and preſs upon it.

And therefore if we ſhould ſuppoſe the Air to have a weight, but a thouſand times leſs than the like portion of Water, a portion of one ſquare foot of Air incumbent upon the Ocean, would have ſome preſſure upon it: ſomewhat like the Problem that paſſed in the Affirmative among Freſh-men in the Univerſity, *That if a Horſe had as much as he could carry, the addition of the weight of the thouſandth part of a Fea-*

ther would break his back.

But this is not the preſſure or Gravitation I am ſpeaking of, but ſuch a Gravitation or preſſure, as would put the ſubjected heavier Fluid into a ſenſible motion, or change of place or ſituation.

In a pair of artificial Scales, a pound of Feathers or Water, will equiponderate a pound of Gold or Mercury, and 2 pound of Feathers will preponderate a pound of Gold or Mercury, notwithſtanding the great diſparity of their intrinſick weight.

And ſo in a Ballance that ſeems more natural, if a Syphon of half an Inch diameter, with one legg of ſix Inches long, and the other of thirty four Inches long, or more, be filled with Mercury to the height of the ſhorter legg, and then ſtopping the Orifice of the ſhorter legg with the finger, fill the longer legg with water, and then opening the Orifice of the ſhorter legg, the Water in the longer legg, though ſpecifically lighter than the Mercury, will drive out the Mercury out of the Syphon, becauſe the extrinſick or quantitative

weight

weight of ſo much Water exceeds the extrinſick or quantitative weight of the ſubjacent Mercury.

If a cubick veſſel be filled ſix Inches high with Water, and a Glaſs-pipe open at both ends be immerſed at one end in the Water, and then ſuperinfuſe gently (to avoid diſturbance) ſo much Oyl as will fill it up ten Inches, *viz.* four Inches of Oyl, and ſix of Water, the Pipe will be filled with Water neer to the level of the Superficies of the Oyl, but not quite level to the Superficies of the Oyl, it will want ſo much, as the like quantity of Water in the Pipe, is heavier than the like quantity of Oyl.

But if a Pipe filled with Oyl, and the upper end ſtopt with a finger, whereby the Oyl remains ſuſpended in the Tube, or Pipe, and then the open end be immerſed in the Water, the Oyl, while it obtains a Superficies in the Pipe conſiderably higher than the Water in the veſſel, will ſubſide 'till it come to ſuch an Elevation above the Superficies of the Water, as is proportionable to the degree of ſpecifical Lightneſs that it

obtains more than the like quantity of Water. And 'till then it ſubſides into the Water, becauſe it hath a greater proportion of accidental weight by its ſo great Elevation above the Superficies of the Water: for the Elevation of one fluid body above another, gives the greater ſtrength and ſwifter motion to its deſcent: whereby though a lighter body, it conquers the reſiſtance of the Water of a lower Superficies.

Which is the reaſon, why a Tube of Water, four foot high, caſts out more Water in the ſame portion of time, through the ſame *lumen*, than a veſſel of the ſame diameter, and but two foot high, as I ſhall hereafter more at large obſerve.

And this is the reaſon, why if a ſmall Glaſs-Tube of ſix Inches long, be filled with Water, and the upper end being ſtopped with the finger, whereby the Water is ſuſpended in the Pipe, and then the lower end being immerſed in a veſſel of Water ſix foot deep, and then the upper end unſtopped, the whole Water in the Pipe will empty it ſelf,

'till

'till it attain a Superficies equal with the Water in the veſſel, and will not be kept ſuſpended in the Pipe by the reſiſtance of the Water in the veſſel, becauſe if it obtain never ſo little more height in the Pipe than in the veſſel, it hath a greater force to preſs downward, than the Water in the veſſel hath ſtrength to reſiſt it.

If a Tube ſtopt at one end be filled with Mercury, and inverted in the open Air, the Air will aſcend and terebrate through the Mercury as faſt as that deſcends; ſo there is a kind of preſſure of the Air *aſcendendo* upon the Mercury, and thereby both the Air and Mercury obtain their ſeveral natural motions, this *deſcendendo*, and that *aſcendendo*, whereby Vacuity is prevented, and the continuity of the parts of the Univerſe preſerved.

But if the Tube be very ſmall, ſo that the Air cannot make its way through the lower orifice, to gratifie the Mercury with a deſcent, by that means the Mercury will remain ſuſpended in the ſmall Tube, and will not deſcend. The

like will happen, if such a small Tube be inverted into Water, the smallness of the orifice not admitting the ascent of the Water to supply the space dereliсted by a descent of the Mercury, the Mercury by force of the Catholick law of Nature will remain suspended, and its natural descent will be thereby superseded.

So that the pressure or Gravitation of a lighter Body upon a more gross and weighty, will be occasioned, 1. Either by the Excess of the quantity and extrinsick weight of the Fluid specifically lighter, or 2. by the advantage of its Position or Elevation above the Superficies of the grosser Fluid, or 3. by the interposition of that common law of Nature, *ut evitetur vacuum.*

I shall conclude these general Observations, touching the Gravitation of Fluids, with that of the Valve, described by the Excellent Author of *Hydrostatical Paradoxes*, *cap. ultimo*, which was certainly a most ingenuous Experiment, though I am not at all satisfied with the Solution he gives of it, nor the Con-

Consequences deduced by him from it, touching the Gravitation of Water upon Water, (I mean sensible Gravitation) of the superior parts upon the inferior parts of the Water in free water.

And I am as much dissatisfied with that obscure Solution that is given thereof by the Learned Author of the *Enchiridion Metaphysicum*.

And because in this one Experiment duly observed and improved, many of the most abstruse Conclusions of Hydrostaticks may be cleared even to sense, I shall distinctly examine it, and the *phænomena* appearing in it.

The Instrument is thus made, according to that form which I made use of.

I took a hollow Tube of Laton, closely sodered at the Sides and joynts, of 39 Inches long, two Inches ½ in the diameter from the top to the bottom, with a Brass Valve at the end of it sodered to it, and a brass Sucker or Cover of the same fashion with those used in Pumps, only in Pumps the Cover or Sucker hath its head upward, in this Instrument the head is downward, whereby

it being inverted it falls out about an Inch below the Valve, but cannot fall out more, becauſe ſtayed by the Frame of the Valve.

Fig. 7. This Sucker exactly covers the mouth of the Valve, that no water can come in, when the Sucker is cloſely ſtrained up, by a ſtring faſtned to it in the inward pin of it, and ſo conveyed up through the Tubes. The Sucker thus faſtned to the Valve or Box, and the Box ſoder'd cloſe to the Tube, and the ſtring conveyed up through the Tube to the open end of it, the Engin is formed according to the Figure in the Margin, repreſenting *A* the Tube, *B* the String, *C* the brazen Box of the Valve ſoder'd to the Tube, *D* the Sucker or Cover of the Valve let down as low as it will go, with a Hook to hold any weight appended to it; which Sucker being ſtrained up with the ſtring, cloſely ſtops the lower orifice of the Tube, and Box of the Valve.

The Valve thus prepared, I ſtrictly weighed the whole Valve, Tube, Sucker, and Thrid, with the wooden

Nut

Nut upon which to roll the ſtring, which weighed in all three pounds, two ounces and a half, or 50 ounces and a half.

The Sucker (for ſo I ſhall call the name of the Valve) weighed ſeven ounces and one half: and I was curious in weighing theſe things, becauſe the great uſe of my Experiments conſiſted in the compariſon of weights of the Inſtruments themſelves, and the Water.

I took then a great glaſs Tube, of about five Inches diameter, and about two foot and a half long, and filled it with Water; though I uſed alſo a Leaden veſſel of ſix Inches diameter, and four foot long, for the immerſion of my Valve, which though it were deeper, yet the Glaſs veſſel was more accommodate to my uſe, and ſerved as well, and therefore I uſed it, and thereupon made thoſe ſeveral Trials.

(*Fig.* 8.) 1. The Tube let into the Water, with the Valve open, would freely ſubſide to the bottom of the Water, be it never ſo deep, the water getting up into the cavity of the Tube: for the

the *moles* of the Tube in that instance, is no more than the length and thickness of the Laton, the Brass Valve and Sucker; but the weight thereof being more than such a single *moles* of water, it must necessarily subside to the bottom of the water.

2. The Valve being drawn up, and sustained by the Thrid wound about the wooden Nut at the top of the Valve, whereby no water could come into the Tube, and then left freely to subside in the water, would subside to a depth of one and twenty Inches, and so swim erect in that depth of water, one and twenty Inches being immersed in the water, and eighteen Inches of the Tube being in the open Air, above the Superficies of the water.

And the reason is, because though the Laton and Brass be specifically heavier than Water, and therefore will sink, as in the last Instance; yet because now the Tube sits upon the water, as one entire Cylinder, and a Cylinder of Laton thirty nine Inches long, and two Inches $\frac{1}{2}$ broad filled with Air only, is not

not heavier than a Cylinder of Water of one and twenty Inches long, and two Inches ½ diameter, but do equiponderate; therefore the Tube ſinks no lower than one and twenty Inches to make an *æquipondium* between it ſelf and the like bulk of Water.

3. I therefore with all the exactneſs I could, meaſured the weight of the Water commenſurate to a Cylinder of two Inches ½ diameter, and one and twenty Inches long, (the quantity of the Tube ſwimming in the Water.)

Firſt therefore filling my Glaſs Tube very full of Water, I immerſed the Valve open into one and twenty Inches deep; then at that depth lifting up the Sucker, and incloſing the one and twenty Inches of Water thus impriſoned in the Tube, and ſo taking it out cloſed; and then when out of the Glaſs Tube ſetting it to run into a veſſel weighed before, I find the weight of the included Water weighed fourty and ſeven Ounces and half, or three pound wanting half an Ounce, which is about three Ounces leſs than the weight of the

the whole Inſtrument. And this abatement it hath for the thickneſs of the Tube and Valve, becauſe the water that is preſſed upon by the Tube and Valve, and ſo raiſed out of its place, is preſſed up by the convex or outſide of the Tube and Valve, and commenſurate to it.

Therefore again ſtraining up the ſtring of the Valve, whereby no water could get in, and filling my Glaſs Tube of reſtagnant water to the very brim or brink of the Glaſs, and then I immerſed my Tube into the water to one and twenty Inches depth; the Valve ſtrained up by the ſtring, and preſerved the water that was impelled up by the immerſion, and thrown over: and this I likewiſe exactly weighed, and found to weigh near upon the point of fifty one Ounces $\frac{1}{2}$, or three pound three Ounces and half, which is about an Ounce more than the weight of the Engine; which diſparity might happen for want of exactneſs. But the ſumme of it is, there is no conſiderable difference between the weight of the whole Engine, and the weight of ſo much Water, as will

coun-

countervail in quantity to so much of the Engine or mingled Cylinder of 21 Inches thereof immersed in water.

Which gives us a plain account, why and how much a Body lighter than the like quantity of water, will sit above water, and why, and how it comes to pass, that some Ships draw more water than others, and how much burthen they will bear, before they will sink, *viz.* if the Ship or Barge with all its Cavities and Lading, be not heavier than such a solid bulk of water, as equals the whole *Moles* and Cavity of the Ship or Barge, the Barge will live, though it draw water neer to the very top of the sides of the vessel. And if the Ship or vessel be lighter than such a *moles* of water as equals the whole continent of the Ship or Barge, so much of the Ship or Barge will emerge above the water. For in the instance in hand, in as much as 21 Inches of immersion of the Tube, was the product of its whole weight of three pound, two Ounces and half; and those one and twenty Inches thus immersed, were

equal

equal in weight to a bulk of Water, commensurate to that Cylinder of 21 Inches immersed, the rest of the Tube *viz.* 18 Inches, did flote erect upon the Water; for if it should have subsided, the *moles* of Water lifted up out of its place would have exceeded the weight of the whole Valve, *viz.* three pound, two Ounces, and half, which by the rules and Laws of *Hydrostaticks* it may not do,

4. If the Sucker be drawn up, and then immersed so low, that the portion of Water impelled up by the Tube, do exceed the weight of the Sucker, *viz.* 7 ounces and half, the Sucker will be sustained by the pressure of the Water upon it: as suppose in the 8th Figure it were pressed even to *L M*, or *N O*, which is nine Inches below the Superficies of the Water. And the reason is, because the Sucker is now the moveable Basis of the included Column of Air, which is a light Body, and so gravitates nothing upon the Water; and the Sucker being as it were the Basis of that Column, and moveable, weighs but seven Ounces

Ounces and half, and the Tube ſubſiding as low as *LM* or *NO*, preſſeth up a portion of Water of double that weight, and this portion of Water bears againſt the Baſe or Sucker more forcibly and powerfully than the Sucker can bear againſt it.

5. But if the weight of a *moles* of Water, commenſurate to ſo much of the Tube as is immerſed in the Water, be leſs than the weight of the Sucker, the Sucker by its own weight will ſubſide, notwithſtanding its immerſion into Water.

By iterated Trials I found, that if I kept up the Sucker by the Thrid, and immerſed it to ten Inches, or more, and let go the ſtring, whereby the Sucker, though now at liberty, would yet not ſubſide, but remain ſuſpended by the preſſure of the Water upon it; yet if I gently raiſed it up, 'till it came only to an immerſion of four Inches and half, the Sucker would ſubſide; wherefore cloſing in the included Water at that depth, by lifting up the Thrid, and ſo cloſing the Sucker, I weighed that in-

cloſed

cloſed Water, and found it juſt weighed as much as the Sucker, *viz.* ſeven Ounces and half, and there could be no conſiderable odds here by the thickneſs of the Tube, the immerſed portion thereof being but ſmall, and the ſides very thin.

6. But becauſe I would purſue the proportion to the uttermoſt, I kept up the Sucker with the ſtring, 'till the Tube came to the immerſion of four Inches and half, and then ſubſided; I then incloſed that four Inches and half of Water, and kept up the Sucker, and immerſed the Tube with the incloſed four Inches and half of Water, and gently raiſing it up, it ſubſided at nine Inches immerſion.

And the reaſon is the ſame as before, for the included cavity of nine Inches, had in it four Inches and half of Air, which weighed nothing, and four Inches and half of Water, which as before is ſhewn, weighs ſeven Ounces and half, and the weight of the Valve which weighs alſo ſeven Ounces and half, the whole weight of the included Air, Water, and Valve, weighing only fifteen Ounces

Ounces, and a Column of Water of nine Inches high, and two Inches and half broad, equal to the cavity of the immerſed nine Inches of the Tube, would have been of the ſame weight with the four Inches and half of included Water; and the Sucker, whoſe weight is now to make good the uppermoſt four Inches and half of Airy ſpace, and ſo there is an *æquipondium* between the included four Inches and half of included Water, together with the weight of the Sucker to a Cylinder of Water of nine Inches long, and two Inches and half broad, commenſurate to the like cavity of the Tube, and the like quantity of nine Inches of Water, impelled out of its place by nine Inches of the Tube immerſed below the Superficies of the Water.

And the ſame rule and proportion will hold upon the like quantity of more Water taken in, and a deeper immerſion, allowing the ſame thing for that thickneſs of the ſides of the Tube, which upon a deep immerſion is more conſiderable than upon an immerſion of four Inches and half.

7. And although I did not make an actual trial how much weight in an empty Tube, deeply immersed, would be sustained by the Sucker without subsiding; yet by this proportion it is easie to be calculated, *viz.* that the Tube being kept empty, and immersed to any depth below four Inches and a half, the Sucker will sustain without subsiding such a weight, as is equal to a portion of Water commensurate in bulk to so much of that empty Cylinder in the Tube, as is depressed below the Superficies of the vessel of restagnant water.

So that if the empty Tube will sustain seven Ounces and half (the weight of the Sucker,) at four Inches and half immersion, it will sustain fifteen Ounces at nine Inches immersion, thirty Ounces at eighteen Inches immersion, sixty Ounces at thirty six Inches of immersion; for an empty Cylinder of thirty six Inches long and two Inches and half broad, will contain a Cylinder of Water of sixty Ounces weight, allowing somewhat as before, for the thickness of the sides of the Tube.

8. In

8. In this it appears that the Water doth not gravitate upon the Water, but gravitates upon a Body lighter than it ſelf, though this Gravitation be immediately upon a Body as heavy or heavier than it ſelf. When there is nothing but Air in the Tube, the Sucker is the moveable Baſis of that Air, and it gravitates immediately upon the Sucker, but mediately and remotely upon the Air above it, when there is a little column of Air in the top of the Tube, and below the Superficies of the Water, and under that a column of Water, and under that the Sucker. If the whole Concrete be lighter than ſo much Water, it gravitates upon the Sucker, Water, and Air, becauſe though the Braſs be ſpecifically heavier than Water, and the Water over it ſpecifically of an equal weight with Water; yet the quantitative or extrinſick weight of both is leſs than the weight of ſo much Water as is equal to a Bulk or Cylinder of Water, entirely commenſurate to the quantity of the Air, Water, and Sucker, below the Superficies of the Water.

9. That when a Body lighter than so much water is within the compass of the Superficies of the body of restagnant water, the water presseth upon it upward, impelling it up, as here upon an immersion of the Valve laden with four Inches and half of water, and likewise with the weight of the Sucker, into nine Inches of water, an equal quantity of water to the *moles* of the immersed Tube, *viz.* nine Inches sustains the Sucker, notwithstanding its own weight and the weight of four Inches and half of water incumbent upon it, because those two weigh but fifteen Ounces, and nine Inches of the exterior water weighs as much, and so there is an *æquipondium* between the *potentia sustinens*, and the *pondus deprimens*.

CHAP.

CHAP. VII.

Concerning the Space derelicted by the descent of the Mercury in the Torricellian *Experiment, and what it is not, or what it is that fills it.*

HAving gone through the two premiſed Conſiderations, preliminary to this Inquiry, I now come to the third General, namely what it is that fills the ſpace derelicted by the deſcending Mercury in the Tube. And firſt I ſhall conſider, whether it be a Space purely void of any Body. 2. If it hath ſome Body that fills that Space, I ſhall conſider what it is not that fills it. 3. I ſhall conſider what it is that moſt probably may be thought to fill it.

Firſt therefore I ſay it is not Nothing, or a pure Vacuity, but it is ſome corporeal ſubſtance that ſucceeds in the head of the Tube, derelicted by the Mercury.

And here 1. I ſhall not enter into

any large debate touching the possibility or impossibility of interspersed or coacervated vacuities in any parts of the Universe; neither 2. shall I insist upon those obscure evidences of the inexistence of a Body in that derelicted space; as namely the communication of Sounds, or the reception of Light, or transmission of Colours, or other visible *species* in or from it. But 3. I shall ground my Conclusion from those more sensible and apparent *Phænomena* which do evince it; namely, those sensible plain Effects in that seeming empty Space, which could never be produced but by the contiguity and presence of some corporeal substance, filling that supposed empty space.

1. It is most evident to any man's sense that will but try it, that if the Tube be open at both ends, and filled up with Mercury, and then one end stopped with the finger, and the other end inverted and immersed in the restagnant Mercury, whereby it descends from the top of the Tube, a strong and sensible Attraction is wrought upon the pulp of the

the upper finger that closeth it, which continues and grows more and more forcible, sensible, and evident, the farther the Mercury is removed from the upper end, and approaching to its usual station of 29 Inches.

This Attraction is impossible to be without the contiguity of some Body to the pulp of the finger, which cannot be the Mercury it self, for That in a Tube of four Foot long is removed above a Foot distant from the finger, by that time it comes to its station; yet all this while the strong suction upon the pulp of the finger continues.

And they that go about to tell us, that it is not Attraction or Suction by any power within the Tube, but by the pulsion of the incumbent column of Air, need no other confutation than their own sense to assure them the contrary; for most evidently the force that the finger feels is from within, and not from without: and this Solution by Pulsion, is given only to gratifie that imaginary Supposition that some have entertained of the Aery Column, whereof in due time.

2. The instance of *Hanoratus Fabri* in the 6th of his *Physical Dialogue*, (though not tryed by my self, yet asserted to be tryed by him) puts it out of question. If at the upper end of the Tube there be fixed a folded Paper, which may be extended by any force, but otherwise contracting it self (in the manner of Paper-Lanthorns made by School-boys), this *plicata charta* will by the subsiding of the Mercury be unfolded and extended, which could not be, but by the contiguity of some Body unto it.

3. The instance given by *Linus*, and improved by *Fabri*, *ubi supra*, of an empty Bladder close tyed, and fastned to the upper end and the inside of the Tube, extended after the descent of the Mercury, and again contracting it self to its former dimension by the inclination of the Tube, makes it plain, that this Extention is the effect of some included Body in that relicted space, which is not the bare gross body of the Mercury, which is removed a Foot or more below it, and in which there is not so much as pretended to be any Magnetick qua-

lity

lity in relation to the Bladder.

And they that tell us it is the Elatery of the Air included in the Bladder, that extends it by a natural expanſion, tell us an invention fitted to ſerve the Suppoſition of the prodigious natural Elatery of uncompreſs'd Air, whereof hereafter.

It is true, that if this Bladder hath any little orifice, or hole open in it, the diſtention will not enſue; but the reaſon thereof is evident, (not upon their Suppoſition of the impediment of the natural Elater of the Air included in the Bladder,) but becauſe in that caſe the Attraction is made as well upon the inſide of the Bladder through the orifice, as upon the outſide, and ſo the Bladder obtains the ſame conſiſtence as at firſt; but where there is no orifice, the Attraction can only be but upon the outſide of the Bladder, upon which there neceſſarily follows an Extenſion of the Bladder, and a neceſſary Conſequent thereof is a Dilatation and Expanſion of that little particle of Air included in it, to the uttermoſt dilatation

that

that that attractive force can give it, or produce in it, which is not by natural Elaſticity, but by forcible Tenſion.

Upon theſe and the like ſenſible and plain Inſtances it ſeems undeniable by any, that will not abandon his own ſenſe, that it is not Nothing that is in that derelicted ſpace, but it is ſome bodily ſubſtance; for otherwiſe it were impoſſible that thoſe, and the like ſenſible effects could be produced: for regularly, all natural bodily effects are wrought by a contact of ſome Active body upon the Patient.

CHAP. VIII.

Concerning the Body ſupplying the derelicted Space in the top of the Tube, and firſt what it is not.

IN the former Chapter I have concluded, that it is ſome corporeal Subſtance in the ſpace derelicted by the Mercury in the top of the Tube, though not conſpicuous to the ſight: and now

I shall consider first what it is not, and 2. what it seems most probably to be.

There are two general Opinions touching it: one that supposeth it is some Body that comes *de foris* into that derelicted space; and those again fall into several Opinions; some suppose it to be the forreign Air that pervades either the Pores of the Glass, or the Mercury; others that it is *Æther*, or Ethereal matter, or (which is a differing kind of Explication of the same thing) that it is *des Cartes* his *materia subtilis*, or his Third Element, the *ramenta* or filings of Atomical Bodies. The other general Opinion is, that it is a bodily substance, not coming *de foris*, but arising from the included Mercurial Body.

