

**An historical and philosophical account of the barometer, or, weather-glass. Wherein the reason and use of that instrument, the theory of the atmosphere, and the causes of its different gravitation, are assign'd and explain'd. And a modest attempt from thence made towards a rational account and probable judgment of the weather / By Edward Saul.**

### **Contributors**

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A N  
Historical *and* Philosophical  
ACCOUNT  
OF THE  
BAROMETER,  
OR  
WEATHER-GLASS.

WHEREIN

The REASON and Use of that INSTRUMENT,  
the THEORY of the *ATMOSPHERE*, and the  
CAUSES of its different GRAVITATION, are  
Assign'd and Explain'd.

A N D

A MODEST ATTEMPT from thence made towards a rational  
Account and probable Judgment of the WEATHER.

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By *EDWARD SAUL*, A. M.  
Late Fellow of *Magdalen-College*, Oxford, and  
Rector of *Harlaxton*, Lincolnshire.

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*The SECOND EDITION, Corrected.*

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L O N D O N :

Printed for A. BETTESWORTH and C. HITCH,  
at the *Red-Lyon* in *Pater-Noster-Row*.

M.DCC.XXXV.







TO HIS GRACE

J O H N,

*Duke of RUTLAND, Marquis  
of GRANBY, &c. Chancellor of  
the Dutchy of LANCASTER, and  
Knight of the Most Noble Order  
of the GARTER.*

My LORD,



THE following Tract Your Grace  
is intituled to upon many Ac-  
counts. It was drawn up in  
Part above Twenty Years ago,  
and design'd for Your Amuse-  
ment in Philosophy, when I had the Honour  
of living in the Family with you at *Bel-  
voir* ; it has, at several times, been talk'd



over to Your Grace in Conversation, as Occasions offer'd : It was some time since presented to You in Manuscript, and now, with such farther Additions and Alterations, as, upon a careful Review, I found Reason to make, waits upon Your Grace from the Press.

I AM very far, my Lord, from pretending herein to offer to Your Grace any thing new, or extraordinary upon the *Barometer*; Mr. *Boyle*, Dr. *Halley*, and other Philosophers of Note, having, in a good measure, anticipated what can be said upon it, and left little more to any subsequent Writers, than the Necessity of treading in their Steps, of building upon their Foundation, or perhaps, in some Instances, of giving some farther Light and Confirmation to those Principles they have laid down for the Explanation of it. Agreeably to which, what lies scatter'd and dispers'd in several Authors and Volumes; what I had formerly the Opportunity of learning under Dr. *Keil* at *Oxford*; what I have since, either seen, read, collected, or observ'd, of any Consequence, or Relation to the Subject, is here work'd up together into one consistent Scheme, and at one View submitted to Your Grace's Perusal.



THE Pleasure Your Grace takes in Speculations of this Kind, especially in such as are agreeable to Nature and Reason, is the best Apology I can make for the Freedom of addressing these to You ; but the real Motive that induces me to it, is rather to do Justice to Your Grace, in what the World must allow to be a very bright and distinguishing Part of Your Character.

It is recorded, by *Plutarch*, of the Elder *Cato*, that he was well advanc'd into Years, before he enter'd upon the Study of the Greek Tongue ; or as the *Roman* Historian says of him, *Literarum cupidissimus, earum studium senior arripuit ; tantum vero in eis progressum fecit, ut non facile reperire possis, neque de Græcis, neque de Italicis rebus, quod ei fuerit incognitum.*

ANOTHER Instance of the like Nature is related of a famous Author of the last Century ; who (being often puzzled and perplex'd by the inquisitive Temper of his Son, and asham'd of not being able to give him a rational and satisfactory Answer) betook himself to his Accidence at the Age of 44, and made so quick a Progress in his Studies, from so late a Beginning, that before he was 60, he had publish'd three or four *Folios* of



vi      *The* DEDICATION:

of Collections and Translations out of the learned Languages.

THESE, my Lord, and the like extraordinary Efforts of a superior Genius, are always mention'd with Marks of Esteem and Approbation; and as they are always previously grounded upon good Sense, attended with great Difficulties, and require an unweary'd Diligence and Constancy in putting them in Execution; it must be, at the least, equally laudable, and highly for Your Grace's Honour, to exert and distinguish Yourself in the same uncommon Pursuits of Learning.

IN Your early Years, You had gone through the customary Forms of a fashionable Education, in acquiring a little Smattering of *French* and *Latin*, a general Inattention to Books, and Attachment to Sports: But this, my Lord, was a Scene of Life too Mean and Ignoble for Your Grace's active Soul to be confin'd in. Conscious of many heavy Hours hanging upon your Hands, You had Recourse to Musick, and made the most surprizing Progress in it. Conscious of the Want of a Fund of Learning, suitable to Your natural Genius and Capacity, You engag'd in Reading the best *French* and *English* Authors: But even these, my Lord, not being fully satisfactory to Your impatient



gent Thirst of Knowledge, You deliberately form'd, and, without Hesitation, executed the noble Resolution, not only of Acquiring a competent Skill in the Language, Style and Beauties of the Clafficks, but even of going back to the Rudiments of Grammar, and of grounding the Course of Your Studies upon a new and regular Foundation.

AND thus, my Lord, the Opportunity, unhappily lost in the former Part of your Life, You wisely retrieve in the Sequel of it; and what shou'd have been the Employment of Your Youth (rather than be defective in any Part of polite Literature) You have made it Your Choice to pursue in Your manly Years; and that with so great Steadiness and Application, as if You were daily accountable for the Progress of your Studies; or that the noble Distinction of Birth, Honours and Fortune, You so liberally enjoy, cou'd not sit easy upon You, without a Superiority of Sense and Learning, answerable to the Superiority of Your Station and Character.

So generous an Ambition, in an Age so much addicted to Pleasure, of excelling in the Improvements of Reason; is what the World, my Lord, deservedly admires, applauds, and congratulates You upon; and  
what



what all true Lovers of Learning, must, with equal Zeal and Unanimity join, in wishing Your Grace the most desiræable Health and Success, in carrying on and accomplishing so laudable an Undertaking ; tho' Your Attention to it, will always give Your Friends great Pain and Anxiety, lest the Constitution of Your Body, like that of Your noble Ancestor, *Edward* Earl of *Rutland*, shou'd be too tender and delicate to support the rapid Progress and Improvement of Your Mind.