Now as to the former of these general Suppositions that it comes *de foris*, I shall discharge the question from that Supposition of *des Cartes* his *materia subtilis*, for there is no probable evidence of any such Principle, it being only an imaginary substitution; and if it be any thing besides imagination, it seems to be but Air, or at most that subtler part

of

of the Univerſe called *Æther*, which poſſibly may be nothing elſe but the ſubtler and more refined parts of the Air, diſgroſſed of thoſe vapours or *Effluvia*, which obtain ordinarily in the inferior parts of the Air, commonly called the Atmoſphere.

And therefore one method of diſcuſſion of this queſtion will poſſibly be applicable to both theſe Suppoſitions, of the admiſſion of forreign Air or *Æther* into the derelicted ſpace in the Tube above the Mercury.

If therefore it be forreign Air or *Æther* that occupies that place, it muſt be upon one of theſe accounts, *viz.* either that the Air or *Æther*, upon the account of its own ſubtlety and tenuity, freely and of its own accord pervades the Glaſs or the Body of the ſubſiding Mercury, and ſo takes up the derelicted room; or elſe that although of its own accord it would not penetrate through either of thoſe two Bodies, yet that it is as it were forcibly ſtrained through the pores of the Glaſs or Mercury, and by the ſubſiding of the Mercury, and the re-

reſiſtence of Nature againſt Vacuity, percolated into that vacant ſpace.

As to the former of theſe Solutions, it ſeems altogether unreaſonable to imagine any free or unconſtrained penetration of the Air, or *Æther*, into that ſpace: for although the Glaſs, and likewiſe the Mercury are not altogether deſtitute of Pores, yet they do not run in a ſtraight uninterrupted line, but are croſſed and obſtructed by interpoſed filaments, that muſt neceſſarily ſtop the free paſſage of the Air or *Æther* through them, ſo that they are not wholly pervious to thoſe Bodies.

And that this is ſo, appears by this one inſtance, which is as good as a thouſand.

If it were true, that the Air or *Æther* did freely paſs through the ſuppoſed pores of the Glaſs or Mercury, the Mercury would never be ſuſpended at twenty nine Inches, but would wholly ſink into the veſſel or reſtagnant Mercury, for the inſinuation of the Air or *Æther* through the Glaſs or Mercury, would ſupply the vacuity, as well below twen-

ty nine Inches as above, and so accommodate the derelicted space in all its Evacuation, as well as in part, and likewise would accommodate the Mercury in its natural descent without any inconvenience; and yet we find, that at twenty nine Inches the Meccury keeps up, and subsides not.

And that which puts it out of question, that the natural irruption of the Air or *Æther* fills not this Space, is this: let but the least orifice, no bigger than the point of a small Needle be made in the top of the Glass Tube, the Mercury would entirely descend, and not be sustained at twenty nine Inches, because here is an admission of forreign Air to supply the space derelicted by the Mercury, as fast as it descends. And the same effect would follow, if the Air or *Æther* did penetrate through the small pores of the Glass or Mercury. And since we see it doth not obtain that effect, we have reason unquestionably to conclude, it hath not any admission *ab extra* through those supposed pores of either of those Bodies.

It

It remains therefore to be considered, whether that by the great contention of Nature against Vacuity, and the forcible stress of the Mercury on its descent downward, there be not a kind of forcible straining of some Aery or Ethereal Particles through the Glass, or at least through the Mercury, which is partly exposed to the external Air.

I answer, first, as touching the permeating of Air or *Æther* through the Glass; it seems utterly impossible, for the reason before given. Indeed the vigor of Light or Fire penetrates the Glass, not (as it seems) by any transition of any Corporeal Substance, but only of a *vis*, *virtus*, or *vigor*, which communicates the quality of *lumen* or *calor* to the Body that it finds there, but conveys not any Corporeal Substance transmitted through the Glass.

Secondly, as touching the supposed straining of the Air or *Æther* through the Mercury, and discharging it in the summity of the Tube: I must needs say, that in some instances the forreign Air will make a visible perforation and tran-

transition through the body of Mercury, as well as of Water.

If a Tube of Glass, sealed at one end, be filled with Water, or Mercury, and then inverted in the free Air, (unless the Tube be extremely small) the Mercury will subside and descend by the sides of the Tube, and the Air ascend through it in a Pillar or Bubbles in the midst, in the very same successive order as the Mercury descends; the Mercury thus laterally descending, making way for the ascent of the Air, and the Air in the same successive moments ascending, filling the room relicted by the Mercury: and this ascent of the Air is evident and conspicuous to the Eye.

But in the matter in question, there seems to be no such pervading of the Air through the pores of the suspended or restagnant Mercury.

First, if such a transition of the Air were through the column and restagnant Mercury, it must needs (as in the former case) make a visible appearance thereof in the Mercury, and raise some tumultuous *phænomena* in it, but no such thing

thing appears to the eye in the *Torricellian* Experiment!

Secondly, the difficulty of the *transitus* of the external Air through the Mercury in the *Torricellian* Experiment is infinitely greater than in the instance above given: for in that instance the Air hath but one motion upward, and is assisted in it by the Mercury giving way to it. But here in the *Torricellian* Experiment, there must be a double intention and motion of the Air, *viz.* 1. It must *descendendo* terebrate through the restagnant Mercury, and then when it hath passed that difficulty, it must terebrate through the erect column of Mercury *ascendendo*. And it is not conceptible that the pores of the erect and restagnant Quick-silver, crossing one another in respect of their position and situation, can accommodate such a crooked and contradictory motion of any particle of Air.

Thirdly, again it cannot reasonably be thought, but that if there were such a transition of the Air through the restagnant and suspended Quick-silver,

but it should be as reasonabe to continue after the subsiding of the Mercury to twenty nine Inches, as before, the passage remaining still open through the Mercury. The consequence whereof would be, that the whole Tube would be supplied with Air, and consequently the whole body of Mercury be emptied into the restagnant vessel; as when a little Pin-hole is made in the top of the sealed Tube.

Fourthly, again if it were forrreign Air or *Æther* that were admitted, it is not easily conceptible, how the finger stopping the upper orifice of the Tube, should be attracted inward, or the Bladder distended, as in the former Chapter; for the immission of forreign Air through the Mercury, or Glass, must rather contract than expand the Bladder, by the accession of an external compression from it, as will happen upon the least hole made in the Tube. Upon these and the like reasons it seems to me altogether improbable, that the derelicted space should be filled with Air or *Æther* from without, by an intromission

miſſion of it through the Glaſs or Mercury.

CHAP. IX

Concerning the other Suppoſition, namely, that this derelicted Space is filled with a Body ab intra.

SInce therefore I have concluded, that this derelicted Space in the Tube is filled with a Body, and that That Body comes not *ab extra*, and there is no Body within to ſuppply that room but the Mercury, or that which muſt be extracted from it: and in as much as the Mercurial conſiſtence it ſelf is deſcended to twenty nine Inches, it remains neceſſary that this Body that fills the derelicted *interſtitium*, muſt be a ſubtle body extracted from the Mercurial body. But how, or in what manner this is effected, is inquirable.

And now before I come to the Inquiry it ſelf, I muſt take notice that there are three kinds of inſtances of the *Torricellian* Experiment.

1. The first is, where the Tube is just twenty nine Inches and half long, and sealed at the top, and then filled with Mercury, and inverted into restagnant Mercury, without any admission of any Air; and though that be difficult to effect, yet if it be effected, there is no vacant space left, but the column of Mercury adheres to the top of the Tube, it being its just station.

2. The second is, when the Tube is above twenty nine Inches and half, suppose four foot long, sealed at the top, and filled up to twenty nine Inches and half, and then inverted, whereby the Air riseth to the top of the Tube, and the Mercury subsides not only to twenty nine Inches and half, but much lower, namely as far as that column of Air in the upper end of the Tube is by tension extendible by the force of the descension of the Mercury, which being about eighteen Inches of Air, possibly by the descent of the Mercury will be extended to above twice the length, whereby the Mercury may subside it may be to about fourteen Inches, (I am not curious in the Calculation.) 3. The

3. The third Instance is, where the Tube for the purpose is four foot long, sealed at one end, filled with Mercury without any portion of Air admitted, whereby the Mercury inverted into a vessel of restagnant Mercury, subsides to twenty nine Inches and half, and so leaves about eighteen Inches deserted by the Mercury.

And though in the pursuit of this discourse there will be use of the discussion of the two former Instances, yet in this place only the last of the three yeilds the Inquiry, namely what it is that fills that space derelicted by the Mercury.

And I adventure to conclude, that it is a subtle Corporeal Substance extracted from the gross Mercurial Body, or forced out of it.

The methods of this Separation are two, the one proposed by *Linus*, the other offered by others.

That of *Linus* (if I understand him aright) seems to be this: namely that by the descent of the Mercury, and *in obsequium naturæ universalis*, for preventing of Vacuity, there are taken away succes-

ſively from the ſuperficies of the Mercury certain ſcales as it were of an indiviſible profundity, and theſe are rarified into a ſubtle inviſible conſiſtence or vapor, which ſupply that deſerted ſpace, and make up a kind of *funiculus* that ſuſpends the Mercury to the Tube, and is coextended to the whole vacant ſpace gradually, as the Mercury deſcended.

This ſeems to be ſomewhat difficult, eſpecially conſidering the heterogeneous parts of the Mercury, whereof ſome ſeem to be of that ſolidity, that are uncapable of ſuch a ſeparation.

Beſides it would be difficult to conceive, how theſe ſuperficies of this Body ſhould in a moment, by the inclination of the Tube, be rejoyned to the Mercurial body and conſiſtence; and in a moment again, upon the re-erection of the Tube to its perpendicular poſture, be rarefied from ſo groſs a conſiſtence into ſo ſubtle and inviſible a nature; both which will be the effects, one of the inclination, the other of the re-erection of the Tube.

Therefore I ſhall rather chooſe another,

ther, and, as I think a more accountable Solution.

It is plain to our daily obſervation, that all Bodies, eſpecially ſuch as are liquid or fluid, do continually ſend out from them certain ſubtle *Effluvia*, ſcarce perceptible to the Eye, but manifeſt in their effects. It is alſo evident, that all Bodies, eſpecially fluids, and ſuch as conſiſt even of Heterogeneous parts, by ſtrong agitation, by heat or motion, have many of their parts reſolved into a more ſubtle conſiſtence, than appeared before ſuch agitation. Thus Water by heat or violent motion reſolves it ſelf into vapours or ſteams.

Mercury is of it ſelf an heterogeneous body, conſiſting of ſome more ſolid, other more fluid and moiſt parts. If any man ſhall take the pains violently to ſhake Water and Mercury together, and throughly waſh it, he ſhall find the ſhining parts that are the more fluid, ſevered from little black or dark granules like Sand, which will gradually ſubſide viſibly in the water into a heap, before the nimble ſhining particles united

to them, and alſo certain Airy corpuſcles riſing to the top of the Water.

And as thus by the ſeparation by water, ſo by a ſtrong heat the Mercurial Bodies will be in a great meaſure reſolved into a fume or ſmoak, which nevertheleſs (as is ſaid) will coagulate again, and aſſume the former Mercurial conſiſtency, at leaſt in a great meaſure.

Mercury, though it be one of the coldeſt Minerals, doth contain and ſend out from its body certain *Effluvia*, and noxious vapors, as they experiment that are converſant in Mines of that kind.

If any man obſerve the deſcent of the Mercury from the top of a long Tube in the *Torricellian* Engine, he ſhall find the deſcent not ſo quick and nimble, as if both ends were open, and (contrary to the uſual acceleration of deſcending heavy Bodies) more and more ſlow and faint, the nearer it comes to its ſtation; which is an evidence that there is a *luctа* and contention in Nature, while it extrates, ſeparates, and abrades the parts, that muſt ſupply the derelicted

ſpace,

ſpace, and likewiſe in giving them a tenſion or dilatation anſwerable to it.

They that have exerciſed much the *Torricellian* Experiments, and thoſe of the like nature with Mercury, have apparently found that the frequent iteration of theſe Experiments have much imbaſed the nature of Mercury, depurating it from thoſe ſubtle ſteams and *Effluvia* that naturally attend it, and thereby the very Mineral it ſelf becomes more vapid, diſcharged of its ſubtle Spirits or parts, and rendred leſs uſeful not only for Medicinal but Mechanical Experiments: whereby it appears that it loſeth ſomewhat of its more ſubtle ſubſtance by iterated Experiments, and will prove more ſluggiſh. For this I call to witneſs *Honoratus Fabri*, in the latter end of his *Philoſophical Dialogues*, and ſome of our own Nation that have aſſerted the ſame, and in my own Experience I have alſo found it true.

It is certain, that when Mercury, or any other fluid falls in a Tube, the higher it falls, the more force it hath, and the greater compreſſion the lower parts receive

receive from the upper; for all Bodies that deſcend, deſcend with the greater force, according to the altitude of their deſcent, as I ſhall have occaſion hereafter to obſerve.

The deſcent therefore of Mercury in a Tube of ſix foot high, is much more powerful than a deſcent from four foot high; and That than a deſcent from three foot, or twenty nine Inches high, and conſequently the compreſſion of the inferior parts by the ſuperior; and in a greater deſcent than in a leſs.
the agitation of all is the more vigorous

And yet (as I before ſaid) it is evident in the deſcent of the Mercury from a Tube of four foot high, ſtopt above, and immerſed beneath in reſtagnant Mercury, is not without a *lucta* or contention; and although the higher the Tube is, the deſcent at firſt is more quick, yet it gradually grows ſlower and ſlower, 'till it come to the common ſtation of its ſuſpenſion, *viz.* twenty nine Inches and half, or thereabouts. But yet even in the firſt efforts of its motion, it is not ſo quick or violent, as its own natural

motion

motion would otherwise attain for it, receives a *remora* and impediment by the difficulty of separating of its subtle parts.

These things are apparently true to any man's observation, and from these observations I frame these Conclusions.

1. That the substance that fills the head of the Tube, as the Mercury descends, are the *Effluvia*, steams, or subtle vaporous parts of the Mercurial Body.

2. That these steams or vapors are separated from the Mercurial body by a double immediate means. First by way of Expression, or driving them out by the strong descending motion of the Mercury, the compression of the inferior parts by the superior, and the great agitation of its parts; the grosser Mercurial parts coming closer together, and driving out the more subtle and vaporous parts. Secondly by way of Extraction, or straining out those parts that are more subtle and fluid, and capable of Expansion, and from hence ariseth that *luctа* and *mora* in the descent

of

of the Mercury, by the ſtraining of the Mercurial vaporous bodies, and raking them out. And

3. That thoſe parts thus extracted are dilated and extended to as great an amplitude and tenſion, as the ſtrength of the deſcent of the Mercury, and the amplitude of the ſpace it leaves requires; which tenſion alſo contributes much to the retarding of the ſwiftneſs of the Mercurial deſcent.

4. And becauſe at twenty nine Inches and half, the weight of the Mercury decreaſeth to ſuch a ſtate, as cannot work any farther ſeparation of ſubtle matter to ſupply any more room, it ſtays there, and deſcends no farther, not having ſtrength enough at that hight to ſeparate any ſubtle matter from it ſelf, to ſupply the ſpace it ſhould leave by ſuch deſcent.

5. Although the immediate cauſe of the ſeparation of the ſubtle matter of Mercury, and the expanſion or dilatation thereof, be the force of the deſcent, and weight, and preſſure of the Mercury, yet this is performed *in obſequium uni-*

universalis naturæ, for the avoiding of the dissolution of Continuity, or, which is all one, *ob fugam vacui*.

6. And the same reason *mutatis mutandis* will be applicable to the suspension of water in a Tube, which will be suspended at 31 foot, or thereabout, as Mercury is at twenty nine Inches. For by the same means that subtle parts are separable from Mercury, subtle parts are much more separable from Water, by a strong tension or compression of it, as appears by the raising of innumerable Airy Bubbles out of a vessel of Water, by the strong tension of the Air in the Air-pump, large instances whereof appears in Mr. *Boyle*'s Experiments, 19, 21, 22, 23, *&c.*

The whole process and model of the suspending of Water in a long Tube above one and thirty foot long, and how it subsides to about one and thirty foot, and no longer. *vide apud Shottum* in his *mirabilia Vari lib. 3. cap. 2. in Experimento Robervalli Magnani & Bertii.*

And now if it be said, suppose the Tube were seven, eight, or ten foot long,

long, or if it were three or four foot long, and the upper end were a Bolts head, that ſhould contain three or four pound of Mercury, this would ſubſide to twenty nine Inches: where ſhould there be *Effluvia* to fill ſo great a ſpace?

I anſwer: the more Mercury deſcends to twenty nine Inches, the more *Effluvia* there will be to fill that place that the Mercury left, and ſo the Supply will neceſſarily be as liberal, as the ſpace the Mercury took up before its deſcent to 29 Inches and half, becauſe there is a greater ſtock of Mercury to yeild it, and a greater continuation of motion to extract it. And there ſeems no neceſſity of any great quantity of ſubtle matter to be driven, or driven out of the Mercurial Maſs, becauſe it is a ſubſtance capable of dilatation to a greater expanſion than its own natural conſiſtency, by the ſubſiding of the Mercury.

Merſennus tells us, that by experience he finds, that by a ſtrong tenſion of a particle of Air, it is capable to an expanſion of neer ſeventy times the ſpace of its ordinary conſiſtency, as in Æolipiles,

piles, and the like Engins. And we ſee that if an Inch of Air be left in the top of the Tube, it will by the bare force of the deſcent of the Mercury be expanded to neer ten times its former ſpace. And upon the ſame account it will fall out, that the quantity of one Inch of thoſe Mercurial effluxes will, by the deſcent of the Mercury, be ſtretched out and expanded to fill the derelicted ſpace of the Mercury, far exceeding their common and ordinary extenſion.

Fig. 9. The moſt conſiderable Objection againſt this Suppoſition ſeems to be this. That if the Tube of four foot long filled with Mercury, and then immerſed in reſtagnant Mercury, whereby the Mercury ſubſides to twenty nine Inches, and leaves a ſpace of about 18 Inches ſeemingly empty, yet if the Tube be inclined, as in *B*, to an altitude parallel to twenty nine Inches of vertical hight. The Tube *B* will be as at firſt filled with Mercury, drawn or driven out of the reſtagnant veſſel, and no vacant ſpace left; and if again it be erected perpendicularly as before, the Mercury

cury will ſubſide as before, *viz.* to twenty nine Inches; what becomes of the ſubtle exhalation upon the inclination of the Tube?

I anſwer, it is true, that by the inclination of the Tube the Mercury that deſcended out of the Tube into the reſtagnant veſſel of Mercury, will be drawn up into the Tube, and the Tube filled again with it, the ſame by the inclination of the Tube becomes of leſs accidental weight. But this doth no way croſs what I have ſuppoſed: I therefore anſwer,

1. That by the inclination of the Tube at *B*, the Mercury doth not preſs ſo urgently upon the ſubjected Mercury, as it doth in its perpendicular poſition; for it is ſuſtained according to the laws of Staticks by leaning upon the inclined Tube. and preſſeth not ſo forcibly upon the fund or Baſe.

2. That therefore the pores or conſiſtency of the Mercury in the inclined Tube are more lax and open, and regain more of that natural texture of its Mercurial conſiſtence, and receives into it

again

again those connatural steams or effluxes, that were shot or drawn out of it by its former compression, and the attraction made upon it by reason of its descent.

3. And by its re-erection unto its former perpendicular posture, they are again thrust or drawn out by its contraction and compression, and the forcible attraction wrought upon it by that Catholick Law of Nature, preserving the continuity of the Universe.

And that which seems evidently to evince the truth hereof, is the instance given by the Excellent Author himself, in his 20, 21, 22, 23, but especially in his 24th Experiment of the Air-pump; wherein the violent attraction of the Pump, and the strong tension of the Air included in the Receiver, raiseth from the bottom of an included vessel of Water Oyl, but especially Spirit of Wine, great Bubbles to the top of the vessels, (which is performed either by that forcible extraction of the more subtle and Aerial Particles included in that liquor, or by subtilizing or rarefying some

parts of the liquor. But as ſoon as that ſtrong tenſion and attraction by the included Air is taken off, by the immiſſion of freſh Air into the Receiver, the Bubbles ſubſided, and the ſubtle parts included in it were again rejoined, and reunited to the ſame liquors from whence they were exhauſted, which by a new tenſion wrought by a new repeted ſuction of the Pump, might be again extracted.

And thus far touching the third General, namely what it is that is included in the ſpace derelicted by the Mercury.

CHAP.

CHAP. X.

The enquiry touching the Cauſe that keeps the Mercury ſuſpended in the Tube at 29 Inches, or thereabout; and firſt what is not the Cauſe of this Suſpenſion.

THE conſideration of what it is that remains in the derelicted ſpace, in the upper end of the Tube, and the conſideration what it is, that keeps up the Mercury to twenty nine Inches, or thereabouts, are of two ſeveral kinds: for although the former Conſideration is neceſſary to be known, before we can arrive at a reaſonable diſcovery of the latter; yet it would not be ſimply of it ſelf impoſſible, that there ſhould be ſuch a corporeal ſubſtance, as I have above conjectured, in the derelicted head of the Tube, and yet the Mercury might wholly diſcharge it ſelf in the reſtagnant veſſel, which yet we ſee it doth not.

Therefore having in the former

Chapters finished the former, which was the fourth general Inquiry, namely, what it is that fills the derelicted space; I now come to the fifth and sixth Inquiry, namely what is not the cause of this suspension of the Mercury, and what seems to me the true cause thereof.

And among those that are assigned for causes of this suspicion, which yet are not causes thereof, I shall mention only these three; namely the renitence or resistance of the Mercury in the restagnant vessel; 2. and the counterpoise of the impendent column of the Atmosphere, equal in base to the base of the Cylinder of Mercury suspended in the Tube; and 3. the Elatery or Spring of the inferior part of the Air.

Of the former briefly in this Chapter, of the two latter more at large in what follows.

Stevinus in the Explication of the 10th Proposition of his Hydrostaticks, affirms, that the resistence of the base of any fluid Body, is greater in proportion than the *pondus deprimens* of a like fluid:

fluid: which *Fabri* in the sixth of his *Philosophical Dialogues*, *pag.* 480. and 493, goes about Geometrically to demonstrate: but I confess that it is performed with so much intricacy, and obscurity, that I do not fully apprehend it.

And if this be so, it may seem at first view, that the resistance of the restagnant Mercury in the subjacent vessel, which is as it were the base or foot of that Mercurial Column of Mercury, that is suspended in the Tube, may contribute something to its sustentation in that position.

But upon due consideration I find this is but an imagination, and contributes nothing to this *phænomenon*.

Indeed, if a liquid be impendent upon solid base, as Mercury upon Marble; or if a lighter or less compacted fluid be bottomed or imbased upon a much more gross and compacted fluid, as a Tube full of Air upon a Superficies of Water, or a Tube full of Water upon a Superficies of Mercury, though the Tube be open at both ends, the Base will sustain the Column of the lighter or less compacted fluid.

But if they are of the same kind and consistence, the Base contributes nothing to the sustentation of the impending Column. But if there be no other impediment, it will wholly subside. And therefore if a Tube, open at both ends, be filled with Water, and the lower end stopt with the finger, be immersed under a vessel of Water, and then unstopped; or if an open Tube stopt at the lower end with the finger, be immersed in a vessel of restagnant Mercury; in the former case the Water, and in the latter the Mercury will wholly subside to the level of the Superficies of the Water or Mercury in the subjacent vessel; which would not be, notwithstanding the Tube were open at both ends, if a Base of the same fluid had any force or resistance against its descent.

Nay the truth is, the position of the Water or Mercury in the Tube, in any the least degree higher than the Superficies of the Water or Mercury in the vessel, hath an accidental Gravitation upon a lower Superficies of the same fluid,

fluid, by reaſon of ſuch poſition or elevation of the fluid in the Tube, above the Superficies of the fluid in the veſſel, and by that poſition preſſeth upon it, as ſhall be farther illuſtrated hereafter. And therefore the *pondus deprimens* of the ſame fluid in ſuch an elevated poſition, conquers and overmatcheth the *potentia ſuſtinens* of the ſubjected fluid, though it were an Ocean of Water. I therefore lay aſide this Suppoſition, as contributing nothing to this *phænomenon*, and proceed to the examining of thoſe, that with great pretenſion and patronage are ſuggeſted to be the Cauſe of this Suſpenſion.

CHAP. XI.

Concerning the supposition of the æquipondium *of a pillar of the Air, or Atmosphere, as the Cause sustaining the Mercurial Cylinder.*

THis latter age, as it produced the *Torricellian* Experiment, so it hath produced a new Systeme in Nature for the Solution of it, namely the Gravitation of the Atmosphere, and an *æquipondium* of a Column thereof to the weight of the Mercurial Cylinder contained in the Tube, whereby it is sustained; a fuller Explication whereof hereafter follows.

And it is admirable to see, how much this new opinion hath obtained among the *Virtuosi* of this latter Age; so that as a new fashion is greedily entertained among the Gallants of the times, and an old fashion despised and contemned; so this new *hypothesis* is as greedily entertained by the great Wits of the times,

and

and hath obtained the ſtile of a *Doctrine*; and the Old Peripatetical Learning, touching *Vacuum*, and the Inſeparability of Bodies, exterminated, under the reproach of *decantata fuga*.

Nay the theory is ſo much idolized, that ſome late Authors have ſtrangely contended for the dignity of being the firſt Inventers of it.

And ſome that have defended the Peripatetical Solution of *fuga vacui*, as *Shottus*, when he wrot his *mirabilia Hydraulica* and *pneumatica*; yet whether overwhelmed and aſtoniſhed with the *Magdeburgh* Experiment and varieties thereof, or whether he was not willing to ſeem to perceive leſs than the *Virtuoſi*, that had eſpouſed the new Solution, becomes a Convert, and fairly retracts his former Opinion, and gives up the Solution of the *Torricellian* Experiment to the *æquipondium* of the like portion of the Atmoſphere, in his *Technica Curioſa*, *l.* 4. *cap.* 6. ℚ. 2.

And 'tis pleaſant to ſee what a wonderful progeny, and voluminous Syſtems of Theories, Conſectaries, and Con-

Concluſions have been ſince built upon this Suppoſition! wherein though the Authors have ſhewn much wit, ſubtlety, and learning, yet they have loſt the expence of much time, and invention, and pains, if at laſt when all is done, it prove but an imagination.

The Suppoſition therefore ſeems to be this:

1. That the Atmoſphere or lower portion of the Air, ſome ſay ſeven, ſome twenty two, others fifty, others an hundred miles high, hath a conſiderable Gravitation upon its inferior parts upon the Earth, and upon all Bodies in this lower world.

2. That where a Tube, ſealed at one end, is filled with Mercury, and then inverted into a reſtagnant veſſel of Mercury, the Mercury will ſubſide to twenty nine Inches and half, and no lower, becauſe a column of Atmoſpherical Air, of the ſame baſe with the cavity of the Tube, and incumbent upon the face of the reſtagnant Mercury, doth juſt counterpoiſe ſuch a column of Mercury of twenty nine Inches and half high:

high: so that if the Mercurial Cylinder be of that bulk, as to weigh five pound, the Atmospherical Cylinder weighs just as much, and so as one artificial scale being charged with an equal weight with the other, stands in this *æquilibrium*: so in this natural Scale the Atmospherical Cylinder pressing upon the restagnant Mercury with an equal weight, to the 29 Inches and half of Mercury in the Tube, sustains and keeps it up in an *æquilibrium*.

3. But if while the Mercurial Cylinder stands thus suspended, there be any little hole made in the sealed top of the Tube, the weight of the Air now pressing in upon the Mercurial Cylinder, takes away that *æquilibrium* which it had with that external column of Atmosphere, while it was protected from the impendent column of Air by the sealed top of the Glass; and now the Mercury is driven down by the equal weight of the Air, and wholly subsides into the restagnant Mercury; for now the Aereal Cylinder without the Tube, and that within and upon the Tube, have

have the same common weight or Gravitation upon the Mercury. And upon these Suppositions they graft innumerable Conclusions, and among the rest that the Air gravitates upon all Bodies; that the exact proportion of the weight of Air is herehence necessarily deducible; for if a column of Mercury, of half an Inch diameter, and twenty nine Inches and half high, weighs two pound (for instance,) then a column of Air of the same diameter, extending from the restagnant Mercury to the top of the Atmosphere, weighs just as much. And from hence they measure the hight of the Atmosphere, or ponderous Air; namely, Air being about a thousand times lighter than the like bulk of Water, and Water being fourteen times lighter than the like bulk of Mercury, it must follow by the rule of proportion, That if two pound of Mercury give a column of half an Inch diameter, to be twenty nine Inches high; then two pound of Atmosphere must give a column of twenty nine times 14000 Inches high: (I am not curious in the pro-

proportion, but only ſhew the method of their inferences:) and abundance of ſuch fine Conſequences are built upon this Platform, which were too large to enumerate.

Now as touching this Solution of the Suſpenſion of the Mercury in the Tube, by the *æquipondium* of a Cylinder of Air, of the ſame diameter with the Cylinder of Mercury, I ſay it ſeems to me an Imagination, and to be utterly untrue.

I will not repete what I have formerly ſaid againſt the Gravitation of the Air, in the fourth Chapter, which yet I take to be ſufficient to evince the untruth of this Suppoſition: but I will ſubjoin two or three homely Experiments, which with the application of them will, as I think, detect the untruth and inefficacy of this Solution.

1. I will begin with one offered by the Aſſerters themſelves of this Solution, of a late learned Author, in the 11. Propoſition of his *Hydroſtaticks*, and the *Scholium* thereupon, which I ſhall agree to be a true Experiment, but the application

cation thereof too much distorted, to gratifie the *hypothesis*, but in truth and reality utterly confounding it.

Take a vessel of restagnant Mercury, of seven Inches deep; then take a Glass Tube of half an Inch diameter in the cavity, and of half an Inch thick in each side, sealed at the one end, and of 3 foot long; whereby the entire Tube will be an Inch and a half in its whole diameter: Fill it with Mercury, and stop it with the finger at the open end, and invert and immerse it to the bottom of the restagnant Mercury. It will then come to pass, that about twenty nine Inches and half, the ordinary altitude of the column of Mercury, will be above the Superficies of the restagnant Mercury, and the whole Tube will thereby remain full to the top: but the Glass being lighter than the Mercury, will be impelled up by the restagnant Mercury neer to the Superficies thereof, whereby there will remain about six Inches of the upper end of the Tube empty of the Mercury, but still there will be about twenty nine Inches and half of the Tube

still

ſtill full of Mercury, namely, the uſual ſtation of its Suſpenſion.

I will ſuppoſe the twenty nine Inches and half of Mercury, ſuſpended in the Tube, to weigh one pound, and that the Glaſs Tube of it ſelf weighs likewiſe one pound.

I will now ſuppoſe, that the upper end of the Tube were fixed by a ſtring to the Beam of a pair of Scales, as in his 319th figure in that book. I ſay that two pound in the adverſe Scale will counterpoiſe this Tube with the included Mercury, and if any little advantage of weight, ſuppoſe an Ounce, were added to the adverſe Scale, that Scale charged with two pound and an Ounce, will preponderate it.

And I ſay no more than what the Author ſays was determined touching it by the *Royal Society*, whereunto he ſubſcribes, *pag.* 727. in theſe words. *Pondus in adverſa lance contraponderans æquipollebat ſuſpenſi hydrargyri cujuſcunque altitudinis, atque ſimul (quantum conjectando æſtimabant) ſuſpenſi tubi ei parti quæ ſtagnantis in ſubjecto vaſe hydrargyri ſuperficiei*

ciei ſupereminebat. Now it is certain that if the one pound of Mercury contributes to this weight, it is not ſuſtained by the adjacent external column of Air, preſſing the Superficies of the reſtagnant Mercury; for if ſo, it is ſuſtained by the *æquipondium* of that Aereal column, and cannot affect the Scale with its weight; for it is ſuſtained by another counterpoiſe, and not by the two pound weight of the Scale.

And again it is as certain, that if the Mercury do contribute to the counterpoiſe of the Scale, it muſt by ſome means be as it were faſtned to the Scale, (we will ſuppoſe it to be *Linus* his *funiculus*,) for otherwiſe the Glaſs would only weigh as a ſeparate thing from the Mercury, which would of it ſelf contribute (*ex ſuppoſitione*) but one pound to the weight, which would be neceſſarily preponderated by the adverſe Scale charged with two pound weight.

And therefore it is moſt clear, if the included column of Mercury contributes one pound weight to the ballance, it is not ſuſtained by the imaginary column

column of Air equal in diameter to the Mercurial Cylinder, but by an intrinsick connection or ligament to the Tube, whereby it weighs as one concrete Body with the Glass, which I call the *Funiculus ex subtilibus Mercurialibus effluviis contextus.*

The Author, to avoid this difficulty, therefore tells us, that this thing *primo aspectu incautis nonnullis ad Staticam minus attentis facile imponeret*; and to avoid the imposture, tells us, that all this while it is not the Mercury that contributes to the weight, for that hath another kind of Sustentation by the *æquipondium* of the forreign Air; but it is another column of Air, that impends upon the upper end of the Glass Tube as its Base, and therefore commensurate to the suspended Mercury in weight. And this is the effect of the Solution, namely, that only the Glass, and the column of Air impendent upon it, makes the counterpoise, and the Mercury contributes nothing to it.

And indeed if the column of Air, charging the Tube, were of an equal

diameter with the Mercury, or the cavity of the Tube, the Evasion were handsome and suitable to their *hypothesis*, though untrue: but the instance in question, as it is proposed, quite shatters this Solution, and renders it not only untrue, but unsuitable to their very principles.

For in this instance, the diameter of the column of Mercury is but half an Inch, but the diameter of the whole Tube is an Inch and half, which gives an *area* to the base of the Cylinder of Air impending on it, more than four times bigger than the Base of the Mercurial Cylinder. And therefore if a Cylinder of the Atmosphere of half an Inch diameter, be commensurate to the weight of the Mercurial Cylinder, and consequently weighs a full pound at that scantlet; the Aereal Cylinder, commensurate to the upper *area* of the Glass Tube, which is an Inch and half diameter, must necessarily weigh above four pounds, and therefore would not be equiponderated by the two pound weight in the opposite Scale.

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This instance therefore which is delivered with the memorial of the day, and place of its Exhibition, seems to make more to the disadvantage, than the advantage of this new Philosophy.

But to this Objection there is a Solution offered, namely, that let the Glass be of what thickness it will, That alters not the case; for the Mercury is pressed up by the counterpoise of a Cylinder of Air, answerable to the cavity of the Tube, not to the crassitude of its sides: for Glass being a Body specifically lighter than the Mercury, the Glass it self is sustained by the restagnant Mercury, which is its Base, and supports it.

But still this Answer, though it be true, avoids not the Objection. For 1. let us suppose, in stead of a Tube of Glass, a Tube of Gold, which being specifically heavier than so much Mercury, would sink to the bottom, and not be sustained by the Mercury, but must be lifted up, and sustained purely by the weight in the opposite Scale: 2. or suppose the Tube of Glass were charged in its closed end with a greater quantity

of Lead, that, though ſpecifically lighter than Mercury, would by its exceſs of extrinſical weight, depreſs the Tube to the bottom of the reſtagnant Mercury: or 3. though the Tryal were made by a Glaſs Tube filled with Water, and inverted into a veſſel of Water; for there the Glaſs Tube, with the incloſed Cylinder of Water, would ſubſide to the bottom, being altogether in its concrete heavier than the Water, and could not be ſupported by the reſtagnant Water, but by the weight in the adverſe Scale: in theſe Inſtances the difficulty will not be ſalved.

Therefore I took a Glaſs Tube, the cavity whereof was half an Inch diameter, the thickneſs of the Glaſs incircling the cavity $\frac{1}{16}$ of an Inch; and conſequently from outſide to outſide the diameter of the Tube was $\frac{1}{8}$ of an Inch; the length of the Tube eighteen Inches, the weight thereof in the Air two ounces $\frac{1}{4}$ of an Ounce, and being heavier than the like bulk of Water, it would freely ſubſide perpendicularly to the bottom of a veſſel of reſtagnant Water dee-

deeper than 18 Inches, notwithstanding the sustentation it had by the included Air, being empty, and so the Water contributed nothing to the support of the Tube when it came to be weighed, but only the thickness of its *medium*, which yet was not able to support it from sinking.

The Water which the Tube would contain, weighed one Ounce and three quarters, wanting about a Grain or two at most.

The Tube was tied at the closed end with a string to the Scale of a Ballance and filled with Water, and stopping it with the finger, inverted into a vessel of Water 18 Inches deep, or more: and then the Tube with the included Water thus immersed in Water, carefully weighed, the Water still remaining suspended in the Tube,(as it will do as long as it stands so immersed,)and the Events were these:

When the Tube was full six Inches above the Superficies of the Water in the Vessel, it weighed just two Ounces and three quarters of an Ounce, which

weight in the oppoſite Scale kept it in an *æquilibrium*; for now the reſt of the Water in the Tube, below the Superficies of the Water in the veſſel, weighed nothing at all, becauſe it obtained ſo far the ſame common Superficies, and was therefore ſuſtained by the common weight which it had with the Water in the veſſel, and only ſix Inches of Water contributed to the counterpoiſe, together with the weight of the Glaſs Tube it ſelf, though refracted by the thickneſs of the *medium*: ſo that now theſe ſix Inches of ſuſpended Water, and the Tube it ſelf, weighed no more at this poſition in the Water, than what the Tube alone weighed in the Air.

But when the Tube, with the included column of Water was raiſed very neer eighteen Inches above the Superficies of the veſſel of Water, ſo that there was as little as could well be to keep the orifice of the Tube under Water, *viz.* about a quarter of an Inch, it then required an addition of very neer one Ounce ¼ in the oppoſite Scale, to hold the Tube in an *æquilibrium*, which equal-

led

led the true weight of the Tube it self and Water included, when in the free Air, *viz.* two Ounces and three quarters, and one Ounce and three quarters, in all four Ounces and half; because now the Water in the Tube had now in effect its due weight, which it had when divided from the Water in the vessel, and so had its due Gravitation upon the Scale.

Upon this Tryal of it with Water these things are observable.

1. That according to the proportion of the Elevation assigned to Water, it would have been sustained in a Tube of one and thirty foot high, and consequently in this of eighteen Inches the Water had not attained a twentieth part of that height, at which it might in a Tube be kept suspended.

2. That according to these mens Suppositions, the Suspension in the Tube, either of Water or Mercury, is supposed to be by the pressure of a column of the Atmosphere upon the Water or Mercury in the vessel, and thereby the column of Water or Mercury is

by that counterpoise driven up in the Tube. This Tube being but of eighteen Inches long, the forreign Atmospherical pillar still will urge the Water or Mercury to rise to an *æquipondium* with it, namely the Mercury to twenty nine Inches, the Water to thirty one foot, or thereabouts.

3. And consequently, according to their Supposition, the Cylinder of Water, in the instance in question, within the Tube, presseth up the Tube, and would lift it up to one and thirty foot high, had the Tube been long enough.

4. But as the Atmospherical Cylinder without the Tube presseth up the Water, so the Atmospherical Cylinder incumbent upon the head of the Tube, presseth it down; and so according to those men it is not the Water in the Tube, that gives any counterpoise to the opposite Scale, but the Atmospherical Cylinder, answerable to the cavity of the Tube, that presseth upon the head of the Tube.

5. And that weight of the Atmo-

spherical

ſpherical Cylinder upon the head of the Tube, is counterpoiſed by the forreign Cylinder, abating only ſo much, as the proportion of the Water thruſt or kept up in the Tube, amounteth to; which being in the inſtance in hand about a twentieth part of what the forreign Atmoſpherical pillar weighs, the Atmoſpherical pillar incumbent upon the head of the Tube weighs juſt ſo much as the Water included in the Tube amounts unto. But upon the whole matter, this fine Theory appears to be but a handſom Imagination. For it is plain, in the inſtance in hand, the Atmoſpherical Cylinder, incumbent upon the head of the Tube, is larger than the cavity of the Tube, and conſequently more weighty by far (if it have any weight at all) than that forreign Cylinder of Atmoſphere, which is ſuppoſed to ſuſtain the included column of Water, and the Tube it ſelf is not ſuſtained nor ſuſtainable by the Water in the veſſel, but is wholly raiſed by the weight in the oppoſite Scale: and therefore the Suppoſition, that the weight that preſ-

ſeth

ſeth upon the Scale, is the weight of the Cylinder of Air upon the Tube it ſelf, is vain; for then it ſhould ſuſtain the weight, not only of the Tube, but another weight far greater than the forreign column of Air could counterpoiſe.

And that which ſeems to me to convince this miſtake in the whole propoſed Theory, is this plain and obvious Experiment.

*Fig.*10. I therefore took a Glaſs-tube of about half an Inch diameter, 18 Inches long, cloſed at one end; and weighing it exactly in the open Air, it weighed two Ounces and three quarters of an Ounce; and heating it very hot, whereby the included Air was highly rarified, I ſuſpended the cloſed end upon one Scale of a Ballance, and let the open end ſink a little into a veſſel of Water, and counterpoiſed it in the other Scale with two Ounces three quarters; and becauſe the end of the Tube did but little more than touch the Water, it held the ſame weight as before upon the Scale, *viz.* two Ounces three quarters.

As

As soon as the Tube was thus contiguous to the Water, it attracted and raised the Water so, that in half a quarter of an hour the Tube was filled twelve Inches with Water, the Air contracting it self to six Inches in the top of the Tube, whereby it appears it was rarified two thirds beyond its natural and ordinary rise and standard, which now againe it acquired by contracting it self.

The Water which it attracted being carefully marked at its higheſt Elevation, and then ſtrictly meaſured, weighed one Ounce and a quarter.

Now the things obſervable in this inſtance are theſe. 1. That the ſingle Tube, with the included rarified Air, did really weigh even in the external Air but two Ounces three quarters, and by that weight in the oppoſite Scale it was perfectly kept *in æquilibrio*. 2. That when it touched the Superficies of the Water, and thereby attracted the Water into it, it preſently grew more weighty, which it gradually increaſed, and accordingly more and more ſubſided, Tube and all, into the ſubjected veſſel

veſſel of Water, as it received into it more Water, and conſequently grew more weighty, 'till its full complement of 12 Inches of Water drawn up into it. 3. That when it was filled with twelve Inches of Water, then it weighed the full weight of the Tube, and the Water, *viz.* two Ounces three quarters for the weight of the Tube, and one Ounce and a quarter for the weight of the Water *in toto* four Ounces, and therefore four Ounces in the oppoſite Scale would keep it juſt *in æquibrio*. Only care muſt be taken, either by depreſſing the Water, or raiſing the Ballance, that the Tube muſt only touch the top of the Water, for otherwiſe the Water will run out, and prevent the tryal. Now to diſcover what it is that thus depreſſeth the Tube gradually, as the Water riſeth up into the Tube, whether the weight of the Tube, or the weight of the Water included in it, I will conſider,

1. What the external column of Air, which thoſe Maſters ſuppoſe to preſs up the Water in the Tube, contributes

butes to it. and ſurely according to this Suppoſition of theirs, this is ſo far from cauſing any acceſs of Gravitation to the Tube or Water included in it, that it rather preſſeth up the Tube, by preſſing and impelling the Water into it; and indeed it is that which they themſelves ſay, and build their Theories upon it, *viz.* that for this reaſon the Water in the Tube weighs nothing.

2. What the column of Air impendent upon the top of the Tube, commenſurate in diameter to the cavity of the Tube, doth contribute, which according to their Solution muſt be it that weighs down the Tube by preſſing upon it. But certainly this doth nothing in this caſe; for if the Tube it ſelf, filled with rarified Air, weighs in the open Air but two Ounces three quarters, it can never come to weigh four Ounces when in the Water, (where by reaſon of the thickneſs of the *medium*, it muſt loſe, and not gain weight,) and it had the ſame column of Air impendent upon its top, as well before its immerſion into the Water, as after. And before its

immerſion (whether it were full of common Air, or of Air thus highly rarified by heat) it ſtill weighed neither more nor leſs than two Ounces three quarters.

3. Therefore it remains, that it is the weight of the Water, that thus creeps up in the Tube, and in its aſcent to twelve Inches weighed juſt one Ounce and a quarter that gravitates in the Tube, and renders the weight of the whole to be four Ounces, which in the oppoſite Scale holds both Tube and Water *in æquilibrio.*

And as the Tube is ſuſpended to the Ballance by the ſtring or thrid, ſo the included rarified Air is ſuſpended to the top of the cavity of the Tube, by the powerful Laws of Nature, and lays hold upon the Superficies of the Water; and as it contracts it ſelf more and more, draws up the column of Water higher and higher; as a Lute-ſtring faſtned to a fixed Body above, and to a ſmall Weight below, after a high tenſion raiſeth the Weight by contracting it ſelf, and this to maintain the continuity of the parts of Nature. And

And this is a plain ſenſible and unforced Solution; and it ſeems to me, that thoſe that tell us, that it is only the Tube, and the incumbent Cylinder of Air only, that gives the weight, were impoſed upon, though not by ignorance of Statical Laws, yet by fondneſs and partiality to a new invented *hypotheſis*.

2. The ſecond Inſtance that I ſhall give, ſhall be this: Take a Glaſs Tube, cloſed at one end, of an Inch diameter in the cavity; fill it with Mercury, ſtop it with a ſmall Engine, and invert it into a veſſel of reſtagnant Mercury of an Inch and half diameter; then opening it by a contrivance which is not difficult, after it is inverted in the Mercury, the Mercury will be ſuſtained at twenty nine Inches and half, as well as if the veſſel of reſtagnant Mercury were of ſix Inches diameter.