As your Grace is now, with so much Honour to Your Self, enroll'd in the Number of the *Literati* ; the Demands and Expectations of the World, will, my Lord, in some Proportion, rise upon You, and from a Man of Sense and Learning, regularly and naturally expect a distinguishing Regard to Persons of the like Character : And that Your Grace will rather follow Your own noble and upright Inclinations in doing Justice to Merit, than be too easy and compliant, in giving up Your Judgment and Patronage to the less cautious Recommendations of others.

It was by such a constant and laudable Partiality to Men of Merit, that *Mecænas* stands upon Record in more bright and lasting Characters, as a Patron of Learning, than



than as a publick, or prime Minister of State. By the very same Methods of Favour and Encouragement, the renown'd *Scipio*, and *Cicero*, in their Intervals of Retirement from publick Business, made each of them their Villa, or Country Seat, a Sort of Academy, or Society of learned Men ; with the great *Roman* Orator, or Statesman (in a private, but undisputed Post of Honour) presiding at the Head of them.

By something of the like Measures steadily pursu'd, Your Grace might also, by Degrees, transplant Men of Vertue, Learning and Merit (which it is always in the Power of great Persons, by suitable Encouragement, to have at Command) into the several Vacancies, as they shall happen, under Your double Right of Patronage; to Your own lasting Honour, to the Service of God and Religion, and to the present and future Benefit of those Multitudes of Souls, whom Providence has in some measure plac'd under Your Care; and whose Instruction in the Ways of Life and Happiness, depends so much upon the Choice Your Grace makes, in the Disposal of Your Presentations.

THAT Your Grace may thus ever employ  
the noble Privilege of being Great, in the  
more noble Power of doing Good ; that  
B You



x      *The* DEDICATION.

You may live many Years in a settled State of Health and Felicity, and grow old with Pleasure in the progressive Improvements of Learning, Wisdom, and Vertue; is the general and unanimous good Wish, of all who Love and Honour Your Grace; but of no Man, with a more unfeigned Zeal, Respect, and Sincerity, than, my Lord,

*Your GRACE's most Obedient,*

*And most Devoted,*

*Humble Servant,*

EDWARD SAUL.





An Historical and Philosophical

# ACCOUNT

OF THE

# BAROMETER,

OR

# WEATHER-GLASS.



THE WEATHER-GLASS being of late grown into common Use, and in most Houses of Figure and Distinction, hung up as a Philosophical, or Ornamental Branch of Furniture; and supplying often Matter of Discourse upon the various and sudden Changes of it: It may not perhaps be unacceptable to many Persons,



who daily see the Effect, and are not rightly appriz'd of the Cause, to explain the Nature and Reason of it.

My Design therefore in these Papers, is not to write for the Entertainment of Philosophers, or of those Gentlemen, who by the Advantage of a learned Education, or of a Course of Experiments, have had better Opportunities of improving themselves in Speculations of this Nature : But for the Satisfaction of many of my inquisitive Countrymen ; who having given themselves and their Parlours an Air of Philosophy, by the Purchase of a *Barometer*, may be willing to know the Meaning of it, and desirous of exerting now and then a Superiority of Understanding, by talking clearly and intelligibly upon it.

THE Design and Use of this Instrument, is to shew the various Changes in the Weight or Pressure of the *Air*, and those of the *Weather* depending upon it.

THE *Air*, in former Ages, was generally held to be a Body specifically Light, or by its own inherent Spring and Activity, rising naturally, and mounting upwards : But the Philosophers of the last Century, by various Experiments have discover'd and demonstrated it in reality to be a heavy elastic Fluid ; heavy, because its upper Parts press upon the lower, and those again upon others below them, with a progressive Weight,



Weight, down to the Surface of the Earth; and elastic, or springy, because the Particles of the *Air*, like Wool, are capable of Contraction and Dilatation; capable of being compress'd within a narrower Compass by any incumbent Weight, and of restoring and expanding themselves again, upon the Abatement, or Removal of it.

AND as these two Properties, the Weight and Spring of the *Air*, have a mutual Connection and Dependence upon each other, and contribute jointly in producing the Effects observable in the *Barometer*; so to avoid the Confusion of arguing from two different Principles, I shall consider them both under one common View, in the Sequel of this Discourse, and by the Pressure of the *Air*, the Gravitation of the *Atmosphere*, and other synonymous Expressions, I wou'd be here understood to mean, not the Weight of the *Air*, distinct from the Spring of the *Air*; but the compound Effect (as they both act in Conjunction) resulting from both, and as for the particular Effects of the Spring of the *Air*, so far as they are necessary, and bear a Relation to this Subject, they will be consider'd and explain'd in their proper Place.

AS the general Gravitation of the *Air* upon the Surface of the Earth, has been much the same in all Ages of the World, and the Effects proceeding from it, constant  
and



and regular ; it was scarce possible for any profess'd Observers of Nature to avoid taking Notice of some of them, and accordingly, the Rise and Support of Water within the Bole of a Pump, the Ascent and Running of Liquor through a Syphon, the Suction and Detention of Water in a Syringe, &c. fell under the Observation of the Philosophers of former Ages : But then to palliate their Ignorance of the true Cause, they falsely ascrib'd these and the like Effects, to an imaginary *Fuga Vacui* ; to a mysterious and unaccountable Dread in Nature of a Space void of all Matter, which it was taken for granted, wou'd be attended with such destructive Consequences, that Nature revers'd her ordinary Laws, and caus'd even heavy Bodies to mount upwards, to prevent or avoid it.

THIS unphilosophical Account was justly exploded by *Galilæo*, a celebrated Mathematician of *Pisa* in *Italy*, who advanc'd and maintain'd it, as an undeniable Truth in Philosophy, as well as Mechanicks, that no heavy Body ascended, without another Body equally heavy descending in counterpoise to it ; and in the Consequence of this, he was the very first that suspected and suggested this præter-natural Ascent of Fluids (as it was then accounted) to have a regular natural Cause answerable to it, in the secret and invisible pressure of the *Air*.