And yet it is apparent, that the rim or round Superficies of the veſſel of reſtagnant Mercury, is not above one fourth part in *area* of the Mercurial Cylinder, and cannot be preſſed with a columnn of Air commenſurate to the cavi-

ty

ty of the Tube; for the incircling column of Mercury is not a fourth part of the *area* of the Tube, neither can it be preſſed with a column of Air of a greater diameter or dimenſion than that little rim of Mercury that incompaſſeth the Tube. So that it is not the *æquipondium* of the Atmoſpherical Column that ſuſtains the Mercury in the Tube, for if it ſhould, a column of Air of the fourth part of an Inch diameter, ſhould be as weighty as a column of Air of an Inch diameter, becauſe it muſt in this Inſtance make an *æquipondium* to a weight of Mercury, commenſurate to a column of Air of an Inch diameter.

Therefore it is not the *æquipondium* of the Air that ſuſtains the Mercury in the Tube, but ſomething elſe, and what that is, we ſhall hereafter examine.

3. My third Inſtance is that common one: If the *Torricellian* Engine be put in practice, in a great Glaſs Receiver, wholly excluding any communication with the forreign Air, the Mercury will be ſuſpended at twenty nine Inches and half, as well as in the free Air.

Air. And yet here can be no Atmoſpherical column, reaching from the top of the Atmoſphere to the reſtagnant Mercury, with its Gravitation, to ſuſtain the Mercurial column, the ſame being intercepted and broken by the interpoſition of the Glaſs.

And this plain obvious evident Inſtance had wholly deſtroyed the *hypotheſis*, and utterly diſordered and ſcattered all the *poriſmata* and Conſequences built upon it, had not another ſupplemental invention ſtept in to relieve it, namely the prodigious Elatery of the free Air, which upon a due examination will prove as great a miſtake, and as impotent to relieve this deficient *hypotheſis* as the former; and if it prove ſo, I doubt our new Philoſophers muſt be fain to return to the *decantata fuga vacui* for a better Solution.

CHAP. XII.

Touching the Elatery or Spring of the Air.

I Come now to consider that subsidiary help, substituted by the New Philosophy, for the Solution of the *phænomena* of the *Torricellian* and other Experiments of this nature: and herein I shall consider these things.

1. What Elatery or Spring is of all hands agreed to be truly found in the Air.

2. What Elatery or Spring is substituted by the late Philosophy, and how applied by them to the Solution of *phænomena* of this kind.

3. The Arguments, Reasons, and Evidences that evince the mistake of this new Elaterical Supposition.

First, as to the former of these, this is agreed of all hands, that the Air being a subtle Fluid, is capable of an accidental Elasticity of very great efficacy and force: namely, when by accidental impression

preſſion upon it, it loſeth that common and natural ſtate or conſiſtence, that otherwiſe belongs to it.

As 1. by a great compreſſion of its parts together, ſuch as we ſee in Wind-guns, whereby it is compreſſed into a ſpace ſometimes ſeven times leſs than that which is natural to it, and then by a natural and ſtrange motion of reſtitution it hath an Elaſticity, whereby to regain its natural ſtate and poſition. 2. By conſtipation of its parts by Cold, whereby it is bound up ſometimes to a narrower room, and then by the approach of convenient heat, that conſtipation is relaxed, and the Air regains its natural liberty, motion, and conſiſtency: and 3. by Rarifaction by heat, whereby it is expanded beyond its natural ſize, and as it grows cold, it obtains a kind of Elaſticity inward, and an inward endeavouring to contract it ſelf to its natural ſize and dimenſion. 4. In a ſtrong tenſion by an accidental or collateral force, whereupon it contracts it ſelf as much as it can to its natural ſtate, and reſiſts that tenſion

which diſcompoſeth and extends it; from whence follows that which is uſually called Suction, or Attraction, of which I ſhall have occaſion hereafter to write more at large.

Again 2. it muſt be agreed, that although the Air in its natural conſiſtence is by a great force compreſſible into a cloſe order, yet it doth reſiſt ſuch a compreſſion, and doth not eaſily yeild to it; and therefore take a Tube of any conſiderable length, cloſed at one end, and the open end inverted upon the Water, and preſſed down, yet the Air included will retain very much of its natural ſtate, and receives but a ſmall contraction by the counterpreſſure of the Water, poſſibly an Inch in two or three, or ſomewhat more, according to the depth of its immerſion.

But theſe Elateries are not ſuch as concern the preſent queſtion.

Therefore I come to the Suppoſition of the new Philoſophy, in relation to this buſineſs of Elaſticity of the Air, which they attribute to the common and free Air in which we breath and live;

live ; and if I miſtake them not, their Suppoſition is this :

1. That the Air is a kind of Spungy Body, not much unlike (as to this purpoſe) to a Spunge or Fleece of Wool, capable of compreſſion, and under that compreſſion endeavouring to looſen and diſcharge it ſelf by that which we call Springineſs or Elaſticity.

And herein we do not conſiderably differ, only they ſay that this Elaſticity is of a vaſt, and almoſt unlimited nature, that ſcarce hath any bounds to it ; we ſay that it hath more contracted and determined limits of its Elaſticity, and thoſe are ſuch as every portion of free Air obtains in a common and uſual ſtate of the temperament of the Weather.

2. Again they ſay, that the Body of the Air, or at leaſt of the Atmoſphere, conſiſts of a great many little crooked filaments like Springes, which when extended to a greater ſtraightneſs than is ſuitable to them, as in its high tenſion or rarifaction, indeavour regaining of their natural curvitude ; and when by any weight or force they are drawn cloſe to-

gether, they spring out to their just extension, and that gives a common Springiness to the Air in such a consistence or circumstance.

3. That the superior parts of the Air gradually gravitate and compress the inferior parts, and therefore the higher the Atmosphere or Air is, the less it is compressed; but the lower it is, the more it is compressed, the lowermost parts receiving and sustaining the pressure of all these parts that are above.

4. That the actual Elatery, or Spring of the Atmosphere, or Air, is the issue or effect of this Gravitation; and the more the Gravitation is, the greater the Spring of those parts are, when they can but get liberty to expand themselves; for the greater weight doth the more bind and incurvate these crooked filaments, which makes them fly out extremely, when they can get themselves unfettered from the oppressing weight, and even while they are under that pressure they have their *conatus* for their liberty.

5. That because the lower parts of the

the Air next the Earth are moſt preſſed upon by the ſuperior parts, therefore the lower parts of the Air have the greateſt Elaſticity and Springineſs, which it exerciſeth according as it gets liberty.

6. That therefore this inferior Air hath a natural vaſt propenſion to Extenſion, and amplifying of it ſelf, inſomuch that if we ſhould ſuppoſe any part of the Univerſe were free from any Body, or had a more ſubtle Body than that of the common Air, if a portion of the lower Air next the Earth were placed there, it would upon the account of its own natural Elaſticity, expand it ſelf as largely, and it may be much larger than thoſe Artificial Expanſions wrought by fire in *Æolipiles*; and other Engines, wherein nevertheleſs the Air may be ſo ordered, as to poſſeſs ſeventy times more room than before it had.

7. That therefore when we ſee a little portion of Air included in a Tube, in the *Torricellian* Experiment, extended upon the deſcent of the Mercury four, five, or ſix Inches, or into a larger room than it poſſeſſed upon its firſt in-

cluſion, this is no forced tenſion of the Air, but a free natural expanſion of it ſelf, having gained room and opportunity, by the deſcent of the Mercury, for its reception; and therefore this natural expanſion of that included particle of Air, is one great help towards the deſcent of the Mercury, 'till it comes to its ſtation.

8. That in as much as the Elaſticity of the Air, when contiguous to the Earth, or other ſolid Body, is impeded in its Elaſticity downward by the reſiſtance of the Earth, it is as it were reverberated upward, and laterally, where it may be exerciſed: which is a great means of that ſupport that the recoiling Aereal particles give to weighty Bodies, which is ſeen in the ſuſtentation of the lower of the adhering Marbles.

9. That every part of the lower Air is under the ſame compreſſion with the ſame region wherein it is, and therefore if a portion of the free or open Air be incloſed within a Glaſs-Receiver, cloſed on every ſide, yet it hath the ſame Elaſticity that the portion of Air had, out of which it was taken.

10. And becauſe that Air in the Glaſs is on every ſide penned up, and its Elaſticity being as it were reverberated from every ſide of the Glaſs, doth the more intenſely and forcibly rccoil inward: and therefore it comes to paſs, that though the great Glaſs Receiver, compaſſing in the *Torricellian* Engine on every ſide, be deſtitute of the weight of the column of Atmoſphère, to ſuſpend the Mercury by its *æquipondium*; yet the included Air doth the very ſame thing by its Elatery or Spring upon the reſtagnant Mercury.

And thus we ſee how, for the accommodating of the *Torricellian phænonomena*, and ſome others of like nature, where the *pondus Atmoſphæricum* cannot be had nor acquired, what a laborious invention and proceſs is framed for the ſupply of that deficiency.

Therefore I come to conſider and examine, whether this laborious proceſs have any thing of truth and reality in it, or whether, as that of the *pondus cylindri Atmoſphærici*, it be only a fine invention to help and ſupport a lame and lan-

languiſhing *hypotheſis* or Solution.

Although whatſoever doth oppoſe the Gravitation of the common Air, doth as neceſſarily conclude againſt this Elaſticity of the free and common Air; and although much of what I have written in the third and tenth Chapters, againſt the Gravitation of the Air, is equally applicable againſt this imaginary Elaſticity thereof, ſince the Elaſticity is by the *hypotheſis* ſuppoſed to be the effect of its Gravitation; yet I ſhall repete nothing, or very little, of what I have there ſaid, but apply my ſelf ſingly to the diſcuſſion of this Elatery or Springineſs of the common or free Air, both by Reaſon and by Experiments.

1. The Spring of the Air is bottomed upon the ſuppoſition of the actual preſſure of the ſuperior parts of the Air or Atmoſphere upon the inferior, and the lower parts being under the greater preſſure, hath conſequently the greater Elatery. But upon what hath been before ſaid, in the third Chapter, there is no ſuch Gravitation or preſſure of the Air or Atmoſphere, and conſequently

no ſuch Elatery in the free and open Air.

2. If there ſhould be admitted any ſuch Elaſticity in a portion of the Air below in this inferior region, included within a Glaſs veſſel or Receiver, (the inſtance for whoſe ſake this invention was principally deviſed,) ſo as to ſuſtain the ſuſpended column of Mercury, then of neceſſity there muſt be the ſame Elaſticity of the ſame or the like portion of the common Air, (for it is all ſuppoſed under the ſame common preſſure of the ſuperior parts:) the conſequence whereof muſt needs be, that either the attribution of that Suſpenſion to the Gravitation of a Column of the Air, and all the delicate Conſectaries thereupon, are more Fancies and Miſtakes, becauſe the whole *phænomenon* is performable and performed by the Elaſticity of the Air, as well without as within this cloſe Glaſs veſſel; or elſe the joint power of the *pondus*, as well as the Elaſticity of the forreign Air, muſt raiſe the Mercury in the Tube to fifty nine Inches, ſince the Elatery of the Air alone, without

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the aid of the Gravity of the Atmoſpherical Cylinder in the incloſed veſſel, is able to keep it ſuſpended to twenty nine Inches and half. But we ſee the contrary in the Experiment tried, as well within as without the incloſed Glaſs; therefore either the weight of the Atmoſpherical Cylinder, or its Elatery, muſt be laid aſide in this Solution, or, which is the truer Concluſion, neither the one nor the other are to be admitted, but both are to be rejected as croſſing one another, and alſo the truth of the Solution.

3. Nay, but yet farther, if this Elatery be admitted, the whole Scheme of the Gravitation of the Air, or any part thereof, muſt be rejected as fictitious, and impoſſible; and on the other ſide, if the ſuppoſed Gravitation of the Air or Atmoſpherical Cylinder be admitted, the Elatery muſt be rejected, and the whole Air will be *in æquilibrio*, in as much as upon this ſuppoſition of this New Philoſophy, the Elatery preſſeth as much upward, as the Gravitation doth downward, and *è converſo* the Gravitation as much

much downward, as the Elatery doth upward: so that after all this laborious *apparatus* of Gravitation, and Cylinders, and Atmosphere, and Elatery, the Air is at quiet, at rest, and *in æquilibrio*, which is easily granted without all this difficult *hypothesis*.

For according to these mens supposition (if we should admit it) the Atmosphere were seven Miles high, we must needs suppose that the greatest Elatery is next the Superficies of the Earth, because there it is more charged with the weight of the superior parts of the Air; and because the terrestrial Globe checks the Elatery of it downward; the Elatery must discharge it self by its motion upward, and so encounter the pressure of the Air, by how much more its Springs and crooked Particles are charged. And a Mile higher in the Atmosphere where is less pressure, there is consequently less Elatery or resistance of that pressure, and yet sufficient to keep that rundle of Atmosphere in an *æquilibrium*.

And it is plain, that this Countermotion of the supposed Spring, or Elatery,

tery, and Gravitation of the Air, must by their mutual conflict, one check and refract the other.

But then it is hoped, that the interposition of another gross Body between the ponderous Air tending downward, and the reverberated, recoiling, Elastical Air tending upward, may part the fray; and thereupon in the instance of the two cohering Marbles, the upper column of impending Air may press down the upper Marble, and the lower column of recoiling Air may press up the lower Marble.

But this will do nothing to help the business in hand, touching the Mercurial column in the *Torricellian* Experiment, (for as for the cohesion of the two Marbles, and the reason of it, I shall in its due place examine.)

For it is plain there, that if there be any Elasticity in the Air next the Earth, there is proportion for proportion as much Elasticity in the Air next the restagnant Mercury, upon which it is incumbent, and which we may if we please, place even to the Superficies of the

the Earth; for the column of Air (*ex ſuppoſitione*) proportionable in baſe to the Mercury, is as really gravitating upon the Mercury, as upon the Earth, and conſequently there is the very ſame Elatery or *ſurſum* preſſure of inferior parts of that Atmoſpherical pillar incumbent upon the Mercury, that would break the Gravitation of that upper Atmoſpherical Cylinder, and render it ineffectual.

Beſides all this, as it requires a ſtrong Phantaſy to ſuppoſe this wonderful Elaſticity of the Air, ſo it requires a much more potent phantaſy to keep the Elaſticity of it within the preciſe lateral dimenſions of the Atmoſpherical pillar in a ſtraight line: for the Elaſtical particles of the Aereal parts, adjacent to that Atmoſpherical Cylinder, will incroach and break it upon this Cylinder, and diſorder and refract its preſſure, beſides what the concuſſion of Winds would effect.

4. But ſuppoſe in the free Air the *pondus deprimens* of the Atmoſpherical Cylinder were too hard for its Elatery, and

so although in an incloſed Glaſs the Elatery doth the whole buſineſs in ſuſpending the Mercury in the Tube, yet in the open Air the *pondus deprimens* conquers its Elaſticity, and the whole *phænomenon* ſhall be there performed by the *pondus deprimens* of the aereal Cylinder: I ſay ſuch a Suppoſition as this would render the lower parts of the Air unmoveable, and bind it up ſo, that it could never ſtir without an admirable relaxation of it by the violence of heat, which is contrary to all the experience of the World. For we ſee by the ſmalleſt winds the motion of Smoak, and a thouſand Inſtances more, the lower parts of the Air are in a perpetual flux and motion, which it could never do, if under ſo rigorous a conſtipation and compreſſion by its ſuperior parts. And though this immediately contradicts the great preſſure of the inferior Air by the ſuperior, yet by neceſſary conſequence it contradicts the ſuppoſed Elatery thereof.

5. But as to the very inſtance before given, of the ſuſpenſion of the Mercury

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in a Tube placed in a closed Glass Receiver, protected from the impendent aereal ponderous Cylinder; I say, that the suspension of the Mercury is not caused either by the Weight or the Elatery of the Air. Not by its weight, because the Atmospherical column is intercepted, and kept off by the interposition of the Glass; it remains therefore that it must be done by the Elatery or Spring of the Air included in the vessel: but that cannot possibly do it, for these Reasons. 1. Because that Elatery that must sustain the column of Mercury, cannot be an Elatery pressing upward or laterally, but it must be such an Elatery, as must press downward, to bear against the excursion of the suspended column of Mercury, and thereby keep it *in æquilibrio*: and certainly if there be any Elatery of the Air, it must bear rather upward against what presseth it down, and causeth it, than downward. 2. But if it be said that by the Receiver, or Glass incloſing the Air every way, the Elatery is as well turned downward as upward, and so counterpoiseth the co-

lumn of Mercury, and so it is not like the recoil of the Spring of the Air from the Earth, which must be principally upward, because checked and reverberated at its base; but here the repercussion is from all parts of the Glass, as well from above as beneath. I say this very objection renders it utterly impossible, that the Elatery of the Air in the Glass can cause this Suspension, or in any measure contribute to it. For let us suppose the Glass Receiver to be spherical, the repercussion of the Elatery of the Air must be equal from all parts: the consequence whereof must necessarily be, that this Elatery presseth as well upwards as downward, and from every part of the Spherical cavity of the Glass, the consequence whereof must needs be, that the whole Elatery is in suspence, and one Elastical line breaks, refracts, and retunds another; so that the tendency of this Elasticity is neither upwards nor downwards, nor from any point of the Compass, but all things are at rest, as where Winds blow with an equal strength every way, the

Air

Air is undisturbed, and so no pressure at all made upon the Mercury, but it is but a meer evasion to shore up an *hypothesis*.

CHAP. XIII.

Certain Experiments, evincing that the common Air in its ordinary consistence, hath no, or no considerable Elasticity or Spring, without an accidental or preternatural Compression.

IN the former Chapter I have given the reasons against the wonderful Elasticity of the Air, or Atmosphere, and the insufficiency of that Supposition to give a Solution to the *phænomena* in the *Torricellian* Experiment. And I now come to some experimental Instances, farther illustrating and proving what I have said in the former Chapter, namely that either there is no Elasticity at all in the common Air, nor in any part thereof inclosed in the vessel, *de quo supra*, or if any at all, yet very little,

tle, and such as is no ways able to keep such a column of Mercury suspended, which may possibly weigh according to the amplitude of the Tube two or three pounds, which yet we see suspended in the *Torricellian* Experiment.

For it is a certain and demonstrable truth, that if any *potentia*, be it what it will, sustains a weight or *pondus deprimens*, the *potentia sustentans* must be of an equal strength to that weight, otherwise it must give way, and yeild to it.

Therefore if the *potentia* of the Elasticity of the common Air (not compressed or constipated accidentally) be not equal in this instance to two pound of Mercury, it can never sustain or keep it suspended: and this is that which I shall endeavour to make good.

Fig. 12. Take a Bottle-Glass *A*, fill it with Water to *B*, which may contain about six Ounces of Water, the rest of the Bottle full of Air; then take the Bolts-head *C*, heat it very hot, that the Air may be in a great measure driven

out

out of it, and the reſt highly rarified and expanded: Invert it into the Glaſs Bottle, ſo that the free Air may come in, (though but at a Pin-hole,) as the Air in the Bolts-head grows cool, and conſequently contracted neer to its natural ſize and ſtate: the Air thus rarified, the Water in the Bottle will be drawn up into the Bolts-head to ſupply the vacancy, which otherwiſe would happen by the reſtitution of the Air. But if the fiſſure between the Bottle and Shank of the Bolts-head had been haſtily ſo cloſed, that no Air could enter into it, ſome Water would ariſe as ſuppoſe to *D*, but the whole Water would never be driven up out of the Bottle by any Elatery of the Air included in it; but only the ſuperior Air in *C*, being ſo highly rarified by the heat, that one third part of the Air in *C*, as it ſtood unrarified, takes up the whole Bolts-head by rarifaction; and as the Air in the Bolts-head grows to its natural temper, and conſequently endeavours to retract it ſelf to its natural dimenſion, ſo having the fluid Water to work upon, it draws it up, and by

the advantage of that attraction gives a tenſion or expanſion to the Air in the upper part of the Bottle, as much as is capable to be obtained by the ſtrength of the attraction and ſuction of the rarified Air in the Bolts-head, which drawing up the Water, and leaving leſs Water there than before, muſt needs expand the incloſed Air in the top of the Bottle, to ſupply that receſs.

Now if the Air in the head of the Bottle, being taken out of the common Air, and of the ſame conſiſtence with it, had that ſtrong Elatery that theſe men ſuppoſe, ſo that it reacheth as it were after a dimenſion five, nay forty times larger than that it hath, it would thruſt up the whole Water in the Bottle as high as *E*, as it would have done if the fiſſure between the Bolts-head and the Bottle had not been ſtrictly cloſed.

And this it ſhould have done the rather, becauſe the ſuperior Air is ſo much rarified, that it takes up three times the room of common unexpanded Air, and ſo is capable of a more effectual impreſſion from the Air in the Bottle, and

would

would not rest at *D*, but drive up the Water as high as *E*.

And if any shall say, that the weight of the interposed Water is too great for its Elatery, to thrust it up as high as *E*; certainly he that shall suppose that the Elatery of the Air, included in a close Receiver, is able to thrust and keep a column of Mercury to twenty nine Inches high, which column weighs possibly a pound or more, cannot doubt but the Elatery of the Air in the top of the Bottle, if it were of that force that these men suppose, would thrust up five or six Ounces of Water, about five or six Inches high, into the Bolts-head.

But the plain truth is, that in this instance, nor any of the like nature, it is neither the weight nor the Elatery of the Air included in the Bottle, that forceth up any drop of Water above its Superficies, but the powerful attraction of the expanded Air in the Bolts-head, endeavouring its own contraction when growing cold, and so attracting the Water to supply that *casma*, that would otherwise follow upon its attraction.

And therefore when by the deſcent of the Mercury a little portion of Air in the top of the Tube in the *Torricellian* Engin, gains four or five times a greater extent than it had before; this is done by the tenſion of that little aereal Cylinder, by the force of the deſcent of the Mercury, as ſhall be more at large ſhewn hereafter, and not as is groundleſly ſuppoſed by the natural Elaſticity or expanſion of that portion of Air. For if that ſhould be the cauſe, it were neceſſary that the finger ſtopping the top of the inverted Tube open at both ends, ſhould be thruſt up, and not drawn in, and an empty Bladder ſhould be more compreſſed than diſtended by ſuch Elaſticity of the included Air, the contrary whereof is evident both to Senſe and Experience.

CHAP.

CHAP. XIV.

The consideration of some Arguments for the weight and Elatery of the Air.

I Shall not spend much time upon These arguments, but only note some general Observations upon them, and then single out some Instances wherein I shall be more particular.

In general therefore I say,

1. That all those Instances and Experiments produced to prove such a Weight or Elasticity of the free Air, that may be capable of effecting the *phænomena* in the *Torricellian* Experiment, yea or in the *Magdeburgh* Instrument, or the *English* Air-pump, are all capable of another Solution, as appears by the answers that *Linus* hath given to them, which I need not repeat.

2. That the application of the Weight and Elasticity of the Air to the Solution of these *phænomena*, is forced, streined, and in many instances contra-

ry

ry to the evidence of Senſe; ſo that though the appearances themſelves are true, yet thoſe Cauſes aſſigned are very inevident, full of difficulties and abſurdities, and require ſuch a train of ſupplemental Suppoſitions to make them but tolerably applicable, that no man diſingaged from a party can eaſily ſubſcribe to them.

3. That there are ſome Inſtances and Experiments that are ſo untractable to this method of Solution, that all the inventions of the moſt Mercurial wits and higheſt ingaged in the patronage thereof, cannot by any means relieve it.

4. That the plain and common Solution of them by the inſeparability of Bodies, and the *fuga vacui*, (pleaſantly by ſome ſtiled *decantata olim fuga vacui*) doth moſt naturally, and without any ſtreſs offered to Senſe or Nature, anſwer all Inſtances and difficulties, and fails in none.

5. That it is moſt evident to any man, that without prejudice or partiality ſhall obſerve it, all or the moſt part of thoſe Inſtances and Experiments,

which (to ſerve the *hypotheſis* of the gravitation and Elaſticity of the common Air) are reſolved into Preſſion or Elaſticity of the Air, are plainly performed by Suction and Attraction of the Air, when put under a great tenſion or rarifaction, which wholly ſubverts the Solution by Preſſure or Elaſticity of the Air.

Now as to ſome particular Inſtances.

Firſt, we are told that the *Torricellian* Engin, wherein at the bottom of the hill, the Mercury riſeth to twenty nine Inches and half, carried up to the top of the hill *Puy de dome* in *France*, ſubſided three Inches: and ſome Inſtances of like nature given in *Lancaſhire*, it ſubſides neer two Inches. From whence it is inferred, that this variation ariſeth, becauſe upon the top of the Mountain, which was 3000 foot high, the column of the Atmoſphere was ſhorter, and ſo gravitated leſs upon the reſtagnant Mercury, than it did at the bottom of the hill, which cauſed the diſparity of the poſition.

I anſwer, admitting the fact true, yet the

the cauſe aſſigned is *non cauſa pro cauſa*, or at leaſt we have no ſufficient evidence that this is the cauſe.

The various Elevation or depreſſion of the Mercury is not in reſpect of the height or lowneſs of the place, where the Inſtrument is uſed, but in reſpect of the temperament of the Air wherein it is uſed. The Excellent Author tells us, in his eighteenth Experiment, that the *Torricellian* Engin placed in his Chamber window for a good ſeaſon, the Mercury had various Elevations and ſubſidings, according to the temper of the Air; and that this variation was conſiderable, namely two Inches, and that in cold weather, contrary to the uſe of other Weather-Glaſſes, it fell much lower than at other times. And if this be ſo, it is no wonder, at the top of the hill, where the Air was much colder, it might ſubſide conſiderably from the height it had at the bottom.

But whether it were colder or hotter, yet certainly there is that difference of temperament in the various regions of the Air, that might make a various poſition

position in the Mercury. What if we should say, that the *vis igneapenetrativa Ætheris* is stronger there than below the hill, and so might strongly dilate that small portion of Air upon the top of the hill, though the sense of heat be there less?

But I cannot chuse but observe, that if we should assign this Subsidency of three Inches of Mercury to the shortning of the Atmospherical Cylinder, by 500 Fathoms of perpendicular height, we must necessarily conclude the great mistakes in the computation of the gravitable Air or Atmosphere, and must render it of a prodigious height beyond all the Estimates of the latter Elaterists, whereof some tell us it is seven Miles high. By others Computation that it is 33893 Feet, which is 5648 Fathoms, somewhat less than seven Miles.

But if a Mile next the Earth should abate but three Inches in the height of the Mercury, six Miles more would hardly abate three Inches more, *viz.* six Inches; nor twenty four Miles more would

would abate nine Inches. For a Mile of Air next the Earth (if the gravitation of the Air ſhould be admitted) would more than ten times counterpoiſe the next Mile about it, becauſe it hath theſe advantages, 1. of the greater incumbent weight of the ſuperior Air, 2. of the ſtubborn reſiſtance of the terreſtrial Globe, whereby it is more conſtipated and bound together the nearer it is to its reflexion and repercuſſion. 3. The great concrement and acceſſion that it hath of groſſer vapors, and terreſtrial effluxes, wherewith the lower parts muſt needs be more laden than the upper; ſo that from the firſt gravitating particle of Air or Atmoſphere to the loweſt, it will increaſe by a Geometrical Progreſſion in every part, as 1, 2, 4, 8, 16, or very near it, which will render the loweſt Mile prodigiouſly more weighty than any of the ſuperior Miles.

But I diſmiſs this buſineſs of the gravitation of the free Air as a meer Notion.

The Inſtances to prove the Elaſticity of the Air, are for the moſt part ſuch as

are

are endeavoured to be made out by the tenſion or rarifaction of the Air by the Wind-pump, or *Magdeburgh* Inſtrument. And the anſwer to any one of them gives an anſwer to all, for the application of them to the Elaſticity or Spring of the included Air is bottomed upon one common miſtaken ground. I ſhall therefore mention but one or two of them.

The Excellent Author in his Book of *Phyſico-Mechanical* Experiments, *Exp.* 5. gives an account, how a dry Bladder well tied, and blown moderately full, and faſtned into the inſide of the Receiver in the Air-pump, upon a ſtrong exhauſtion of the Pump was broken; and in the 16th Experiment, a Glaſs included in the Receiver, broken by the exhauſting of the Air. And in the Continuation of new Experiments, *Exper.* 7 and 9, the ſame Inſtance of breaking of included Bladders and Glaſſes is repeted, and attributed always to the natural dilatation of the internal Air included in the Glaſs and Bladder, the circumjacent Air being rarified by tenſion.

But

But the true Solution of both is quite another matter. The Bladder is dilated by the attraction wrought by the tenſed or expanded Air, upon the outſide of the Bladder, and thereby the included Air neceſſarily expanded by that force, ſtretching out the ſides of the Bladder that includes it, and when it is capable of no greater ſtretching it breaks, not by the natural expanſion of the included Air, but by the ſtrong tenſion wrought upon the Bladder by the attraction of rarified or tenſed Air in the Receiver, that tears the Bladder.

And as to the Sealed Glaſs-bubble, the fracture thereof with that violence is not by the natural Elaſticity of the Air included in it, but by the ſtrong attraction wrought upon every part of its external Superficies, by the tenſion of the ſtrongly circumjacent tenſed Air in the Receiver.

And therefore if the Bladder or Bubble were filled with Water, and cloſed faſt, (which is not capable of any natural Elaſticity) I make little queſtion but the ſtrong attraction of the expanded Air

Air in the Receiver would break the Glaſs and Bladder, eſpecially if it have any angles, (though I confeſs I cannot be very confident of what I never tried.)

And yet if it ſhould ſucceed according as I ſuppoſe, though the natural Elaſticity of included Air would be thereby convinced of untruth; I expect there muſt be another expedient invented by the Elateriſts to ſalve it, *viz.* as prodigious a weight in the included Water, as there is ſuppoſed an Elaſticity in the included Air.

In the late Book intituled, *New Experiments about the Preſſure and Spring of Air upon Bodies under Water*, Experiment the ſecond I find this Experiment, which is to the effect following.

Take a Bladder, and ſqueezing out the greateſt part of its Air, tye the neck very cloſe, and faſtning a competent Weight to it, place it in a great large Glaſs, and placing that Glaſs upon the Air-pump, fill it with Water, and then covering the Glaſs with a large Receiver well luted to the Pump, the Air pumped out of the large Receiver, the

Bladder below the Water would gradually swell, 'till by often pumping out the Air, the Bladder would be full blown. And the Supposition is this, that the Air being highly rarified and extended in the Receiver, whereby the strength of its counterpressure or Spring was weakned and abated; the little portion of Air in the Bladder, notwithstanding the interposition of the Water, having the advantage thereby of expanding it self, did accordingly fill up the Bladder.

The truth of the fact is unquestionable, but the Solution of it by the natural Spring of the Air in the Bladder, is an assignation of *non causa pro causa*; but the true Cause is, that by the strong tension of the Air in the Receiver, it lays hold and attracts upon all the parts of the Water, and all that is included in it, and the Bladder being within the reach of that forcible attraction, hath its sides thereby distended, and the included portion of Air expanded and rarified by the tension upon the Bladder; not by any natural Elasticity of the included

cluded Air, but by the forcible attraction wrought upon the external Superficies of the Bladder, and pulling it asunder, whereby the included Air by the common Law of Nature is necessarily expanded to prevent a vacuity.

And as if there had been no Water interposed, the Bladder would thus have been extended, and the Air included in it expanded, by the strong attraction of the rarified Air in the Receiver; so the same effect will as necessarily ensue, notwithstanding the interposition of the body of Water: for that *vis attractiva* of the expanded Air in the Receiver, though it immediately fasten upon the Superficies of the Water in the vessel, yet thereby and therewith it also pervades the whole body of the Water, which being a fluid body hath thereby a tension made upon it, and all its parts, and all that is included in it.

And the truth of this appears beyond dispute, for the Learned Author in his 19, 21, 22, 23, *&c* Experiments, tels us, and that truly, that by this pumping and rarifying of the Air in the great Re-

ceiver, Water, Spirit of Wine, &c. will be raiſed to run out of a Glaſs included in it, & that bubbles will thereby be formed at the bottom of the included veſſel of Water: whereof the true cauſe (whatever be otherwiſe aſſigned) is the forcible attraction of the tenſed and expanded Air in the Receiver upon the included Water, which ſtrongly pervades the whole body of Water, penetrates to the very fund or bottom of it, and puts it altogether into a various agitation.

And therefore as this attraction pervades the whole body of water, ſo it pertingeth to the included Bladder in the very ſame manner as it doth upon the Water, though with a more ſenſible extumeſcence of the Bladder, becauſe more capable of it.

We need not reſort to a more evident Inſtance than that common and ludicrous Experiment, yet taken notice of by *Regius*, of immerſing the ſmall end (*Fig.* 13.) of a lighted Tobacco-pipe *B* under Water in a Vial, and ſucking another Pipe *C*, not touching the water.

the

the Glaſs being cloſely covered, the ſtrong attraction of the Mouth upon the one Pipe will, through the Water upon the orifice of the immerſed Pipe, draw the Smoak into the other, notwithſtanding the interpoſition of the Water, and will put all the parts of the Water, to the very bottom of it, and the granules of Sand lying at the bottom of the Water, into motion and elevation, as in the Figure.

And the very ſame Anſwer is moſt clearly to be given to the third and fourth Experiments in that place, and to others of like nature, without recurring to an imaginary natural Elaſticity in a ſmall portion of included Air, whereby to expand it ſelf without any forcible attractions to ſuch a prodigious amplitude.

And thus I have done with what I have to ſay againſt the Solution of the *Torricellian* Experiment, either by the Weight or Elaſticity of the Air or Atmoſphere; which to me ſeems a Suppoſition contradictory to our very Senſes, a Suppoſition attended with infi-

nite absurdities and inexplicable difficulties.

And yet, as I have before said, it is wonderful to see with what tenacity, and with how great confidence it is asserted, and how marvellously it hath obtained among the *gens literata*, and what Systems of new Physicks, what rare trains of Consequences, what Propositions, *porismata*, *Scholia*, it hath multiplied! wherein if the Foundation it self prove but a mistake, men have spent much labour in vain upon it.

Therefore laying aside this Solution as untrue, I proceed to that which the more steady Modern Philosophers, consonant to the ancient Principles, have given in this case, and seems to be most consonant to truth.

CHAP.

CHAP. XV.

Concerning the true Cauſe of the ſuſpenſion of the Mercury at twenty nine Inches and half, or thereabout, in the Torricellian *Engin.*

I Come now to conſider of that cauſe of the ſuſpenſion of the Mercury at twenty nine Inches and half, or thereabouts, in the *Torricellian* Engin.

They that aſſign the Diverſity of the Weights of fluid Bodies, tell us;

1. That although Air be intrinſecally heavy, yet it is neer one thouſand times, or as *Merſennus* will have it, about 1300 times lighter than the like quantity of Water; and this they endeavour to evince by Experiments. But this Concluſion is very doubtful and difficult.

2. That Water is fourteen times, or very neer thereabout, lighter than Mercury, quantity for quantity, and this as it is eaſie to be tryed, ſo upon try-

al I find it very neer the truth, though Water it ſelf in ſeveral places differeth ſomewhat in weight, and therefore it is not eaſie to make this the common ſtandard for all Waters, though the difference be not conſiderably great.

Though Water be ordinarily fourteen times lighter than Mercury, yet this is not the juſt proportion of the ſuſpenſion of one and the other in a Tube.

For if a Tube of Water, above one and thirty foot long, ſtopt above and immerſed at the other end in reſtagnant Water, it will ſubſide as is ordinarily ſaid to thirty and one foot, others ſay more, whereof ſee the Experiment *apud Schottum in Technicis Curioſis, l. 3. cap. 2. Exper. 2, & 3.*

But in the caſe of Mercury, if the Tube of above twenty nine Inches and half long, ſuppoſe four foot, be ſtopt at the top, and immerſed at the open end in reſtagnant Mercury, it will ſubſide to twenty nine Inches and half, or thereabout.

But although in theſe two fluids, of this

this different gravity, the ſubſiding of either vary, yet the reaſon both of the ſubſiding and ſuſpending of the one and the other will be the ſame.

Therefore what I ſay in relation to the ſuſpenſion and ſubſiding of Mercury, will be in its reaſon applicable to the other, and therefore I ſhall here only treat of the ſuſpending of Mercury, becauſe the Inſtruments to try the Experiment in Water are more maſſy and untractable, but, as I ſaid, the reaſon of one will be the reaſon of the other.

There be three Inſtances of the ſuſpenſion of the Mercury in the *Torricellian* Engin, which though they all are reſolvible into one common reaſon, yet that reaſon hath a various application ſeverally to them.

Firſt, when the Tube exceedeth in length the ordinary ſtation of the ſuſpended Mercury, *viz.* twenty nine Inches and half, as ſuppoſe it be four foot long, and the Tube receive only thirty Inches of Mercury, or though the Tube be filled more than twenty nine Inches and half of Mercury, yet it is not

ſo

ſo perfectly filled, but that there remains a portion of Air in the head of the Tube, upon its inverting into the reſtagnant Mercury.

In this Inſtance, if the portion of Air be ſo great before its Expanſion, that being expanded by the deſcent of the Mercury, it can reach below twenty nine Inches and half, as ſuppoſe to 20, 23, 24 Inches or leſs, then the Mercury will ſubſide to that ſcantlet that the portion of Air is extendible unto.

If the portion of Air be leſs than can be extended, below twenty nine Inches and half, or the diſtance be ſo great that the extenſion of that portion of Air cannot by its expanſion ſupply a greater room than what juſt anſwers to that ſtation: as ſuppoſe the Tube were above 4 foot long, and filled with Mercury all but half an Inch, and then inverted into the veſſel of reſtagnant Mercury, whereby before its ſubſiding there would be about half an Inch of free Air in the head of the Tube; and by the deſcent of the Mercury to twenty nine Inches and half, if that little portion of

Air

Air were yet ſo much as were capable of ſuch an extenſion, it would be extended to that length, *viz.* eighteen Inches and half; but if that task were too hard for ſo ſmall a portion of Air to be extended unto, then the ſame would be ſupplied by the ſubſidiary ſteams and *effluvia* out of the Mercury, to make a retreat for the Mercury, to a deſcent of twenty nine Inches and half, as hath been ſhewn, and ſhall now farther be declared in what follows.

In this Inſtance theſe things are to be noted. 1. That by the deſcent of the Mercury there is no vacuity left in the place derelicted by the Mercury, as hath been ſhewn *Chap.* 2. That there is no new Air admitted into the Tube *de foris*, as hath been ſhewn before, *Chap.* 3. But that little portion of Air is extended from the very head of the cavity of the Tube to the ſubſided Mercury, if it be of that ſubſtance that is capable of ſuch an extenſion to the Mercurial ſtation of twenty nine Inches and half: and if it be too little for ſuch an extenſion, it is ſupplied by a ſuitable portion

of

of the Mercurial steams, as hath been shewn. 4. But that extension or dilatation of that little portion of included Air, is not by any natural Elatery or expansion of its own, as hath been shewn in the two former Chapters, for it is a portion of the free Air; but it is a strong tension of that portion of included Air, to prevent that *casma* and separation of Bodies without any thing intervening, or the *fuga vacui*, so often mentioned by the Ancients. 5. And consequently, though in relation to the laws of the Universe, it be a natural expansion or dilatation of the Air in this circumstance, *in obsequium naturæ universalis*, yet in relation to the particular state and consistence of that portion of the Air thus expanded or tensed by the subsiding of the Mercury, it is forced and violent. As the erect posture of my Body is natural to me, while it makes one common composition with my Soul and Spirits, and *in Concreto*, though it be violent in relation to the *moles corporea* of my Body, which would otherwise fall down to the Earth. 6. And the consequence of this

this tenſion of the included portion of Air (conſidered conjunctly with the natural inſeparability of the parts of the Univerſe, which is all one with that which the Ancients called *fuga vacui*) is the ſuſtentation of the Mercury, that column of deſcended Air, which *Linus* not abſurdly calls *funiculus*, being inſeparably united, and adhering to the top of the Tube at one end, and to the Mercurial Cylinder at the other end, and this *funiculus aereus* not being capable to be extended farther than to twenty nine Inches and half, being the Mercurial ſtation, by the force of the deſcent of the Mercury, ſuſtains and holds it up at that ſtation: and ſo the *pondus deprimens* of the Mercurial Cylinder is equal to the *potentia ſuperne ſuſtinens* of the Aereal deſcended Cylinder upon it, in a kind of *æquilibrium*, the Mercurial Cylinder by its natural motion endeavouring its deſcent downward, and the aereal column by a motion of reſtitution to its natural ſize and ſtaple, retracting it as much as it may upward; and the ſame reaſon will hold of the portion of included

ded Air, be ſo much as is capable of an extenſion below twenty nine Inches and half of the Tube: but not ſufficient by ſuch a force to be dilated to a full depletion of the Mercury out of the Tube, as poſſibly to 20, 15, 10, or 5 Inches from the reſtagnant Mercury, in which caſe the Mercury will ſubſide to ſuch a degree, and no lower.

The reaſon therefore, 1. Why the Mercury ſubſides ſo low as twenty nine Inches and half, its uſual ſtation, (or lower, if the portion of included Air be greater, as is before ſaid) is, becauſe the weight of the deſcending Mercurial column is of that ſtrength, to give the included Air that tenſion or dilatation. 2. Why it ſubſides no lower, is becauſe when the Air hath attained its utmoſt tenſion that the deſcent of that column of Mercury can give it (which ordinarily is at the height of twenty nine Inches and half) that aereal deſcended Cylinder holds it there, and keeps it up to that height, the weight of the Mercury being now leſſen'd.

And that this is the cauſe of its ſuſtentation,

tation appears evidently by these few Instances. 1. If the Tube of Mercury in this sustentation be suddenly lifted up from the restagnant Mercury, there will be a strong resilition of the Mercury towards the top of the Tube, that will endanger breaking it; as we see a Lute-string, if hanged upon a Nail, and overcharged with a Weight or strength at the lower end, by which it breaks in the middle, the upper part of it will forcibly *resilire* in its contraction to its ordinary size. 2. If the Tube be inclined to a Level in the same parallel line to twenty nine Inches and half of the erected Tube, whereby it loseth its weight by the incumbence that it hath upon the sides of the declined Tube, the Air will contract it self to its former consistency, which it had before that tension, being by this inclination of the Tube delivered from it.

And they that object against the tension of the Air in this case; because if it had a tension in length, as the Lute-string hath, it would have likewise a contraction in its bredth, and so would

not

not fill the Tube, muſt remember that the Air is a tenſible Body of ſuch a nature, as is at the ſame time tenſible in bredth as well as length, and in ſuch its tenſion as cloſely adheres to the ſides of the Tube, as it doth at one end to the top of the Tube, and at the other end to the Mercurial column.

I ſhall not here enlarge with Inſtances, to ſhew, that the tenſion of the Air, or any other tenſible fluid Body neceſſarily effects attraction on the Bodies to which it is contiguous, but ſhall reſerve that to the following Chapters: and I have been the longer in the explication of this Inſtance, becauſe it fully opens the reaſon of the ſecond Inſtance, which now next follows. Therefore,

2. The ſecond Inſtance is, where a Tube cloſed at one end, above twenty nine Inches long, ſuppoſe it four foot long, is entirely filled with Mercury, and no Air admitted into it, and then inverted into a veſſel of reſtagnant Mercury, without admiſſion of any Air into it, either upon its inverſion or immerſion, (which though it be difficult, may

may yet be done) in this case the Mercury will subside to twenty nine Inches and half in the Tube.

This derelicted space of eighteen Inches and half, is, as I have before said, filled with a Mercurial steam or vapor, extracted out of the Mercury it self, and abraded from it by the descent and compression of the parts of that Mercurial column, as I have before shewn *Chap.* and thereby likewise rarified or tensed, as the Air is in the former Instance.

And this being either real Air included within the pores of the Mercury, and expressed from it, or else a subtle Ingredient into the Mercurial composition, and extracted, and in its extraction dilated, as the Air is in the former Instance. It performs the same office in relation to the suspension of the Mercury, as the included extended Air did in the former Instance, and therefore it need not to be repeated.

Only I shall adde this farther, 1. That it appears the extraction of the subtle *effluvia*, and their dilatation, is perform-

ed with a great ſtreſs or ſtraining of them out of the Mercurial Body, and with little leſs labour extended; which appears by the ſlow deſcent of the Mercury, ariſing from the *lucta* or conteſt that grows between the weight of the Mercury deſcending on the one hand, and the ſtraining and abrading of thoſe ſubtle particles, and their tenſion or rarifaction of the other hand. And the like ſlow deſcent there appears in the firſt Inſtance, eſpecially as the Mercury more and more ſubſides; for then the Mercury having neer acquired its ordinary ſtation, grows lighter, and the ſtrength of its preſſure begins utterly to languiſh and decay too, being neer equally matched with the *potentia ſuſtinens* of the extracted ſubtilized particles in this Inſtance, and by the tenſion of the Air in the former inſtance; the reaſon whereof ſhall be farther enlarged, when I come to the third Inſtance.

2. Whereas in the former Inſtance, by the inclining of the Tube, the Air regains its former contracted extent, here by the inclining of the Tube theſe ſubtle

tle particles extracted out of the Mercury, and dilated, are not only contracted, but resumed into the Mercury from which they were extracted, as is shewn in the Chapter. 3. That upon the over sudden Elevation of the Tube out of the restagnant Mercury, there will be the like resilition of the Mercury into the top of the Tube, as in the former instance.

By this *funiculus subtilis materiæ* the Mercurial column is sustained at twenty nine Inches and half, as in the former Instance of the *funiculus aereus*.