THIS



THIS Hint of *Galilæo*, was farther pursu'd and improv'd by the famous *Torricellius*, a *Florentine* ; who, about the Year 1643, amongst other Experiments for discovering the Weight of the *Air*, form'd the first rough Model of a *Barometer*, in a Pipe, or Tube, of 60, and afterwards of 40 Feet in Length ; which being immerg'd and suspended in a Vessel of Water, and the *Air* extracted by a Sucker, the Water was always observ'd to follow the Sucker, and to rise and continue suspended within the Tube, to the Height of 32, or 33 Feet, with some little Variation, but cou'd by no Art be drawn or kept up to the Height of 38 or 40 Feet : which plainly prov'd the *Fuga Vacui* not to be infinite, but to be limited within narrow Bounds, and those prefix'd by natural Causes, admitting of no Encrease, or Excess.

BUT this Instrument of *Torricellius*, being of an unmanageable Length and Size, and requiring the help of a Windmill Sail to invert the Tube ; by comparing their specific Gravities, and filling a Tube of Glass with Quick Silver instead of Water (which some Authors say, was altogether Accidental) he found the Effect equally, and surprizingly to answer ; and by the Advantage of so heavy a Fluid, he reduc'd the *Barometer* in its Length, from 40 Feet, to 32 or



or 33 Inches. This was the State in which *Torricellius* fram'd and left the *Barometer* (from him in the Writings of the modern Philosophers usually call'd the *Torricellian* Experiment) and which indeed, was only apply'd at the first to prove the general Gravitation of the *Air*, without drawing any other Philosophical Conclusions from it.

THE Honour of still farther improving the *Barometer*, and of bringing it to a greater Degree of Exactness and Perfection, was reserv'd for the noble and sagacious Mr. *Boyle*; who by frequent Observations and Experiments, was the first that convinc'd the World of the great Inequality in the Gravitation of the *Air* at different Times and Places; and that contrary to the receiv'd Opinion, the Pressure of the *Air* was greatest, when it was most clear and serene, and least, when it was most charg'd with Clouds and Vapours; because in fair Weather, the *Mercury* usually rose and kept up to the Height of 29<sup>1</sup> or 30 Inches; but in changeable, rainy, or stormy Weather, usually settled to 29, 28 $\frac{1}{2}$  and even sometimes below 28 Inches.

AND from hence not only by observing a regular Correspondence betwixt the Rise and Fall of the *Mercury*, and the Changes of the Weather; but by marking and adjusting the precise Limits to both, upon a graduated Plate of Brass, on each Side of  
the



the Tube, he brought the *Barometer* into more general Use and Service; either as a certain Measure of the Weight of the *Air*, or as a variable Indication of the Changes of the Weather.

How, and why it is so, will appear from the Construction of the *Weather-glass*, which in the common Form, is made after the following Manner.

TAKE a Glass Tube of about 35, or 36 Inches long, and near half, or the third Part of an Inch in the Diameter; clos'd or hermetically seal'd at one End, and open at the other. Fill it up with *Mercury*, or Quick-Silver, well clear'd and purify'd; then, stopping the Orifice close with your Finger, invert the Tube, and plunge it together with your Finger into a Basin of Quick-Silver, and when it is fix'd or suspended in a perpendicular Posture, with the Orifice of the Tube below the Surface of the *Mercury*, at a little distance from the Bottom of the Basin, withdraw your Finger from the Orifice of the Tube.

It is found by Experience, that only such a Part of the Quick-Silver within the Tube, will subside and run out into the Basin, as exceeds the Weight of a proportional Column of *Air*, and that the remaining, and far greater Part of the Quick-Silver will continue supported within the Tube, exactly at such an Height, as comes to an *Æquilibrium* with it.



FROM hence it follows, 1<sup>st</sup>, That by the subsiding of the *Mercury* from the Top of the Tube, the intermediate Space (being usually about six or seven Inches) is left entirely void of *Air*, and this is absolutely necessary in a good *Barometer*, as well to give Liberty to the outward *Air* to exert its Force, as to give room to the Rise of the *Mercury* within the Tube, upon any Increase in the Gravitation of the *Air*. 2<sup>d</sup>, If there be any Bubble of *Air* confin'd within the Cylinder of *Mercury*, it will by a constant Endeavour to free it self from Pressure; after some little Time, disengage it self, and make its Way to the Top of the Tube; and there rarefying and expanding into a larger Compass, it will in some measure defeat the Use and Exactness of this Instrument; upon which Account the true *Torricellian* Tube, is not made entirely of a *Cylindrical* Form (as in the common *Weather-Glass*) but spreads out into a large Bolt Head, or spherical Cavity at the Top, so that if there be any *Air* remaining in the Tube, it may have there sufficient Room to expand it self, without affecting or depressing the *Mercury*. 3<sup>d</sup>, From hence also it farther appears, that the *Mercury* within the Tube is kept suspended, by the Gravitation of the external *Air* upon the Surface of the stagnant *Mercury* in the Basin.

To



To make this still more evident, take a strong *Glass Cylindrical Tube*, clos'd at the upper End, with a Sucker well fitted to the inward Cavity, well moisten'd, and press'd up to the very Top of it; immerge this with the *Air* within it, into a Vessel of Water, and no Water can, or will rise up in it, because the Resistance of the *Air* within the Tube, is equal to the Pressure of the *Air* without; then keeping the lower and open End still under the Water, draw back the Sucker by main Force, and the Moment the *Air* and Sucker are extracted out of the Tube, the Water will immediately rush in, and shoot up with surprising Force and Velocity to the Top of it.

To account for this, we must have recourse to a known Law in *Hydrostaticks*, viz. That all Fluids, under a State of Compression, direct their Motion that Way, towards which there is the least Resistance. Now the Tube, by the Experiment above-mention'd, having no *Air* within, and the *Air* without, lying as a Weight incumbent upon the Surface of the Water, it is evident that the Pressure of the outward *Air*, can only act and exert it self, by forcing the Water up the Tube, where there is no Resistance, nothing to oppose its Passage. And this it will do, 'till either the Extremity of the Tube stops its Ascent, or 'till



the Weight of the Water, within the Tube, is equal to the Pressure of the *Air* without.