But now how it comes to pass, that since there is yet remaining twenty nine Inches and half in the Tube, which doubtless hath a residue of subtle matter extractable out of it, to supply a greater room, that what is yet left above twenty nine Inches and half, how it comes to pass that by the weight of that twenty nine Inches and half of Mercury, there is not more of the Mercurial effluxes extracted and dilated, which may give a total descent and evacuation of the Mercurial column into the re-

reſtagnant Mercury remains to be conſidered, which ſhall be done in the third Inſtance which follows.

3. The third inſtance is, when the Tube is but juſt twenty nine Inches and half, or ſhorter, ſuppoſe 25, 20, 10, or 5 Inches long, and filled entirely with Mercury, and then inverted into the veſſel of reſtagnant Mercury; in that caſe the entire Mercury will remain ſuſpended, and remain contiguous to the top of the Tube, and no part will deſcend, neither will there be any ſuch *funiculus* of Air or ſubtle Matter to connect it to the top of the Tube.

The reaſon of this is what in effect was given in the former inſtances, though the application be different.

Firſt, if in this inſtance the Mercury ſhould any whit ſubſide, either it muſt leave the *interſtitium* between it ſelf and the top of the Tube vacant of any Body, or it muſt yeild ſome ſubtle matter to ſupply the place it leaves abraded from it ſelf, as in the ſecond Inſtance. And if it can do neither of theſe, *manet ſors tertia*, only to continue its ſtation united to the top of the Tube. The

The former of these cannot be, for I have supposed, and shall further inforce the contradiction of the Law of the Universe to that Supposition.

Therefore it remains, that either there must be a subtle matter extracted out of the included Mercury, or of necessity the Mercury must hold its entire possession of the whole Tube.

Although the remote cause of this extraction of subtle parts out of the Mercury, in the second Instance, be that law of the Universe, to hold together the continuity of its parts, and consequently to avoid a *vacuum* or *casme* in the Universe destitute of matter; yet the immediate cause of this extraction and rarifaction is the descent of the Mercury from the station that it hath, and the weight of its Body is the cause of that descent.

And because it requires a strong compression of the Mercury, either to drive or draw out this subtle matter, and as it were to rake it out of the bowels of the Mercury, and to extend it, and consequently a strong weight to effect that

compreſſion and extenſion, if that weight which it hath at 29 Inches and half, or under, be not effective of ſuch an abraſion or extenſion of the ſubtle matter ſo abraded; ſuch abraſion or extenſion not being effectible by that weight, the column of Mercury muſt hold its poſition, and becomes its own *funiculus*, and remain ſuſpended to the top of the Tube.

Now it ſeems, that although a Mercurial Cylinder of a height above thirty Inches, as ſuppoſe three or four foot, hath ſuch a forcible preſſure, weight, and gravitation upon the reſtagnant Mercury, not only to drive down the Mercurial Cylinder to twenty nine Inches and half, but alſo to extract and ſtrain out of it, and extend a ſufficient portion of ſubtle matter out of the Mercurial Body to ſupply the room it leaves; yet that the weight only of twenty nine Inches and half, or below it, will not be able to drive, or draw out, or extend a portion ſufficient for that Exigent.

And that is the reaſon, why at twenty nine Inches and half, or under that

gage

gage, whether the Tube be juſt twenty nine Inches and half, or longer; yet the Mercurial Cylinder reſts there, wanting a ſufficient *potentia* below that ſtation by its weight, to extract or to rarifie any of its ſubtle parts, to ſupply the place which then it ſhould deſert or leave.

And herein the bigneſs or ſmallneſs of the Glaſs Tube, or the Mercurial Cylinder included, makes no odds; though poſſibly according to the various diameters of the Tubes, one Cylinder of Mercury of 29 Inches and half high, may weigh five times another Cylinder of the ſame height, and yet both would remain ſuſpended in the Tubes.

But the diſparity of the *potentia deprimens*, is from the diſparity of the height of the Tube. And therefore the cauſe why the Cylinder of Mercury, filling a Tube of 3 or 4 foot long, will ſubſide upon inverſion unto twenty nine Inches and half, and there ſtay, is, becauſe before its deſcent to that ſtation, its *potentia* was ſufficient to abrade and extend the ſubtle matter, but at twenty nine Inches and half that *potentia* was ſpent.

And therefore the reason why the Tube of twenty nine Inches and half, or under, doth not subside at all, but remains cohering to the top of the Tube, is, because it hath not that *potentia* at that gage to abrade from it self matter to supply that place, if it should leave it.

And for this purpose it will not be amiss to take notice of what *Galilæus*, and after him the Excellent *Mersennus* have given us in relation to the disparity of the *motiva potestas* of the same fluid in different positions of height or elevation.

The acceleration of motion of heavy Bodies is *ut quadrata temporum*, in which they move downwards; as if in the first Minute, a Body moves one foot, in the second minute it will move four foot, *viz.* two times two; in the third minute nine foot, *viz.* three times three; or, which comes to all one account, heavy bodies in their descent, in every given portion of time, as a minute will percur portions of space *per numeros impares ab unitate*; as if in the first minute

nute it descend one foot, in the second it will descend three foot, in the third five foot, in the fourth minute seven foot, and so onward.

Mersennus partly upon this Theory, and partly upon his own experience, makes two Conclusions, (which I have experimentally found true) that are apposite to explicate what I mean in this matter.

First, if there be two vessels of equal height, but of differing diameters, and with an equal *lumen* or hole in the bottom of each of them, and both filled with Water; the smaller vessel will in the same portion of time empty from it self as great a quantity of Water as the greater, for the Gravitation of the Water upon the *Lumen* is *secundum altitudinem*, not *secundum latitudinem vasis*: and upon the same account it is, that if the *lumen* be at the side, and the vessels be placed in the same horizontal parallel, the Parabolical line made by salient Water out of each vessel, will be of the same length and amplitude.

2. That if there be two Tubes or vessels

veſſels of Water, *A* and *B*, of the height of nine foot, containing nine Gallons of Water, and *B* were a veſſel of ſixteen foot containing ſixteen Gallons of Water, and each veſſel had a ſmall *lumen* in the ſide next to the Baſe, of equal bigneſs, and of that bigneſs, that were there but one Gallon in the Tube, it would empty that Gallon in one minute. In theſe Inſtances, *A* filled with Water would empty five Gallons in the firſt minute, three Gallons in the ſecond minute, and one Gallon in the laſt minute. Again *B*, if filled with Water, would empty ſeven Gallons in the firſt minute, five in the ſecond minute, and three in the third minute, *viz. in ratione ſubduplicata altitudinis.* And this I have experimentally found to be true.

The conſequence whereof is, that every fluid Body the higher it is elevated, hath the greater and more effectual preſſure by its poſition upon its lower parts or other fluid, than what barely ariſeth from its weight: ſo that in a column of Mercury in a Tube of four foot high,

high, though the loweſt foot and the higheſt foot of Mercury be of an equal weight, yet the preſſure of the uppermoſt or fourth foot, which I call its *potentia deprimens*, is to the third as ſeven to five, and the third to the ſecond is as five to three, and the ſecond to the firſt as three to one, namely when it hath a liberty of deſcending motion, as the Mercury hath in this Experiment; for the intermediate weight contributes to the preſſure of the uppermoſt foot.

And hence it is that the power to ſerate and ſegregate, and ſtrain, and extend the ſubtle matter out of the Mercury, is vigorous and effective in a Mercurial column of 4 foot high, and gradually is leſs and leſs 'till it come to twenty nine Inches and half; and then though it hath a conſiderable Gravitation, yet it is not equal to effect ſuch a ſeparation, and therefore muſt needs ſtand ſuſpended at that height, or leave a *vacuum* behind it, which the Catholick laws of the Univerſe do not permit.

And thus far touching the Explication of the Solution, which ſeems to me

to

to be the true Solution of the *Torricellian* Experiment.

And in the next place I shall subjoin some Instances that seem to me to confirm it, and answer some Objections that are made against it.

CHAP. XVI.

Concerning the two Suppositions that are necessary to maintain this Solution, viz. *Natures abhorrence of* vacuum, *and the Attraction of tensible fluids, or other bodies when under a tension.*

THere are two Suppositions that are necessary to be proved, to render the Solution above given evident or probable. 1. The exclusion of a *vacuum* or space in the Universe wholly empty of any Body. 2. That any Body, capable of tension, or rarifaction by tension, (such as are the Air and thin *effluvia* of Mercury) to be attractive upon the contiguous Bodies, when actually under that tension.

1. As

1. As to the former of these, I need not much labour for it, upon two reasons. 1. Because there have been large Tractates upon this Position, and to repeat them would be but *actum agere*. 2. Because the exclusion of the Gravitation and Elasticity of the Air, invented or substituted by the modern Elaterists, doth necessarily conclude, that there can be no *vacuum* in Nature; for all those Experiments and Instances, which they produce to prove that Gravitation or Elasticity, and by which they go about to solve them, must (if those Solutions prove untrue, or ineffectual) of necessity maintain that ancient Peripatetical position, because they are uncapable of any other Solution. And in my judgment that Gravitation and Elasticity of the common Air is sufficiently convinced by what hath been before said touching it.

And when I meet with those Objections that I find used by Learned men, namely how the Mercury or Water comes to know there will be a *vacuum*, if they do not leave their natural Gravity,

vity, and so ascend or remain suspended to supply it, and how those stupid inanimate Elements or Minerals come to understand, that Nature so much abhorreth a *vacuum*; are much of the same kind, as if a man should ask the Sun, if it move according to *Ptolemy*; or the Earth, if according to *Copernicus* it move; how they came to know that when they come to the Northern Tropick, they must move again to the Southern Tropick? or when it hath touched the Southern Tropick, it knows that it must come back to the Northern, and steer its course accordingly? Or as if a man should ask, how doth the Stone understand that he must descend, when yet all the men in the world can never give any satisfactory reason for its motion to the Earth, more than to the Moon, but only Nature that is the *principium motus & quietis*, or rather the God of Nature, whose standing and staturninated Law Nature is, hath so order'd it, and ordered so in the best way for the use, beauty, and accommodation of the Universe. The plain truth of it is, the very

very consideration of the many attempts that have been made to explicate the reason of the descent of heavy Bodies, is enough to let us see, that we tire our selves in vain to determine the clear reason of it, without resolving it into the statuminated Law of Nature: though the Stone and the Earth are inanimate, or at least unreasonable Bodies, such kind of Objections therefore as these are fond and weak.

2. As to the second, namely the attraction of Bodies extended, whether by rarifaction or tension, especially of the Air, or this subtle matter that ariseth from the Mercury. This affection and effect is as natural as any thing in Nature, as is truly observed by the learned *Fabri*, *in primo tractatu physico*, *prop.* 205, 206, 208. For a strict contiguity in all parts of several Bodies is a kind of continuity of the Universe and all its parts; neither can I imagine how those that are fond of the *Epicurean hypothesis*, can better maintain the cohesion of the parts of solid bodies, their *atomi hamati* being but fancies of what men never saw in them. The

The Air is the common cement and connecter of the different parts of this inferior world at leſt, and ſtrictly interpoſeth between their fiſſures and *interſtitia*, to maintain a kind of common continuity between the different parts of the Univerſe, and makes it as it were one continued Body.

But to come to particular Inſtances, which ſhall not be laborious but familiar and common, to evince this coheſion of the parts of tenſed or rarified Air, and the contraction that it makes upon contiguous bodies, in its endeavour of reſtitution to its natural ſtate and conſiſtence.

1. The inſtance of Cupping-glaſſes, where the Air is highly rarified or evacuated by the included burning Tow, and applied to the fleſh, draws up the fleſh ſtrongly unto it, when by the extinction of the Tow the rarified Air contracts it ſelf to a narrow room, which can be no otherwiſe than by the coheſion of the particles of Air to the skin, and driving it in to the Glaſs, while it contracts it ſelf to a narrower com-

compaſs. And certainly they that tell us, that this is done by the preſſure of the ambient Air upon the contiguous fleſh, which thruſts it up into the Glaſs, either do not believe themſelves while they ſay it, or are ſo tranſported with a love unto or ingagement for their beloved *hypotheſis*, of the prodigious gravitation of the free Air, that they are content to ſay any thing in its behalf.

Qui amant ipſi ſibi ſomnia fingunt.

Shottus (who while he wrote his *mirabilia hydraulica*, was well ſatisfied with the Solution of the *Torricellian* Experiment by the common Solution of *fuga vacui*) was indeed afterward, when he wrote his *mirabilia Magdeburgica*, converted to the new Solution, being not willing it ſeems to be thought to ſee leſs in Nature than the new Tribe of *Virtuoſi* that were concerned in that Engine. But for all that, this Inſtance of Cupping-glaſſes was too hard for that new Solution, and were fairly fain to have recourſe to the *decantata fuga vacui*, or elſe it muſt ſtand unſolved, and ſo muſt any elſe that means an impartial and

unpreingaged search into Nature.

2. If an empty Bladder be tied close about the neck, and fastned to the top of the Tube, Hermetically sealed in the *Torricellian* Experiment, upon the subsiding of the Mercury the Bladder will be expanded, not by the natural Elatery of the little particle of included Air, but by the strong attraction of the tensed Air in the Tube, by the descent of the Mercury, whereof before.

3. The Instance given in the tenth Chapter, of the Tube heated, and appended to a Ballance, so as it touch the Water, the Water rising in the Tube, the Tube will be drawn down, which is only done by the adhesion of the two extremes of the incloſed rarified Air, the one Extreme laying hold upon the top of the cavity of the Tube, the other end laying hold of the Water, and drawing it up, and therewith necessarily drawing the Tube down, whilst the included Air is contracting it self to its natural and narrower dimensions.

And because the Experiment made by a wide-mouth'd Glass would yeild some

some discoveries of this attraction by the rarified Air, which are not so visible in so narrow a Tube, I took a Beer-glass, as in the *Figure* 14, and suspended it by a Thrid to one Scale of the Ballance, and weighing it with a weight in the opposite Scale, and found it weigh two Ounces and half; then, as we used when we were School-boyes, sticking up a Candle in a Bason, I let down the Glass over the Candle contiguous to the Superficies of the Water, the Candle going out there was a portion of Water drawn up into the Glass, the Air upon the Candles going out, and the Glass drawn down into the Water, the included Air being under a cause of rarifaction, namely by the heat of the Candle, and by the extinction of the Flame now gradually contracting it self, and thereby drawing up the Water to supply that place.

The water drawn up into the glass was about half an Inch; we marked exactly the weight that was required now to lift up this Glass and included water was an addition of 4 Ounces and $\frac{1}{4}\frac{1}{8}$ of an

Ounce; so that the whole weight that raised the Glass and Water inclosed, and severed it from the Water beneath, was six Ounces $\frac{1}{2}\frac{1}{4}\frac{1}{8}$ of an Ounce, and then, though not without reluctance, the Glass was raised out of the Water.

Then taking the exact quantity of other Water, equall to that formerly included in the Glass, (which was not difficult to do by the help of the remaining Mark) we weighed it, and found it to weigh exactly three Ounces and half, and a very few Grains.

So that the weight of the Glass and inclosed Water amounting to six Ounces, there was requisite an addition of about half an Ounce to sever the Glass from the Superficies of the restagnant Water, which did apparently to the eye and touch adhere together, notwithstanding the counterpoise of six Ounces, equal to the weight of the Glass and included Water.

And this half Ounce of additional weight was due purely to the adhesion of the glass, Air, & inclosed water to the Superficies of the restagnant Water.

1. It

1. It seems evident, that not only the Glass, but the Water included in it, gravitates upon the Scale, for the counterpoise of six Ounces in the opposite Scale, equals the weight both of the Glass and Water inclosed in it, which could not be, unless both contributed to the *æquipondium*.

2. That it is impossible that the included Water could gravitate upon the Scale, unless the rarified Air were contiguous and cohering to the top of the Glass, and also to all the parts of it included within the cavity of the Glass above the Superficies and whole body of the included Water, and also firmly adhered to the Superficies of the included Water, for they all make up but one common weight, and there must be a *vinculum* that must connect the Glass and the inclosed Water, and otherwise they could not gravitate together; so that the *vinculum* that binds the Water to the Glass is this *funiculus* (as *Linus* well calls it) of the rarified Air, as the Thrid is the *vinculum* that binds the Glass to the Scale: for otherwise the

Glass would be only raised, and leave the Water to subside into the vessel of restagnant Water, and would never hold an *æquipondium* to more than two Ounces and a half, which was the just weight singly of the Glass.

But as for the fancy above mentioned, *Chap.* 10. that it is not the Glass and Water that make up the weight of six Ounces, but the Glass and the column of Air incumbent upon it, the vanity of that imagination is sufficiently convinced in that Chapter.

3. That consequently, the included rarified Air thus fastning upon the cavity of the Glass and the included Water by a strict cohesion, according to the nature of tensed fluids, contracting it self as much as it can by its motion of restitution, draws up the Water in the vessel into the Glass, and raiseth it as high, 'till there be an *æquilibrium* between the *pondus naturale deprimens* of the Water, and the *potentia sustinens* of the Air, thus now contracting it self, and indeavouring its restitution to its just natural dimension.

4. As

4. As a *ſpecimen* of this coheſion of the Air and Water included in the Glaſs, there is alſo a coheſion of the Limb of the Glaſs and the included Water unto the Superficies of the reſtagnant Water, which requires half an Ounce of weight to break that continuity between the upper and lower Water. And no other imaginable cauſe can be aſſigned for it, but that *Natura ægrè patitur disjunctionem partium continui.*

And as with the hand you lift up the Glaſs towards the Superficies of the reſtagnant Water, the Water included will riſe with it much above the Superficies of the external Water, which cannot be by the imaginary preſſure of the external Air, but by the adheſion of the column of Water to the included tenſed Air, and of that to the concave Superficies of the Glaſs *per modum unius continui*, which any man's tryal will make more plain and evident to him, than words in writing can eaſily expreſs.

But ſome exception is taken to the word *funiculus*, and we are asked what Grappers there are belonging to this *funiculus*,

niculus, that can so steadily lay hold of the Water and the Glass, and hold them thus tight together?

And I must confess, that I wonder, that any that approves the Atomical or Epicurean Philosophy, can make that Question, since all their pretence of the cohesion of the imaginary Atomical Particles in any the most solid *continuum*, are certain *atomi hamati*, that interlock one in another, which yet they never saw.

But let it be: I answer, the power of the laws of Nature are so efficacious, that they can and do colligate strictly parts even of most distantial textures and consistences, without the help of Vellicle, Hooks, or Grappers. What are the Hooks or Grappers, whereby the Humane Soul and Body, yea the Souls and Bodies of Animals are knit together, whereby the Bloud and the Spirits are colligated, whereby the Loadstone attracts the Iron, notwithstanding an interposed Plate of Brass or body of impervious Glass, and a thousand more Instances of Attraction between Bodies,

without

without the intervention of ſenſible Grappers and Hooks, or ſuch groſs Mechaniſmes.

This, and ſome other as light as this, and ſome toying with the word *funiculus*, are the greateſt Objections that I find againſt what *Linus* hath in this matter delivered, which ſeem to me of no moment. Words were made to render Conceptions of things, and if they do that, they do their office.

And thus far concerning the Solution of the *Torricellian* Engin. I ſhall adde a few words, as I promiſed, touching the coheſion of two poliſhed Marbles, and the inſufficiency of the Solution thereof given by the Elateriſts, and the truth of the ancient Solution thereof.

CHAP.

CHAP. XVII.

Concerning the Cause of the Cohesion of two polished Marbles.

THere are two Experiments, for the Solution whereof the Gravitation and Elatery of the Air is by the late Philosophers applied, which in this last place I shall examine according to my premised method.

The first is that of the cohesion of two polished Marbles. For instance, take two polished Marbles, of one dimension and figure, and exactly in the centre of each Marble let there be a Ring, whereby to suspend the upper, and whereby a weight may be appended to the lower. These two Marbles, especially if their smooth sides be a little oyled, and applied each to other, will adhere so strongly together, that the upper being suspended by its Ring to a post or frame, (*Fig.* 15.) the lower will sustain a weight of 20, 30, or 40 pounds, though the Marbles

Marbles be not above three Inches diameter.

And as it will do this in the open Air, it will also perform the same, though the Marbles be inclosed within a close large Glass-Receiver, whereby it is severed from the common Air, or any impending column of the Atmosphere.

The reason that the vulgar Philosophers were wont to give in these cases are these:

First, as to the strict cohesion of the two Marbles, they give this reason; that the cohesion is *ob fugam vacui*. For if they should be severed by the appended weight, the separation of them would be in the same indivisible moment, because they do *contingere in puncto*.

And in as much as all Bodies move successively, and not in an instant, it would be impossible for the circumambient Air in the moment of the separation of these two Marbles, to pervade the whole *interstitium* that would happen upon the first separation, and consequently there would be a mean time wherein the *interstitium* would remain empty,

empty, therefore the coheſion is ſo obſtinate to prevent that monſter in Nature, namely *vacuum*.

And to evidence that this is the reaſon, they ſay that if the aperture be attempted at the ſides, either by pulling them at one ſide, or by appending the weight more to one ſide than the other, they are eaſily ſeparated, becauſe that aperture makes an Angle, (*Fig.*16.) and gradually admits the Air into it; for then the aperture is not all at once, but is *apertio continuata* from the firſt opening. For although if the Baſe of the acute Angle, *viz.* ∠*A*, were but a hairs breadth, the Angle were diviſible Mathematically unto the uttermoſt extremity of it; yet it is not ſo Phyſically, it but gains a ſucceſſive latitude, according as it gradually opens, and ſo is accommodated Phyſically to a ſucceſſive intromiſſion of the Air: but if the aperture were altogether, the ſeparation in all parts of the Superficies muſt be Phyſically as well as Mathematically in the ſame inſtant, which were too quick to give an admiſſion to the ſucceſſive motion

tion of the aery body in the ſame inſtant.

But now we will conſider what Solutions the late Philoſophy gives in this inſtance.

Namely 1. That in the free and open Air there is an impending column of Atmoſphere, reaching from the ſummity thereof to the upper Marble, and commenſurate in its diameter and circumference to the *area* of the upper Marble that preſſeth it, with an exceſſive weight downwards, and ſo upon the upper Hemiſphere if ſuſpended parallel to the Horizon.

2. That again there is a returning or recoiling Cylinder of Air, reaching from the Superficies of the Earth upwards, of as great a *potentia ſuſtinens* as the ſuperior column of Atmoſphere hath a *pondus deprimens:* and this inferior or reſulting column is commenſurate alſo in its diameter and circumference to the lower Marble, or brazen Hemiſphere, and thruſts that as vigorouſly up to the upper Marble, as the upper column preſſeth downward. And ſo the *potentia ſuſtinens* being equal to

the

the *pondus deprimens*, the lower Marble is able to ſuſtain a weight equal to the weight of the upper atmoſpherical Cylinder; the reaſon of which admirable power (according to their Suppoſition) is opened *ſupra cap.* 5.

3. And in as much as there runs down as weighty and potent aereal Cylinders or Atmoſpherical portions by the ſides, as well as perpendicularly, therefore although the Marbles were not placed parallel to the Horizon, but vertically (as when each is drawn ſeveral ways) this lateral preſſure of the Atmoſphere is as effectual to hold the Marbles together in that cloſe poſture, as if they ſtood parallel to the Horizon.

4. And becauſe they will have a Salve for all Sores, although theſe Engins be placed in a cloſe Glaſs-Receiver, whereby the aereal Columns, as well ſuperior as inferior, are wholly intercepted by the interpoſition of the great Glaſs Receiver, the Elaſticity of the portion of Air included within that Glaſs Receiver, undertakes and effectually performs the *phænomenon*, by its vigorous

gorous Elaſticity or counterpreſſion both upward, and downward, and laterally, upon the included Marbles or Hemiſpheres.

And this is the Solution that now obtains among the *Virtuoſi*.

And upon theſe premiſes there are admirable trains of Philoſophical Conſequences deduced with great induſtry and ſubtlety, in this particular inſtance of the Marbles, which a man may read at large in the late book of *Hydroſtatical Experiments*, *Exp.* 13, and elſewhere.

And now for ought I know the matter is brought to this iſſue, whether this or the former Solution be the truer, (for I know not a third) and if this prove untrue or uneffectual, the former of the Vulgar Philoſophy muſt obtain, 'till ſome third be found out.

And therefore I will proceed in the examination of this new *Hypotheſis*.

And although I think I have ſaid enough againſt this whole Scheme of the Gravitation and Elatery of the Air, as it is propounded in the fourth, tenth, and eleventh Chapters; yet I ſhall here add

ſome

ſome things more ſpecifically applicable to theſe Engins and Experiments, and remit the Reader to thoſe Chapters, as to the general untruth of the entire *hypotheſis*.

Firſt therefore, as to the coheſion of the Marbles I offer theſe conſiderations:

1. It is plain, that the lower Marble, if there were nothing elſe to ſuſtain it but the recoiling Cylinder of Air impelling it upward, it would certainly fall to the Earth, notwithſtanding that imaginary *potentia*; for if it were otherwiſe, it would be a neceſſary conſequence, that though it were not contiguous to the upper, it would be ſuſtained by that *potentia ſuſtinens*, and ſo we ſhould have Milſtones floting in the Air, according to the fancy of the laſt mentioned Author of Hydroſtatical Experiments.

But the help for this is, that in that inſtance the impending ſuperior column of Air being of equal ſtrength with the recoiling column of Air, there is an *æquipondium* between that *pondus* and *potentia*, and ſo the ſolute Marble or Milſtone

ſtone, having the advantage of his own weight, and the weight of the ſuperior column would conquer the inferior; but here the inferior Marble is protected from the weight of the ſuperior column of Air, and ſo hath nothing but his own weight to contend with the inferior column, and its *potentia*, which latter overmatcheth it, and ſo keeps it ſuſpended.

But this will not cure the Sore; for ſuppoſe it were two pieces of Wood, or that the Marbles were not excellently poliſhed, ſo that they did not *contingere in puncto*, but ſome little fiſſure or *interſtitia* did let in any ſmall portion of Air, the Marble would fall off; and yet there the lower Marble is protected from the impendent column of Air by the ſuperior piece of Wood, or unpoliſhed Marble as well as here.

And to ſay theſe little filaments of interpoſed Air, which if all put together would not make a column of Air of a larger diameter than a ſmall pin, ſhould conquer the reflected Cylinder of Air, and its *potentia*, which theſe Maſters

ſuppoſe to be equivalent in power to thirty, forty, nay one hundred pound weight, renders the whole Suppoſition it ſelf to be but utterly improbable. Somewhat therefore elſe it is, that keeps the lower Marble ſuſpended to the upper, and not the imaginary *potentia* of the reflected column of Air commenſurate to the *area* of the inferior Marble.

2. If the lower Marble were ſuſtained upon the account of the *potentia ſuſtinens* of the inferior column of Air, and by force thereof it could ſuſtain (for inſtance) forty pounds weight, ſuſpended in the center of the Marble, it were not eaſily conceptible how if but an eighth part of that weight were hanged near the limb or circumference of the lower Marble, it would fall aſunder, as it will; for the *potentia ſuſtinens* of the ſubjected column of Air is applied equally to all the *area* of the ſubjacent Marble. And the ſeparation will follow, if the Marbles being oyled, the one may be ſlided off from the other without any difficulty; and then when they are ſo ſlided off, they are eaſily thereby ſevered, becauſe

becauſe no vacuity or inſtantaneous motion of the Air would follow thereupon: which could never be done, if they were ſo ſtrongly wedged up one to another by ſo ſtrong and powerful a counterpreſſure of the reflecting column of Air, which preſſeth up according to the new *hypotheſis* with a *potentia* able to ſuſtain neer a hundred pound weight.

3. *Stevinus* tells us in the obſervations upon the tenth Propoſition of his Hydroſtaticks, that if a veſſel be made in the form of *Fig.* 17. with a hole in the bottom, and a piece of Wood lighter than Water, *viz. B B.* Cover that hole, and then let the veſſel be filled with Water; as great a ſtrength will be required by the ſtring at *A* to move that rundle of Wood from the hole it ſtops, as if a weight of Water commenſurate to the *area* of the rundle, from *B* to *A*, were impendent upon it. And this the Learned Author of Hydroſtatical Paradoxes avouches to have tried himſelf, and yet the Water included is not an half nor a quarter of that weight of Water. And the column of Air that

theſe Maſters ſuppoſe to preſs the Water at *A*, can be no larger than the orifice of the Pipe at *A*, which is not one fifth part of the amplitude of the rundle *B*, nor of the hole which it ſtops. But if there were ſuch a reflected or recoiling column preſſing upward to the hole of the veſſel and rundle that covers it, which is five times larger than the orifice at *A*, to let in a column of gravitating Air; this rundle, and the Water incumbent upon it, ſhould be forcibly thruſt up by the recoiling column of Air: and yet Experience tells us, that it is ſo far from being thruſt up by the *potentia ſuſtinens* of the inferior aery column, that it is hardly to be raiſed without difficulty by a Thrid.

4. Again, take a veſſel of Laton, of a cubical or cylindrical figure, about eight Inches diameter; make a round hole at the bottom of four Inches diameter. Then take a round piece of Braſs or Lead, or ſmoothed Wood, of ſix Inches diameter, which may weigh two Ounces; wax it well, and exactly, and cloſely cover the hole, that it may overlap,

lap, that no Air may go in or out by it, then rarifie the included Air, but not to any considerable height, for then growing cold it will draw up the cover when closed. Then close the top very close with Laton and Soder, that no Air can get in; the Air I suppose rarified may take up more room than its natural dimension by about two square Inches, which is more than the dimension of the Stopper: so that the supposed Elatery of the Air hath no resistence to its impelling upward, because it hath room for its reception. I say that this Stopper will not be impelled up by the pressure of the recoiling Cylinder of Air, though it weigh but two Ounces, and will be lifted up by a force or weight of three Ounces. And yet according to these mens Suppositon, this recoiling column hath a *potentia* to impell or keep up forty pound, nay an hundred pound weight, being commensurate in power to an Atmospherical Cylinder of six Inches diameter, which according to their Supposition must weigh about 500l weight, namely a Cylinder of

Mercury of six Inches diameter, and twenty nine Inches high, *viz.* 783 square Inches of Mercury, which is near 5001 weight. It is true I have not tryed this, but my observation of the third Experiment makes me little doubt of this.

CHAP. XVIII.

Concerning the Magdeburgh *Hemispheres, and their Cohesion, and the reason thereof.*

THE Air is capable of tension by force, and of rarifaction by heat; both which agree in this, that they both give a large expansion of a less portion of Air into a greater space than is natural to it.

But herein they partly differ, and partly agree; that the immediate effect of a strong tension of Air by force (such as are the Air-pump, and the *Magdeburgh* Engin, and the *Cacabus Evacuatorius* described by *Shottus* in his *Technica curiosa, lib.* 1. *cap.* 5. *& sequentibus*) is attraction of the Superficies, to which the included tensed Air is contiguous.

But the immediate effect of rarifaction

of

of the Air, which is performed by heat, is a laxation of the filaments of the Air at first; for the Air being dilated, takes up more room, is more relaxed and expanded: but consequentially there follows a contraction as the heat decays, and the Air endeavours its restitution to its natural texture, and so endeavours its contraction, and consequently lays hold on the contingent Superficies, within which it is imprisoned, and attracts it with its own contraction. The instances of both which motions and effects we have in the *Magdeburgh* Hemispheres described by *Shottus*, *ubi supra*, and hereafter more fully explicated.

Fig. 18, 19, 20. The Engin is thus described. Let there be two Brazen concave Hemispheres *AB*, with rings in the Poles or center of the convex Superficies of each of them at *C* and *D*, and a ring of Leather dipt in Wax to be placed between the two Hemispheres, *viz. E*, to keep the limbs or joints of them close from admission of any Air between the commissures or joints of the Hemispheres; and a Stop-cock in the lower

Hemiſphere at *FK*, both the Hemiſpheres conjoined with the Leather between them. Theſe Hemiſpheres thus joined, the Stop-cock at *F* to be left open, whereby in the *Cacabus Evacuathius* or *Magdeburgh* Engin, the Air in the cavity of the Hemiſpheres may be as much exhauſted as may be, and conſequently that which remains being thereby put into a great tenſion, to be incloſed by turning the Stop-cock, that no forreign Air may be admitted. Theſe Hemiſpheres thus ordered, will cohere ſo ſtrongly together, that the ſtrength of many Horſes will not ſever them, if the Hemiſpheres be large.

And the event is infallibly true, but the conteſt is touching the reaſon or Solution of the *phænomena*.

The modern Philoſophers, with *Schottus* in his fourth Book of his *Technica curioſa, cap.* 7. *ℓ.* 3. (being now a Convert to the Gravitation of the Air) tells us, that the reaſon hereof is, that the weight of a column of Air impendent uppon the upper Hemiſphere, and the reverſe column of Air preſſing upon

the

the lower Hemiſphere upward, is the cauſe of this coheſion.

And that in caſe the Hemiſpheres be not placed erect, but laterally, with their Poles parallel to the Horizon, the lateral preſſure of the two adverſe columns of Air perform the buſineſs, and keep them ſtrictly together againſt a moſt powerful force indeavouring their ſeparation.

But ſtill with this caution, that the ſeparating force work upon the centre of the Hemiſpheres, and ſo draw upon all parts alike: for if the *potentia ſeparans* be applied unequally, *viz.* at one ſide of each Hemiſphere, and not equally from the centre, then the ſeparation will eaſily follow upon the application of a ſmall ſeparating ſtrength, which is alſo moſt certainly true. Again, if but a little portion of Air be let into the Stop-cock, the ſeparation of them quickly follows, which is alſo true.

But now the vulgar Speculators think, that this Solution is untrue, and that the true reaſon of the coheſion of theſe Hemiſpheres is, becauſe that the included

included portion of Air is not wholly exhauſted, neither is it poſſible by humane power wholly to evacuate it. But a great part therereof is exhauſted, and that which remains incloſed is under a very great and violent tenſion, and hath a ſtrong natural *conatus* of reſtitution to its natural ſtaple and ſtandard, and that the filaments of the Air lay hold upon every point of the concave Superficies, and draw them inward, as it endeavours its own contraction.

That there is not, nor can be, any *caſma* or interval of empty ſpace between the convex Superficies of the included Air, and the concave Superficies of the including Hemiſpheres, for that is contrary to the common law of Nature; and yet the Air by its intrinſick texture, and proper motion of reſtitution, to that juſt dimenſion that Nature hath aſſigned to it, affects its own contraction to its own ſtate, and with it draws together, and holds together the ambient body including it.

Not much unlike the tenſion of Lute-ſtrings, highly wound up by their Pins,

which

which have a tenſion and contraction of the extremes, to which they are faſtned, namely the Bridg and the Pins.

That the reaſon why, if any Air be let in, even at a Pin-hole through the Hemiſpheres, it is greedily ſucked in by the tenſed and ſtretched Air, to relieve it from the Rack upon which it is ſtretched, and being taken in it relieves that tenſion, looſeneth its contraction, and takes off its forcible attraction upon the concave Superficies of the including Hemiſpheres, and gives the included Air a fair relaxation to its due ſize, ſtaple, and ſtandard; and ſo the coheſion ceaſeth.

Fig. 21. That the reaſon why an aperture is eaſily wrought, when the divulſion is only of one ſide, is partly the ſame with the reaſon of the like divulſion of the the two cohering Marbles. 1. Becauſe the aperture is angular, and not all at once. 2. The aperture is *cunei formis*, which every body knows is more forcible than a parallel aperture. And 3. by this kind of angular opening the filaments of the Air are broken ſucceſſively

ceſſively one after another; but in a parallel aperture all the filaments muſt be broken at once, and ſo make one common reſiſtance to the force. As a piece of Cloth may be torn with eaſe by one man, when thrid is broken after thrid, but cannot be torn by four men, when all the thrids are ſtrained together, and ſo have an united and uniform ſtrength and reſiſtance.

And they ſay, that although this Engin is contrived with great pomp, yet in truth it is no more than that Experiment, which we practiſed with our Nutſhels when we were children, where by clapping half a Nutſhel to our lips, or the back of our hands, and ſucking out the Air, they would ſtick ſo cloſe, that we could not eaſily fillip them off.

Theſe are the two reaſons that contend for the Solution of this Experiment, the Gravitation of the Air or Atmoſphere of the one hand, and the *motus* or *conatus reſtitutionis* of the Air, and the natural inſeparability of Bodies without any intervening Body of the

other

other hand. If the former be laid aside as untrue, the latter needs no great labour to prove it; for these be the only two Competitors for the Solution of this Instance, that I ever heard of.

And I think it is very plain, that the imaginary gravitation of the Air, neither hath nor can have any thing at all to do in this business.

And because I had not those Evacuatory Engins before described, and if I had had them, yet I would not have singly rested upon them, without making trial by rarifaction by heat, I took the method hereafter following, for the full examination of this Instance.

For it is obvious beyond dispute, that that if there be a cohesion wrought after rarifaction of the Air by heat, in the Instances hereafter given, as there is when there is a tension of the Air by a forcible Evacuation, as in the former Instance; the true cause of each cohesion must be one and the same. And if the *pondus externi aeris* contribute nothing to the cohesion of the Hemispheres after rarifaction of the included

Air

Air by heat, it contributes as little to the cohesion of the Hemispheres forcibly evacuated by an Air-pump, or the *Cacabus Evacuatorius* before mentioned.

And on the other side, if the cohesion of the Hemispheres after rarifaction by heat be caused by the *motus restitutionis* of the included rarified Air, and by the strict continuity (as I may call it) of the filaments of the Air to the cavity of the Hemispheres, to avoid that Vacuity which would otherwise happen by the contraction of the Air into a less room than would fill the whole cavity; the same is unquestionably the reason of the cohesion of the Hemispheres forcibly evacuated as above.

The Instances therefore that I tryed are these that follow, which I shall mention severally, with my observation to each of them. For if I mistake not, this one Experiment, duly improved, wholly sets aside the imaginary Gravitation of the Air, so usually applied to the Solution of the *Torricellian* Experiment, the cohesion of Marbles, the raising of Water in Pumps, and by

by Suction, and many more of like nature.

First, I caused two Brass concave Hemispheres to be cast, each of six Inches and a quarter in the cavity, and about seven Inches diameter in the convexity, exactly closing one to another on their rim, and the lower let up into the cavity of the upper about half an Inch, for their more exact closure; and the outward rims of each about a quarter of an Inch in bredth, exactly closing one upon another, so that being closed they made one perfect Sphere, according to the form of the *Magdeburgh* Hemispheres above described.

The lower Hemisphere weighed six pounds, seven Ounces, and a half, *viz.* 103 Ounces, and half; the upper weighed only six pounds.

I then took a circular piece of Calf-skin, a little above half an Inch broad, and in length sufficient to compass the Hemispheres, and dipping it in melted Bees-Wax, with a very little Rosin, so that it might just lye between the commissures of the two Hemispheres, and stop

ſtop out all acceſs of the forreign Air between them.

Firſt therefore, without any thing more done, I applied the two Hemiſpheres each to other, with the interpoſed girdle of waxed wet Leather, and preſſed them cloſe and hard together, that no commerce might be between the included and the common Air.

And ſo there neither was nor could be any force of compreſſion uſed to the included Air, becauſe 'till the cloſure of the Hemiſpheres it had a free intercourſe with the external Air, and when perfectly cloſed it was but juſt as much as the Hemiſpheres would freely contain, and conſequently of the ſame texture with the forreign Air.

In this Inſtance, the upper Hemiſphere raiſed gently by the ring, there ſeemed a little weak coheſion between them, becauſe the rims were perfectly cloſed, and the ſeparation was altogether in the ſame moment, but the coheſion ſo faint and weak, that it would not ſuſtain the hundredth part of the weight of the lower Hemiſphere, and ſcarce perceptible. And

And the reaſon of the diſparity between the coheſion of theſe Hemiſpheres, and that before mentioned of the 2 poliſhed Marbles, are theſe. 1. Becauſe the contiguity of the two poliſhed Marbles is in all points of their Superficies, but here the contiguity of the rims of the Hemiſpheres was but in a circle of a quarter of an Inch broad, and ſo the forreign Air had a ſhorter journey to go in the moment of the ſeparation of the Hemiſpheres, than in the moment of the ſeparation of the poliſhed Marbles. 2. Becauſe the contiguity of the poliſhed Marbles is without any interpoſition of Leather, which poſſibly would impede the firmneſs of the coheſion of the two Marbles themſelves.

But now if the preſſure of the aereal Cylinders either in the poliſhed Marbles, or in the inſtances of the Hemiſpheres, before and hereafter given, were the cauſe of their coheſion, what imaginable reaſon can be given why theſe two Hemiſpheres ſhould not cohere as firmly in this Inſtance.

For though there be Air included between the two Hemiſpheres, yet all communication between the included and forreign Air is perfectly excluded by walls of Braſs, and the impervious Leather girdle.

If it be ſaid, that the Elaſticity of the included Air reſiſts the compreſſion by the forreign Air, and ſo impedes the coheſion.

I ſay if any ſuch Elaſticity were admitted in the Air, (which I do not) yet moſt certainly the included Air hath no greater Elaſticity than the common Air, whereof it was but juſt now a portion, and hath received no more compreſſion by the juncture of the Hemiſpheres, no more than Air in a Bottle covered with a flat Board or Paper.

The conſequence whereof is, that the Elaſticity of the forreign Air is as ſtrong as the Elaſticity of the included Air, and muſt needs keep it in *æquilibrio*. And the conſequence thereof is, that if the *pondus externi aeris* (if it were any way conſiderable) would have its free exerciſe upon theſe Hemiſpheres, though filled with

with Air; for according to these Masters supposition, the Cylinder of Air of each side pressing each Hemisphere, is above seven hundred pound weight, which it may freely exercise, the imaginary Elasticity of the included and forreign Air being *ex suppositione* equal. But the ensuing Experiments will render this more evident.

Secondly therefore, I took a handful of flax, and leaving the mouth of the lower Hemisphere upward, I put in the flax, and gave fire to it, holding the upper Hemisphere close over it, whereby the Air in both was greatly rarified, and a considerable portion of the space taken up by the flame of the flax. Then clapping the upper Hemisphere upon the lower, with the interposed Leather girdle, I pressed them together with all the strength I had, neither were they possibly capable of a neerer or closer contiguity to the interposed Leather, though the imaginary Cylinder of the Atmosphere had pressed them, and hereupon the flame and fire was presently extinguished.

The Events were as followeth.

1. There grew a preſent coheſion of the two Hemiſpheres together, even while they were hot, and the included Air under a high degree of rarifaction by the heat, and ſo could not have any conſiderable tenſion while the heat continued.

And the reaſon of this coheſion was plainly this. That the fire and flame had not only rarified the Air included within the compaſs of the Hemiſpheres, to an expanſion far greater than was natural to it; but alſo the flame and fire took up a conſiderable portion of the ſpace between the Hemiſpheres, which being extinct in the moment of their juncture, that very rarified Air that was within, was forced to take up ſo much more ſpace as the flame took up before its extinction. And from thence grew neceſſarily an attraction upon the cavity of the Hemiſpheres, though that very Air was under a rarifaction by the continuing heat.

2. But this coheſion was but weak, becauſe the Air was then under a ſtrong

ſtrong dilatation by the continuing heat, and therefore the upper Hemiſphere lifted up by the ring, would not ſuſtain the weight of the lower Hemiſphere.

3. But when the Hemiſpheres thus heated, and the included Air greatly rarified thereby, were permitted to continue together cloſed 'till they were perfectly cold, and thereby the Air had opportunity to contract it ſelf, or at leſt to endeavour it as much as it could. Now the coheſion of the Hemiſpheres grew ſtrong, ſo that the upper lifted up would raiſe the lower in conjunction with it, with the addition of ſome weight appended to the lower ring. And the reaſon was, becauſe the heat which was the cauſe of the great dilatation of the included Air was now ceaſed, and the Air by its motion of reſtitution endeavoured to contract it ſelf to its natural Expanſion.

And becauſe the included Air (it may be) was expanded to above four times its true natural ſize and dimenſion, and now endeavoured to contract it ſelf into

into that ſpace, but could not attain it, unleſs three fourths of the ſpace included within the Hemiſpheres ſhould have been left perfectly empty, the Air endeavouring its contraction, according to the particular inclination of its own motion; yet by the common law of the Univerſe was kept under its former Expanſion, to prevent the *caſma* between the Air and the concave Superficies of the Hemiſpheres, and ſo as much as was poſſible attracted upon them, and kept them together, no forreign Air being admiſſible for the relief of the included Air, to help to reſtore it to its due ſize and texture: as a living Oyſter contracts its ſhell together by its own contraction within its ſhell, when a perſon is opening it. The compariſon is homely, and ſuits not in all things, becauſe the Oyſter is a vital Being, but yet it ſerves to explicate the method of this attraction, by the filaments of the Air upon the contiguous concave Superficies.

And from this inſtance of fired flax (reſembling very much the common

inſtance

inſtance of Cupping-glaſſes,) it appears plainly, that in thoſe Glaſſes the fleſh is not driven up by preſſure of the forreign Air upon the glaſs or the contiguous parts of the fleſh; but purely by the attraction of the included reſidue of Air upon the extinction of the flame. For the Hemiſpheres were at firſt preſſed together as cloſe as they could be, and no man can imagine that the external Air can have any influence through theſe Brazen Walls, that are neer half an Inch thick, where yet the Attraction upon the included Superficies is viſible and apparent; and in this and my other Experiments it was not poſſible for the Hemiſpheres to receive a greater or cloſer contiguity than I gave them on their firſt union: and therefore I do not wonder, that *Schottus*, though too haſtily ſubſcribing to the preſſure of the Air, as a Solution of ſome Experiments, yet in his *Technica Curioſa*, *l.* 4. *cap.* 12. § 1. is forced to confeſs *carnem & ſanguinem ſubintrare cucurbitas, nec preſſione Aeris externi carni circum illas incumbenti, nec preſſione aeris illas incumbentis & deprimentis,*

primentis, ac intra carnem mergentis, ſed ſuctione & attractione.