THE very same Effect is clearly shew'd, and undeniably prov'd, by placing the Tube of a *Barometer*, with its Cistern of *Mercury*, in the *Air Pump*; for so long as the *Air* within the Receiver continues in its natural State, the *Mercury* will keep up to the same Height; but when the Pump is working, and the *Air* exhausting, the *Mercury* will gradually subside in the Tube, 'till it comes to near the same Level with that in the Basin. Open the Communication with the external *Air*, and let it by Degrees into the Receiver; and then the *Mercury* will gradually rise up again in the Tube, and recover its former Height. And thus, as often as you repeat the Experiment, the *Mercury* will alternately fall, or rise in Proportion as the Pressure of the *Air* is diminish'd by pumping it out, or renew'd by the Re-admission of it.

To this I shall only add a more easy and obvious Experiment, *viz.* that of pouring Water upon the *Mercury* in the Cistern, rais'd for this Purpose to the Height of two or three Inches; for as the Water is heavier than the *Air*, it will to a greater Degree increase the Pressure upon the stagnant *Mercury*, and in the Consequence of it, raise that in the Tube proportionably higher. Draw off the Water by a Pipe, and, in Proportion as  
the



the Weight decreases by the *Air* succeeding in its Place, the Quick-Silver in the Tube will gradually descend, and settle as before, to its lower Station.

FROM these Experiments, and the Conclusions grounded upon them, it is to Demonstration evident, that the general and perpendicular Pressure of the incumbent *Air*, or *Atmosphere*, upon the Surface of the Earth, is the Force that raises up the *Mercury* in the empty Tube; that the very same Pressure of the *Air*, is the Counterpoise that supports the *Mercury* at its proper Height; and that they are only the various Changes in the Gravitation of the *Air*, that produce the correspondent Changes in the Rise and Fall of the *Mercury*.

FROM hence also it appears, that the little Vacuity in the upper Part of the Tube, is in reality the main Spring and Engine that keeps the *Barometer* in play; that directs and determines the general Pressure of the *Air*, to its particular Use and Service; and even confines it to discover the daily Changes it undergoes in its own Gravity, by bringing it there to the Test, and weighing in a Philosophical Balance, a Column of *Air*, against a Cylinder of Quick-Silver.

FOR if you break the Tube, and destroy the *Vacuum* in the upper Extremity, by letting in the outward *Air*, you destroy the Balance that keeps the *Mercury* suspended; which will immediately fall down into the Cistern,



Cistern, and the Effect we are here accounting for, entirely cease.

So ridiculous and groundless is the Dread of a *Vacuum* in Nature, and so useful when rightly apply'd (in Pumps, in Fire and Water Engines, &c.) in doing the Drudgery, and contributing to the Ease and Benefit, the Relief and Entertainment of Mankind.

By the Premises it is abundantly prov'd, that in a common *Weather-Glass*, the *Mercury* within the Tube, gravitates as much upon that Part of the stagnant *Mercury*, lying directly under it, as the *Air* does upon the rest of the Surface of the *Mercury* in the Basin; and consequently, that a Column of *Air*, reaching to the Top of the *Atmosphere*, is of the same Weight with a Column of *Mercury* of the same Base and Height with the *Mercury* in the Tube, *i. e.* in other Words, 29 or 30 Inches of Quick-Silver, is equivalent in Weight to a proportional Column of *Air*, rising and reaching above 5 Miles in Height. For so high, at the least, must we extend the *Atmosphere*, or that mix'd Fluid, consisting of *Air*, *Clouds* and *Vapours*, that surrounds the Earth, and gravitates upon it, as will appear by the following Calculations.

FOR as the comparative Gravity of Quick-Silver to Water is as 14 to 1, and the comparative Gravity of Water to *Air*,  
as



as stated by Dr. *Halley*, is as 840 to 1, consequently by these Proportions one Inch of a Cylinder of Quick-Silver, is equivalent in Weight to 14 Inches of an equal Cylinder of Water; and to 11760 Inches, or 980 Feet of an equal Cylinder of *Air*; and from hence it follows, that a Column of Quick-Silver of 30 Inches (being the usual Height to which the *Mercury* in the *Barometer* is observ'd to rise in fair Weather) is equal in Weight to a Column of *Air* of the same Base, and 294000 Feet high; which is something more than five Miles and an half.

BESIDES this, there is another Way, equally easy and entertaining, of computing the Height of the *Atmosphere*; and that is, by taking the perpendicular Height of any very high Mountain, and at the same Time nicely remarking the different Elevation, or Depression of the *Barometer* on the Ridge, and at the Foot of it; for then, as the Difference in the Height of the *Mercury* above and below, is to the whole Height of the *Mercury* at the Foot of the Mountain, so will be the Height of the Mountain, to the Height of the *Atmosphere*. For Instance;

LET us suppose the *Barometer* to stand at 30 Inches in the Valley, and to sink down to 27 on the Ridge, or Top of the Mountain, and the perpendicular Height of the Mountain it self to be 1000 Yards, then it will follow, that as 3 to 27 the Height of  
the



the *Mercury*, so 1000 Yards, the Height of the Mountain, to 9000 Yards the Height of the *Atmosphere*, which is much the same with the other Computation, being about five Miles and five Eights in Height.

How little the Proportion here allotted, of 1000 Yards to 3 Inches Fall in the *Mercury*, varies from the Truth, appears from hence that Mr. *Casswell* (a noted Mathematician of *Oxford*) measur'd *Snowden Hill* in *North-Wales* (reputed the highest Mountain in *Britain*) and found it to be 1240 Yards high; and the celebrated Dr. *Halley* afterwards, by several exact Tryals, at the Foot and Top of the Mountain, found the *Mercury* to descend three Inches and eight Tenths of an Inch. Vide *Harris's Lexicon. Barometer. Derham's Astrotheology*, page 114, and 115.

FROM whence it follows, that the Fall of the *Mercury* one tenth Part of an Inch, is very near equivalent to 32 Yards and two Feet; the Fall of the *Mercury* one Inch, is equivalent to 326 Yards two Feet, and the Fall of the *Mercury* three Inches, is equivalent to 980 Yards.