3. Becauſe I would improve the Experiment to the uttermoſt, I made a tryal with a ſtronger heat. I therefore put burning Coals and red hot Iron into each Hemiſphere, 'till they were hot as I could well touch them, and then caſting out the Coals, the Air within the cavity of each Hemiſphere was highly rarified; then clapping the Leather girdle about the rim I cloſed the Hemiſpheres very cloſe, as my ſtrength could force them together; the Events whereof were theſe:

1. While the Hemiſpheres were hot, and ſo the included Air under a high degree of rarifaction, there was very little or no coheſion, for the Air was under the ſame laxation as at firſt, and therefore they would preſently fall aſunder, the upper being raiſed by the ring.

2. As the heat decayed, and the Heſpheres grew gradually colder and colder, and conſequently the Air more and more endeavours to contract it ſelf, and

as

as a consequence thereof attracted more forcibly upon the cavity of the Hemispheres, the stronger was there cohesion; because as the Air grew colder, it endeavoured more and more to acquire its just natural dimension and texture.

3. At last, when the heat was quite extinct, and the Hemispheres grown perfectly cold, the cohesion was so strong, that the upper Hemisphere suspended upon a hook, did not only sustain the lower Hemisphere, which weighed neer seven pounds, but also a weight of twenty eight pounds more, in all about thirty five pound weight, before they would be disjoyned.

For now the Air being discharged of that heat that kept it laxe, and without a bent, or tension, or contraction inward, did now endeavour its contraction strongly, and therewith pulled inward the Hemispheres, from which it could not be severed, by reason of common Natures declination of a Vacuity.

4. My fourth Tryal was this, that when

when the Hemiſpheres were firſt heated, and clapt together, and thereby when they became cold, cohered exceeding ſtrongly; yet when they were under that ſtrong coheſion, that they would ſuſtain a conſiderable weight as before, without parting aſunder, yet if afterwards they were brought but to a moderate heat, either by a chafing-diſh of Coals put under them, or by holding them neer the fire, they would ſuddenly fall aſunder of themſelves, without any weight appended to ſever them.

The reaſon whereof is apparent, namely that by the heating of the Hemiſpheres the included Air is again expanded, and its tenſion laxed, and the filaments thereof which were before under a tenſion and contraction by the Air, ſtriving to gain its natural temperament, are now let looſe, as a Lute-ſtring is let down by the unſcrewing of the Pins. And conſequently the ſuction and attraction of the Air upon the concave Superficies of the Hemiſpheres, which before held them together, is relaxed and diſcharged.

And

And thus we have the true *phænomena* of this Engin, and, as I take it the true reaſon and ſolution of them.

And upon theſe Inſtances I do conclude,

1. That men have had very little reaſon to conclude the Gravitation or Preſſure of the Air upon the inferior World, or the parts thereof; for the coheſion of theſe Engins is moſt plainly upon another reaſon, as appears by what is before declared.

2. That this inſtance is ſo far from concluding the Gravitation of the Air in that meaſure, that the late Maſters contend, that plainly that Suppoſition neither hath nor can have to do in the ſolution of theſe Inſtances.

For moſt unqueſtionably, the Air doth as much gravitate (if at all) upon the Hemiſpheres, when the included Air is rarified by heat, in theſe Inſtances, as it doth when the Hemiſpheres are grown cold; and yet in the former caſe there is no coheſion, but contrariwiſe a ſeparation of the cohering Hemiſpheres if again they are heated.

3. That

3. That the cause of the cohesion therefore is not *ab extra*, or *de foris*, but *ab intra*; namely, one specifical to the Air, whereby becoming cold after a great expansion by heat, it endeavours its contraction to its due space and texture, by a motion of restitution; the other common to all parts of the Universe, that common law of Nature that preserves contiguity, or indeed rather continuity of the parts of the Universe: and therefore suffers not the Air to contract it self, so as to leave an empty space between it self and the concave of the Hemispheres, whereby it comes to pass, that the Air endeavouring to contract it self, layes hold upon, and endeavours to contract and hold together all parts whereunto it is contiguous, when no access of forreign Air is admitted.

4. That the least admission of forreign Air, though through a Pin-hole, in the Hemispheres, gradually gives a relaxation of the tension of the included Air, which greedily sucks it in, and thereby is delivered gradually from its tension, and lets go its hold of the contiguous

guous Superficies, which is the natural and neceſſary effect of that tenſion.

I cannot eaſily perceive how theſe Concluſions againſt the imaginary Gravitation of the Air can be evaded.

If it ſhould be ſaid, that the reaſon why the Hemiſpheres cohere not when they are hot, is, becauſe the convexity likewiſe of the Hemiſpheres are alſo hot, and ſo retund the Gravitation or Preſſure of the Air upon them by their heat, which is not ſo done when they are cold.

I anſwer 1. That though the convex Superficies were admitted to be as hot as could be indured, yet the Sphere of that Activity is not two foot in circumference, which could never break the preſſure of a column of Air of at leaſt ſeven Miles high, and near a thouſand pound weight, according to the Suppoſition. 2. Neither is the heat required to make ſuch a disjunction of that Extremity, as to make any ſuch impreſſion upon the Air; for if the Hemiſpheres be made but bloud warm after their coheſion, they will fall aſunder.

3. But

3. But wholly to prevent this imagination, if the Hemiſpheres be caſed over with a flat or ſpherical Cover of Wood, Lead, or Braſs, which may receive the ſuppoſed Gravitation of the Air, yet the coheſion, while the air is hot within, will not laſt; for it is the laxation or relaxation of the tenſion of the Air within that, gives the ſeparation, or eaſie ſeparability of the Hemiſpheres.

CHAP. XIX.

Concerning the raiſing of the Water by Pumps or Syringes, and the Cauſe thereof.

IN the two former Chapters I have conſidered the coheſion of poliſhed Marbles, and the *Magdeburgh* Hemiſpheres, both in truth reſting upon Solutions ſomewhat of the ſame nature. And therein I have as I think excluded the Gravitation of the Air, or Atmoſphere, or aereal Cylinders, from any contribution thereunto.

I have choſen in this Chapter to conſider

ſider the Elevation of Water in Pumps and Syringes, both which are in truth but the ſame Engin, though circumſtantially varied.

And although I ſhall herein have occaſion to ſay ſomething touching the Gravitation of the Air, and ſhall in ſome meaſure evidence, that the Water is not raiſed in theſe Engins by the weight of the Air, preſſing upon the reſtagnant Well or other veſſel of Water, yet I ſhall not labour that, much, in this diſquiſition, becauſe enough hath been ſaid thereof before.

But my principal ſcope herein is to diſcover, even to ſenſe, that there is no ſuch Elaſticity in a ſeparate portion of common Air as the Elateriſts ſuppoſe, whereby to ſalve the ſuſpenſion of a co-column of twenty nine Inches of Mercury in the *Torricellian* Experiment, when the ſame is pent up in a cloſe veſſel or room, every where excluding the imaginary preſſure of the Atmoſpherical Cylinder; and conſequently that the Solution of that Experiment, either by the Weight or by the Spring of the Air,

Air, is a mistaken Solution, and hath no reality in it.

The raising of Water by common Pumps or Syringes (especially as it is this day ordered, sometimes with double, sometimes with single Valves, to hinder the regress of the Water) is so well known even to ordinary Plummers, that it needs no accurate description.

But the reason of this Elevation of the Water is variously rendred, according to the different *hypotheses* that men have entertained.

The ancient and common, and I think the true reason thereof, is this:

The lower end of the cavity of the Pump or Syringe being immersed below the Superficies of the restagnant Water, there is a Cylinder of Air in the cavity of the Pump or Syringe, between the Superficies of the Water and the bottom of the Bucket and upper Valve of the Pump, or between the Superficies of the Water, and the bottom of the *Embolus* of the Syringe closely penned up.

That by the Elevation of the Bucket

in

in the Pump, or *Embolus* in the Syringe, that portion of intermediate Air is under a tenſion, and draws vigorouſly upon the Superficies of the reſtagnant Water, and that again upon the contiguous Water, and ſo the tenſed *funiculus* of the Air raiſeth a *funiculus* of Water, commenſurate to the cavity of the Pump or Cylinder, which again by depreſſion of the Bucket riſeth through the Leather-valve that covers it, and by an iterated elevation of the Bucket or *Embolus* draws up more, whereby there is a continued ſupply of a *funiculus aqueus*, which is finally thrown out at the orifice, or noſe of the Pump.

That it is a certain truth, that Water is raiſed either by a *pondus* or preſſure, that is equivalent to the weight of the Water that is elevated, as in the Engins where Forcers or preſſures are uſed to raiſe Water; or elſe by an attractive *potentia* equal to the weight of the Water drawn up, as in Pumps and Syringes.

That conſequently, the *vis* or *potentia ſuctoria* or *attractiva*, will raiſe ſuch a

weight of Water as is less than this *vis* or *potentia*, (for whether the Elevation of Water be by a *vis deprimens* as in pressing Engins, or *vis fuctoria* or *attractiva* as in Pumps or Syringes, or the preponderation of the *potentia* to the weight of the Water) thus it sustains, impels, or attracts, and therefore they are all reducible to the reason of the *libra* or Ballance.

And on the other side, if the weight of the Water exceed the *pondus* or *potentia* which must raise it, it cannot either draw, or impell, or keep it up beyond an *æquilibrium* with that *pondus* or *potentia impellens* or *attrahens*.

And therefore if there be an excessive distance between the Superficies of the restagnant Water, and the bottom of the *Embolus* or Bucket, suppose it 50 or 60 foot of perpendicular height, whereby the *potentia attractiva* is overmatched with a *pondus* of Water more than its strength, it will not raise it to a due height. For still as I said, where any weighty body is raised out of its place, it must be by a greater weight, or

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at leſt by a *potentia*, exceeding that weight of the Body to be raiſed.

But the modern Philoſophy tells us, that the raiſing of the Water in the Pump or Syringe, is not by a *vis attractiva* or *ſuctoria* of the Bucket or *Embolus*, but that it is forced up by the weight of a Cylinder of Air, commenſurate to the cavity of the Pump or Syringe.

And that the Elevation of the Pump or *Embolus* of the Syringe, attenuating the Air incloſed in the cavity of the Pump or Syringe, and thereby diſabled by its laxity to reſiſt the preſſure of the external Cylinder of atmoſpherical Air, the Water is driven up into the cavity of the Pump or Syringe.

And becauſe a Cylinder of Mercury of twenty nine Inches and half, is by them ſuppoſed to be of equal weight to the Cylinder of Air of like diameter, reaching from the top of the Atmoſphere unto the veſſel of reſtagnant Mercury in the *Torricellian* Experiment, and a Cylinder of *Mercury* of twenty nine Inches and half high, countervails in weight a Cylinder of Water of like

diameter of about thirty three foot high, and conſequently a Cylinder of the Atmoſphere counterpoiſeth a Cylinder of Water of about thirty three foot high, therefore the Water in a Pump will be raiſed but juſt to that height, *viz.* neer thirty three foot, and no higher, becauſe ſuch a column or Cylinder of Water is counterpoiſed by an Atmoſpherical Cylinder of like diameter. Thus I think it is rendred by *Schottus* in his *Technica Curioſa*, *l.*4.*cap.*8.*Q.*4. and by the Excellent Author of *Hydroſtatical Paradoxes*, *n.* 5. and by other learned men of this latter age.

But under their favour I think this is not the true Solution of the inſtance in hand, but the firſt is the true Solution thereof.

If the elevation of the Water in the Pump may be more conſiderably higher than 33 foot, certainly this latter Solution cannot ſerve. And though this poſſibly hath not been fully tryed, and requires exact Engins to effect the Tryal to the uttermoſt; yet there are many that do experimentally affirm, that

that a Pump or Syringe well ordered will raiſe Water above forty foot perpendicular height; and if ſo, the counterpoiſe of the aereal Cylinder will not do the buſineſs. But this I have not tryed, I will therefore apply my ſelf to what I have tryed.

Fig. 22. I took therefore a great and ſtrong globular glaſs Bottle, *A B C*, holding five Quarts of Water, of about nine Inches Diameter, with a double orifice, *viz.* one at *A*, wherein to faſten my Pump hereafter deſcribed, another at *B*, to let in or pour out Water, to leave open or cloſe, as I ſaw cauſe.

In *A* the neck of the Bottle I faſtned a Laton Pump or Syringe, of about an Inch and a half diameter, marked *D*, with a ſmall Pipe about half an Inch diameter, reaching neer the bottom of the Glaſs, *viz.* *E*; an *Embolus* at *G* reaching down neer *H*, and a little crooked Pipe at *H* to drive out the Water by the depreſſion of the *Embolus*.

This Pump was faſtned and ſtrongly luted in the neck of the Glaſs with a double Valve, one about *A* to receive the

Water into the Pump, and to ſuſtain it from returning, by depreſſing the *Embolus*, another at *K* the top of the orifice, to keep the Air from entring upon raiſing the *Embolus*.

So that now the Bottle was the Well, which I filled up with Water.

Therefore leaving open the orifice at *B*, whereby the Air had free acceſs into the Bottle, by lifting up and depreſſing the *Embolus G* the Water was freely and eaſily without any difficulty drawn out at the orifice *K*, through the Valve there placed, and ſo I emptied half the Bottle of Water, namely to *I* the ſuperior half, being full of free uncompreſſed and common Air; and the lower half at *I* being full of Water.

The Pump being in this poſture, I took a ſhort piece of Cork, firſt boyled and then dipt in melted Bees-wax and Roſin with it, I cloſely luted up the orifice at *B*, ſo that no air could poſſibly enter. And then I lifted up and depreſſed the *Embolus* ſeveral times, ſo long 'till I could ſee the whole ſucceſs of this Tryal.

Firſt, the *Embolus* was raiſed, but not with

with equal facility, as it was done when the orifice *B* was open.

The reaſon whereof is, becauſe every elevation of the *Embolus* gave a violent tenſion to the Air in the ſuperior cavity of the Glaſs, which upon every portion of Water drawn up muſt neceſſarily be expanded into a larger ſpace to ſupply the ſpace left by the raiſed Water. So that the expanſion of the Air was not natural, or of its own accord, but by a violent attraction wrought upon it, and tenſion of it.

Secondly, yet notwithſtanding the excluſion of the Air, I did freely pump out above a quart of Water, whereby the Water ſubſided an Inch and a half below *I*, and conſequently the Air expanded and dilated to ſo much more ſpace than it had before, *viz.* whereas the ſuperior cavity of the Glaſs held by the Air was two quarts and half, now it took up the room of three quarts and half, and ſomewhat more.

So that here was a quart of Water raiſed up by the ſuction of the *Embolus*, and yet no poſſible Gravitation of that

imaginary atmoſpherical column to preſs or drive it up; ſo that ſurely the aſcent of the Water in the Pump is not by the Ballance, *æquipondium*, or preponderation of a column of the Atmoſphere to the column of Water raiſed in the cavity of the Pump, for here was no acceſs for any ſuch column: whether the imaginary Elaſticity of the included portion of Air may be called in to help the matter, we ſhall ſee hereafter.

Thirdly, but when I had raiſed up this quart of Water, and emptied ſo much out of my Bottle, all my iterated tractions and truſions of my *Embolus* could raiſe not one drop more.

But all that was done by theſe repeared motions, was only the rarifying of the Air included in the Pump, when the *Embolus* was lifted up, and condenſing it again as the *Embolus* was depreſſed, but no Water raiſed.

Now in this inſtance, the reaſon why a quart of water was raiſed, though the orifice at *B* were ſtopped, was becauſe the *potentia ſuctoria* or *attractiva* of

of the Pump was ſtrong enough to give a dilatation of the Air to a greater ſpace by a quart than it had before.

And the reaſon why it could raiſe no more, is this, namely, in as much as every portion of Water raiſed out of the veſſel, muſt of neceſſity leave a ſpace devoid of ſo much Water as is ſo raiſed up, and that derelicted ſpace muſt either be wholly vacant of any Body, which by the univerſal law of the Univerſe is prohibited, or elſe the Air muſt expand it ſelf to fill it. And in as much as the Air having undergone as great an Expanſion already (by the evacuation of the firſt quart of Water) as this *potentia* or *vis attractiva* was able to effect. The included Air thus expanded reſiſteth any further expanſion with an equal ſtrength to the attractive power of the Pump, and ſo renders it *conamen irritum*, to give it a larger expanſion, and conſequently no more Water is raiſed.

But if a greater ſtrength were applied, ſtrong enough to maſter that reſiſtence, as if the Pump were longer, that it might

might give a ſtronger ſuction, that might overmatch the reſiſtence of the included Air againſt a higher degree of tenſion; yea or if the ſuperior Air, after this quart of Water was evacuated, had a ſtrong external heat applied to it, whereby it might be capable of a larger expanſion, the Water (while the Air was under this forcible expanſion) would be as eaſily raiſed by the Pump as at firſt. But this I durſt not try, for fear of breaking my Glaſs, or unluting of it.

Upon this conſideration and tryal it is manifeſt,

Firſt, that the Gravitation or preſſure of the external Air is not the cauſe of raiſing the Water in the Pump; for here it is raiſed where there is no Gravitation, the orifice at *B* being perfectly ſtopt.

Secondly, that the common Air hath no ſuch Elaſticity, as the modern Philoſophy aſſigns to it; for here a portion of Air included in the Glaſs is of the ſame texture with the common Air, and a portion of it, and yet evidently there

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is no ſuch Elaſticity in it as is ſuppoſed.

And this appears, 1. becauſe it is not expanded to one third part of greater ſpace than it had before, without a force offered to it, as above is ſhewn. 2. When it is expanded to a third part of ſpace more than it had, it is ſo far from a natural expanſion of it ſelf farther, that it reſiſts the *attractiva potentia* of the Pump to give any larger expanſion. And 3. if it had yet a natural expanſive power without force or violence added to it, it would certainly drive up the reſt of the Water that remains, eſpecially when the Air in the Pump is rarified or extended by the elevation of the *Embolus*, and yet no Water follows it, in this inſtance, which yet it would do, if the Air had a continuing Spring or Elaſticity to drive it up.

It is true, that naturally all the ſpaces of this lower World (at leſt) are and muſt be filled with ſome body or other: and as one body moves or is moved out of one ſpace to another, ſome other body ſucceeds in that ſpace that is ſo left, and fills it. And the fluid Bodies of Air and Water,

Water, or ſome fluid bodily ſubſtance, equivalent to either of them, are in reſpect of their fluidity fitted more than other ſolider Bodies, to ſupply and make good the *interſtitia* of other Bodies; and if they be contiguous unto them, to ſlip into the ſpaces deſerted by their motion into other ſpaces, and accordingly will do it, if they are not impeded by the reſiſtance or interpoſition of other more ſtubborn and untractable Bodies. And by this means upon the ſucceſſive motions of Bodies, there is maintained a ſucceſſive and continual circulation in the motions, eſpecially of thoſe Bodies that are fluid, and ſo more ready and apt for motion.

In the Inſtance of my Pump, ſuppoſe that the orifice at *B* be left open, and the veſſel or Bottle have a Gallon of Water in it, and there ſtands by it an empty veſſel, ſuppoſe *M*, that contains a Gallon of Air: if I pump out a Gallon of Water out of the Pump into the veſſel *M*, as the Pump is gradually emptied of the Gallon of Water into *M*, the Water leaves its place in the Pump, and takes

up

up as much room in *M*, and the Air in *M* leaves as much ſpace there, and takes it up in the Pump, to which it hath a free acceſs; ſo that the two Elements change their ſtations, and while they hold their natural texture, hold the ſame extenſion of ſpace, though not the ſame ſituation. And thus a circulation is naturally conſequential upon the motion eſpecially of fluid Bodies; and therefore when the Water leaves its place in the Pump, and diſpoſſeſſeth the Air in the veſſel *M*, and the diſpoſſeſſed Air gradually ſucceeds into the ſpace left by the Water, as faſt as the Water leaves it, and takes up another room equal to what it had before, though in another *ubi*; here is no Gravitation of an Atmoſpherical column upon the orifice *B*, but only a natural motion and ſucceſſion of the like portion of Air into the place relicted by the Water, and a natural deſertion of that ſpace which it before had in the veſſel *M*, which it cannot retain againſt the weightier and more prevalent Element of Water taking it up. So that it is neither a Gravi-

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tation of the atmoſpherical Cylinder upon the orifice *B*, nor any great Elaſticity of the Air that drives up the Water, but a natural circulation of the portion of Air into the ſpace derelicted by the Water; and the immiſſion or inſinuation of the Air into that Cavity, is the Effect not the Cauſe of the receſſion of the Water.

And now to reduce all this long proceſs to the thing I principally intended, we are told by the late Philoſophy, that the ſuſpenſion of the Mercury at twenty nine Inches height in the *Torricellian* Experiment, is cauſed by the counterpoiſe of the weight of an external atmoſpherical Column, commenſurate in its craſſitude and weight to the Mercurial Cylinder ſuſpended in the Glaſs Tube.

And when it is replied, that the like ſuſpenſion happens, if the Mercurial Engin be placed in a cloſe room, yea or in a Glaſs every way cloſed, that admits not any ſuch Mercurial column, but intercepts it and its preſſure by its cloſure every way. We are again told, that that little portion of Air included within

in

in that room or Glaſs, hath ſo potent an Elaſticity, that it will as effectually ſuſpend the Mercury in the Tube, as that tall Atmoſpherical Cylinder of at leaſt ſeven Miles long. This I ſay ſeems to me utterly incredible for theſe reaſons:

1. The Air included in a cloſe room or Glaſs, hath only the advantage of its imagined Elaſticity, but not the advantage of the ſtupendous weight aſſigned by this New Philoſophy to the external aereal Cylinder.

The external Air hath the ſame Elaſticity attributed to it, as the Air included in the cloſe room or Glaſs, and alſo the ſuppoſed advantage of the weight of the Cylinder of the Atmoſphere beſides.

If the bare Elaſticity of incloſed Air be ſufficient to ſuſpend the Mercury at twenty nine Inches and half, within the room or Glaſs; the ſame Elaſticity in the external Air, with the advantage of its weight, ſhould ſuſpend the Mercury to fifty nine Inches high, which was never yet done.

2. If the Elatery of the Air cannot drive

drive up a succeſſive portion of Water of half an Inch diameter into my Pump, without the attraction of the *Embolus*; nor yet is that attraction alſo effectual to raiſe the Water, when it hath expanded the Air to about a fourth part of ſpace more than is natural to it. It is impoſſible that the Elaſticity of the Air, included in a cloſe room or Glaſs Receiver, can drive and keep up a Cylinder of Mercury twenty nine Inches high, which yet according to the amplitude of its diameter may weigh, two, four, or ten pound.

I do therefore conclude upon the whole matter, that it ſeems to me, the new *hypotheſis* of the Weight and Elaſticity of the Air, as it is delivered by the late Philoſophy, is an Ingenuous Invention, but wants Reality to ſupport it ſelf, or to give a right and true Solution to the *Phanomena* whereunto it is applyed.

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