THESE Computations, it must be own'd, are not entirely exact and accurate, nor indeed capable of being made so, because the *Atmosphere* is not in all Places of equal Height, or of equal Weight and Density: But still they are sufficient to justify the  
Conjec-



Conjectures of Philosophers in extending the Height, and Gravitation of the *Atmosphere*, to the Distance of five or six Miles, tho' others upon Account of the *Air* growing lighter in Proportion, as it rises higher, carry it much farther.

AND as the *Atmosphere*, or Body of *Air* surrounding the Globe is unequal in its Height and Density, it must be consequently unequal in its Pressure, sometimes lying with a greater Weight upon the Surface of the Earth, than at others. When the *Air* is light, or the *Atmosphere* low (as on the Top of an high Hill, where the Cylinders of the incumbent *Air* are proportionably shortened) the Counterpoise that supports the *Mercury* in the Tube being diminish'd in its Weight, the *Mercury* must consequently fall ; but if the *Atmosphere* be deep, or the *Air* grows heavier, and presses with a greater Weight upon the Surface of the stagnant *Mercury*, the *Mercury* within the Tube must consequently rise higher, that it may be equal in Weight to the Column of *Air* pressing upon it, or to the present Weight of the *Atmosphere*.

FROM hence it follows, that the *Mercury* rising and falling (as it regularly does) according to the different Changes in the *Air*, may be fitly us'd and apply'd, as a proper Measure and Indication of the Gravity of it, and upon this very Account, it receives the



Name of a *Barometer*, because it measures and marks out to us, the different Degrees of its Gravitation ; sometimes the *Mercury* may be observ'd to rise to the Height of  $30\frac{1}{2}$  Inches, sometimes it stands at 29, or 28, and at other times sinks even so low as  $27\frac{1}{2}$  Inches, but seldom under ; and as this Difference is produc'd by the Pressure of the *Air*, it is certain the *Air* it self must be some Way or other liable to a proportional Change in its Gravitation.

FOR as Gravity is inseparable from Matter, and is always proportionable to the Quantity of Matter that weighs ; it is impossible that the *Air* should change its Gravity, without changing in like manner its Quantity of Matter ; and upon this Account, some have (without due Consideration) imagin'd, that this Difference of the *Air's* Gravity proceeded from its being more or less charg'd with Vapours : If this were the Cause of it, there must be as much Vapour in the *Air* at a Time, as is equal to the Weight of three Inches of *Mercury*, for so much do we commonly find the *Mercury* to rise and fall. Now *Mercury*, as we have before observ'd, being 14 times heavier than Water, there must be consequently in the *Air* at once, as many Vapours as will equal in Weight a Column of Water 42 Inches in Height, and whose Base is equal to the Surface of the Earth ; which

is



is not only incredible, but found in Fact to be more than falls in Rain in a whole Year.

FOR at *Paris* and *Lisle* (where the *Mercury* varies, as with us, near three Inches) the Quantity of Rain falling in one Year, by a Medium of six Years, amounts to no more than 21 Inches in Height. At *Zurich* in *Switzerland* to 32 Inches. By the accurate Observations of Mr. *Derham* at *Upminster* in *Essex* to  $19\frac{1}{4}$ . By the Tables of Rain kept by Mr. *Townley* of *Lancashire*, it is stated by a Medium of 15 Years, at 41 Inches. But as these two *English* Accounts, seem each of them to border upon opposite Extremes, the mean Proportion of Rain falling one Year with another, and taking one Part of *England* with another, may be fairly estimated at the perpendicular Height of 30 Inches.

THE Reason then, why the *Air* is heavier at one Time than another, cannot be from the Quantity of Vapours floating in it ; but seems rather to arise from there being more *Air* on that Part of the Earth's Surface, where such Pressure is encreas'd. And this seems chiefly to proceed from the Winds. For Example :

IF the Wind, which is nothing but a Stream of *Air*, shou'd blow upon any Place, and the *Air*, thus set in Motion, shou'd be check'd in its Progress, or reflected upwards, by the Opposition of Mountains and Hills ;



or if two contrary Winds shou'd, at the same Time, blow towards the same Place, the *Air* will be, as it were, pil'd and heap'd up for some Distance on each Side, by their Meeting and Opposition; and consequently there being in both these Cases, more *Air*, its Gravity will be encreas'd.

BUT if the Wind blows with any Degree of Strength, or Steadiness, over a plain Country, the *Air*, which before rested upon it, will be swept along with it; or if two contrary Winds shou'd at the same Time blow from off the same Continent, the *Air* impendent over it, will be thereby greatly thin'd and attenuated; nor can the Spring of the *Air* bring in Supplies fast enough to answer such a double Evacuation. So that in each of these Cases, the *Air*, growing less in Quantity, will be consequently lighter: As, at the same Time, the great Force and Swiftnefs of its horizontal Motion, will, it is reasonable to imagine, intercept and abate some Part of its perpendicular Pressure.

THUS also, as the *Air* is condensable by Cold, when the Wind blows from the *Easterly* or *North-Easterly* Points, it will of course bring from those frozen Climates, a great Quantity of their heavy and condens'd *Air* along with it: As on the other Side, the *Air* being dilatable by Heat (when the Wind blows from the *Southerly* Quarters, it



it will, in like Manner, drive a Stream of warm and rarefy'd *Air* through the *Atmosphere*; and, by this means, the Quantity of *Air*, being encreas'd in the one Case, and diminish'd in the other, the *Atmosphere* lying within the Course of these warm, or cold Winds, will be consequently lighter, or heavier. And as besides these ordinary Streams of *Air*, there are other irregular Blasts of Wind, that do not move horizontally, but in oblique, or spiral Directions, sometimes rising upwards, or inclining downwards: so to these we may probably ascribe some of those sudden and extraordinary Variations in the Weight of the *Air*, which are not so easily accountable for in a more common and natural Way.

IN these therefore, as well as in other Instances, the Winds seem to be the chief Agents in varying the Quantity and Temper of the *Air*, and causing so great a Difference in its Gravitation.

WHEN the *Air* is heavy, the Vapours rise with the greater Ease and Freedom, and continue supported in larger Quantities at a greater Height from the Surface of the Earth. And this Exhalation of Vapours, proceeds partly from a subterraneous Heat streaming out from the Center, or Bowels of the Earth; and in its Passage through the Waters, raising sometimes a sensible Reek, or Steam, like that of warm Water over a Fire,



Fire, and carrying it up into the *Air* along with it) but chiefly, from the Rays of the Sun; which, falling obliquely upon the Surface of the Water, and being many of them reflected back, with minute aqueous Particles adhering to them, or thin watry Cases furrounding them, are, by that means, suppos'd to raise copious and continual Exhalations from it.

THESE Vapours being rarefy'd to a great Degree, and (as Dr. *Halley* and Mr. *Derham* imagine) form'd into real, but imperceptible Bubbles by the Heat, and actuated by the Rays of the Sun, grow specifically lighter than the *Air*, and consequently must rise 'till they come to an *Air* of the same specific Gravity with themselves, where they will rest.

As in a Glass Vessel, fill'd with three different Liquors, and each of them of different specific Gravities; (suppose salt Water at the Bottom, Wine in the Middle, and Oyl at the Top) the Consequence will be, that the very same Cube of Oak-Wood, that rises up through the Water, and swims in the Wine, will yet sink down through the Oyl: The middle Liquor being therefore of the same specific Gravity with the Wood, there it will rest. To carry on the Parallel still farther, let us suppose it possible, by some chymical Infusion to make a common Mixture of these three different Liquors,  
either



either of equal Weight and Density with the Water, or of equal Levity with the Oyl: Then it is evident, that the Cube of Wood will, in the former Case, rise and float at the Top; and in the latter Case, sink down to the very Bottom.

AND thus, in Proportion to the Weight of the *Air*, and the Density, or Rarefaction of the Vapours themselves, they will either float near the Surface of the Earth, under the Appearance of Mists, or Fogs; or else mounting up out of Sight, they will range themselves in higher or lower Regions of the *Atmosphere*, suitably to their specific Gravity, where they will rest. And if at any Time, during their Suspension, the State of the *Atmosphere* varies by any sudden Attenuation, or Compression, in the Regions above, the Situation of the Vapours will, in like manner, change with it, either by a farther Ascent upwards, or Depression downwards, according as the Weight of the *Atmosphere* is encreas'd, or diminish'd.

IT is only a vast Collection of these Steams, Mists and Vapours, thus rais'd from the Surface of the Earth and Sea, thus carried up and supported at different Heights, thus floating in seemingly large compacted Bodies, and those confusedly driven together and accumulated by the Winds, that form the Clouds; which are, in reality, no other than exalted Mists, or Magazines  
 8 of



of Vapours, rang'd above, in higher or lower horizontal Planes, in Proportion to the comparative Density, or Rarefaction of the Vapours themselves, with that of the *Atmosphere*, or Medium, wherein they are buoy'd up. (And in this Sense, we may clearly understand, and rationally account for the Balancings of the Clouds; an Expression frequently admir'd in the Book of *Job* (37. 16.) as being strictly true in a Philosophical, noble and elegant in a Poetical Sense, and very just and natural in both.

THAT the Clouds and Mists are much alike, and differ chiefly in their Distance, Situation, and Appearance, is sometimes evident to Sight, because the very same Body of Vapours floating near the Earth as a Mist, when they are rais'd higher, or driven farther off by the Wind, or Sun, change their Appearance into that of Clouds, which they so nearly resemble, as not to be with any certainty distinguishable from them. And for a farther Proof of this, *Varenius* (*Geog. Gen.* pag. 66.) speaking of the Mountains of *America*, relates, that *Multa Peruvianorum montium fastigia perpetuis teguntur nivibus tam æstate, quam hyeme; multa nubibus involvuntur; quædam ultra mediam aeris regionem elevantur.* And afterwards of the Pike of *Teneriff*, pag. 69. *Vertex illius supra nebes attolli videtur manifestè; cum hæc medium montem cingant; vertex*



*Vertex extare supra has nebulas conspiciatur.*  
 i. e. As Clouds are commonly observ'd to adhere to the Sides, and to hang round the middle Parts of the Pike of *Teneriff*, and other exceeding high Mountains: So some curious Persons and Travellers (who have happen'd to climb these Mountains when they appear'd thus begirt with Clouds) have, for some Time, in their Ascent upwards, found themselves involv'd in thick and heavy, in damp and drizzling Mists; which, to themselves afterwards from above, and to the Spectators from below, have still retain'd the Appearance of Clouds.

OUT of these Magazines and Collections of Vapours, thus floating and supported in the *Air* (according to the different Changes they undergo from the Season of the Year, the Temper of the Winds, and the Warmth, or Coldness, of the superior Regions) the several Kinds of aqueous Meteors are form'd and supply'd, which under so many different Appearances, fall back upon the Surface of the Earth, as that excellent Author, Mr. *Derham* (*Phys. Theol.* pag. 20. &c.) in a Manner very rational, deduces and explains.

SUCH Vapours as are rais'd by the declining Sun, or hang near the Surface of the Earth, being condens'd by the Coldness of the Nights, in the Summer fall back in Dews, and in the Winter in hoary Frosts.



In what we call a black Frost, either the Rise of the Vapours is quite intercepted ; or rather they are rais'd too high to be reach'd and precipitated by the Cold below. When the Vapours approaching nearer to each other, are frozen in the Clouds, and broken by the Resistance and Fluctuations of the *Air*, or the cold Winds passing through them, they then fall down in Flakes of Snow. When the Vapours are beginning to run into small Drops, and are precipitated by the Cold above, before they are completely form'd, they then fall down in mizzling Rains ; or, if frozen, in Sleet. And as the ordinary Drops of Rain, freezing in their Descent, form Hail ; so whenever they happen afterwards in their farther Descent downwards, to pass through a Cloud of Snow, they encrease in Bulk, and gathering, in a literal Sense, as a Snow Ball, form those larger Hail-stones (of six, or more Inches in Circumference) of which we often read, and sometimes with Surprise admire and observe.

So long as the *Air* continues heavy (being, as we above observ'd, either condens'd, or accumulated in Quantity) the Vapours will be sustain'd, and the Weather hold fair ; but if the *Air* by any Rarefaction, or Diminution of its Quantity turns lighter, the Vapours, which were before in *Æquilibrio* with it, will preponderate ; and being heavier



vier than the *Air*, in which they floated, will consequently descend. In their Descent, as they approach nearer to each other, and are continually check'd by the Resistance of the *Air*, they must be condens'd; and this Condensation of the falling Vapours will gradually encrease, 'till they are compress'd and collected into small Particles, or Globuli of Water; and these again, incorporating with others in their farther Descent, they are at last form'd into bigger Drops, and fall down in Showers of Rain; and these Showers will be more or less violent, and the Drops larger or smaller, in proportion to the Quantity of the falling Vapours, and the Height from whence they descend.

FROM these Premises it clearly follows, that when the Quick-Silver in the Tube, rises and continues high (being supported by the extraordinary Weight of the *Air*) then the Vapours will be supported too, and the Weather continue fair: But when (by any great Diminution of the Weight of the *Air*) the *Mercury* subsides and keeps low; then the Vapours, not being supportable, will descend with it, and the Weather be rainy, and the Rain more or less in proportion to the Depression of the *Mercury*.

AND as these Effects usually follow, and, for the most part, regularly correspond with the Causes here assign'd: So it is upon these Principles that the common *Weather-Glasses*



are made ; and upon these only, that they are capable of being rightly understood and explain'd.

FROM hence also ( especially from what has been said above upon the *Air* and Winds ) may be drawn several other Observations and Conclusions relating to the same Subject, and giving some farther Light to it.

1. As the Winds encrease the Quantity and Weight of the *Air*, and by that means support the Vapours ; so are they sometimes the immediate Occasion of their falling : For when, for Instance, the Winds blow from opposite Quarters, the Mists and Vapours floating in the different Streams of *Air*, must be forcibly driven against each other, and confusedly mix'd and blended together : And as they were before separately *Æquipo*ponderant to the *Air*, and for that reason floated in it ; so after such Confluence and Conjunction, they will doubly exceed the Weight of the *Air*, and force their Descent through it. And this is usually the Cause, both of the largest Drops, and of the greatest and most plentiful Rains, as we shall have Occasion more fully to describe in another Place. But when either of these opposite Winds rises and prevails, and turns the whole Stream of Clouds and Vapours only one Way, it soon clears the *Hemisphere*, and restores better Weather. From hence  
also



also we may farther observe, That the particular Effect the Winds have upon the Changes of the Weather, depend, in a great measure, upon the present State and Quality of the *Atmosphere*; for when that is moist and damp, or charg'd with Clouds and Vapours, the Change of the Wind into an opposite Quarter soon produces Rain: But when the *Atmosphere* is clear and free from Vapours, it adds to the Weight and Quantity of the *Air*; and, by that means, continues and prolongs fair Weather.

2. To such an Accumulation of *Air*, as we have above-mention'd, may very probably be ascrib'd the constant and settled Dryness of the Coasts of *Peru* and *Chili*; where from 3 to 30 Degrees *South*, and for 12 or 13 Degrees to the *West*, according to *Dampier*, and other Travellers, it never rains. To account for this, it is observable, that a constant *East* Wind blows round the Globe for several Degrees on each side of the *Æquator*; that the *Andes* in *Peru* and *Chili* (being a Ridge of the highest Mountains in the World, and running from *North* to *South*) lie directly cross to the general Current of the *Air*; and thereby, either break, or intercept the Clouds and Vapours on the *Eastern* side of the Mountains; or else raise and accumulate the *Air* on the *Western* side, to such an Height and Quantity, as to support the Vapours floating in it to the Distance of 250 or 300 Leagues from the Shore; where



where the general *East* Wind (sinking again to the Level of the Sea) brings, as in other Places, Vapours, Clouds, and Rain along with it. *Dampier*, Vol. 2. W. 78, 79.

3. THE Coasts of *Guiney*, are, by the same Author, (page 80.) reckon'd among the wettest Places in the World, because lying near the *Æquator*, they are exceeding hot and sultry; and the Soil (being as Travellers farther observe, a loose and deep Sand) imbibes and retains the Heat of the Sun to such a Degree, as to rarefy and attenuate the lower Region of the *Atmosphere*; and by such Rarefaction, as well drawing in the Winds upon the Coasts (*Dampier*, W. 14, 15, 16,) as precipitating the Clouds and Vapours; which the *Air*, weakened by excessive Heat, has not either Weight, or Density sufficient to support.

4. To such an extraordinary Thinness, or Attenuation of the *Air*, may be attributed, what we sometimes with Surprise observe; *viz.* the sudden overcasting of the Sky, when in a calm sultry Morning, without any visible Clouds arising from below the Horizon, a clear *Hemisphere* (by the Descent of the Vapours into the lower Regions of the *Air*) unexpectedly becomes hazy, thick and cloudy, and even sometimes misty and rainy.

5. It was an Observation made many Years ago by the accurate Dr. *Halley*, that  
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the *Weather-Glass*, in a moderate *Easterly* Wind usually rises highest. The Truth of which, to a careful Observer, seldom fails of being fully confirm'd by yearly Experience. For to go back no farther than the Year 1728, in the Latitude of *Grantham*, a settled *Easterly* Wind, blowing exceedingly sharp and cold for several Days, in the Consequence of it, so far condens'd the *Air*, as to raise the *Mercury*, *Feb.* 24 and 25, within a Trifle of  $30\frac{1}{2}$  Inches. In this Instance, the Sky was perfectly serene, the Sun shin'd very bright, and the Frost held very sharp and severe.

ON *January* 11, 1729, The Reverend and learned Dr. *Stukely* being with me, we measur'd the Height of the *Mercury*, and found it standing again at  $30\frac{3}{4}$  Inches (above which in this Latitude and Situation, it is very rarely observ'd to rise) but in this latter Case, the Weather was milder, and the *Atmosphere* in all parts equally thick and hazy; the Wind having been for some time before in the *West*, then setting in for four or five Days full *East*; and afterwards, just at the time of making the Observation, by a very sudden Turn, reverting back into the *West*. From which alternate Change, and quick Succession of the Winds, it is very certain, that they must both of them, for some time, and at no great distance,  
 conti-



continue blowing in direct Opposition to each other; and, by that means, accumulated the *Air* impendent over us, to a Degree answerable to such an extraordinary Elevation of the *Mercury*.

IN each of these Instances the Weather was settled; and continued Fair, Dry, or Frosty, for about Ten Days before and after the Time of Observation. To which we may farther add, that as the *Westerly* Wind is most frequent and common, and blows by Intervals, for more than half the Year with us; it is seldom that an *East* Wind can continue for a Week together, without meeting with a superior Opposition from that Quarter; and thereby, for some time at least, encreasing the Quantity and Weight of the *Air*, and raising the *Mercury* in the Consequence of it.

6. As in a moderate *East*, or *Northerly* Wind, for the Reasons above given, the Weight of the *Air* is encreas'd: So in a very strong Wind, be the Quarter what it will, (especially if it be *Southerly*, or *Westerly*,) the Horizontal Flux and Velocity of the *Air*, takes off part of its perpendicular Pressure. This is evident in Fact, from the *Mercury* subsiding always, and keeping low in tempestuous Weather. And was even visible to the Eye in the great Storm 1703. During the Height of which, the *Mercury* was observ'd to shake answerably to the Concussions



cussions of the *Air*, in a sensible Tremor and Vibration: Sometimes apparently yielding and sinking under the Violence of an approaching Blast; and immediately after, rising again, upon the Relaxation of it.

IN Hurricanes and other violent Storms, besides the Horizontal Blast, there are often spiral Eddies and Circumvolutions of the *Air* working upwards; and even sometimes raising and carrying Bodies of Weight and Substance aloft with them. From whence it is obvious to infer, that the Pressure of the *Air*, must of consequence be the least downwards; when by such a contrary Impulse, it is revers'd and forc'd upwards: And, in this case, the Quick-Silver, having no steady Counterpoise, will be more unsettled, and sink lower than in any other, as in the Storm 1703, above-mention'd. Which is the only Instance, or Account, I have met with of the *Mercury* falling below  $27\frac{1}{2}$  Inches. Tho' in some of those unaccountable Eddies, that rebound back from the Earth, and seem (*pro tempore*) to suspend the Pressure of the *Air*, by exerting their Force contrary to it; it is very possible that the Vibration, or Subsiding of the *Mercury*, may be still lower.

8. FROM hence also we may farther observe, that such an extraordinary Depression of the *Mercury*, lasts no longer than the Violence of the Storm that causes it. For



as soon as that of *November* 1703, was over, the *Mercury* rose again very fast; being, within less than twelve Hours, near changeable, from whence it began falling the Day before. And this the learned Dr. *Halley*, in a like Case, with good reason ascribes, partly to the general Recoil of the *Air*, after the protrusive Force of the Wind was spent; and partly to the quick and sudden Accession of new *Air*, to supply the great Evacuation made by the Storm. For whenever any Part of the *Atmosphere* is thus attenuated beyond its mean Density, the neighbouring Regions of the *Air*, being more compress'd, will, by a progressive Expansion, continue pouring in from all Quarters 'till the *Æquilibrium* be restor'd: And in the consequence of this, will raise the *Mercury* to much the same Height it was before, and in less time than wherein it was falling.

9. IN misty, or foggy Weather, (if it be of any Continuance) the *Glass* is commonly observ'd to stand very high; because the *Air* is usually then perfectly still and calm, and presses with its full perpendicular Weight upon the stagnant *Mercury*, without any Interruption, or Abatement.

THE learned Dr. *Wallis* is of Opinion, that the Mists and Vapours hanging thus in the *Air*, add to, and encrease its Pressure: Which, no doubt, is true in general; because the collective Body of the *Air* and Va-  
pours



pours taken together, must be of greater Weight than the *Air* alone.

AND, upon this account, not only in misty, but in dark, settled, calm Weather, (when the Vapours are raised and supported at a very great Height; and so equally and copiously dispersed, that the Sky appears uniformly thick and hazy in all Quarters; without the least Gleam of Sun-shine breaking through, or any Cloud distinctly form'd in any Part of the *Hemisphere*:) In such a dense State of the *Atmosphere*, the Weight of it is greatly encreas'd; and the Height of the *Mercury* raised by it, is usually near 30 Inches.

BUT as soon as this State of the *Atmosphere* changes, either by the Wind rising, the Sun breaking out, or both together dispersing the *Hemisphere* of Vapours, and forming many of them into large Clouds, sailing above; the Weight of the *Atmosphere* immediatly diminishes upon it, and the *Mercury* will in few Hours settle to  $29\frac{1}{2}$  and sometimes to 29 Inches.

FROM hence it seems observeable; 1<sup>st</sup>, That the Calmness of the *Air*, adds very much to the Weight of it. And 2<sup>d</sup>, That the general and equal Distribution of the Vapours, whether in Mists below, or in a hazy Sky above, acts with a stronger and greater Degree of Pressure, than any partial, or unequal Distribution, or Collections of



them in Clouds : Which, whether suspended in the *Air*, or moving horizontally, intercept and take off some part of the perpendicular Pressure from the Regions above.

AND agreeably to this latter Observation, if we examine the Effect of any particular Column of *Air*, acting upon the *Barometer*, the Opinion of the Vapours adding to the Weight of it, must be understood with such a Limitation. For the only Reason of the Clouds and Vapours floating in the *Air*, is because they are Bulk for Bulk lighter than the *Air*. If therefore we suppose them to exclude, or take up the Space of a Portion of *Air* equal to themselves, and heavier than themselves, it will consequently follow that a Cylinder of clear *Air*, must and will exert a greater Degree of Pressure, than a compound Cylinder of *Air* and *Vapours* intermixt of the same Dimensions. As an entire Column of solid Oak, is heavier, than an equal Column compos'd of several Pieces of Oak, Fir and Cork joyn'd together.

AND this will in part explain the reason of the *Mercury's* rising and standing high in fair, calm and clear ; but subsiding and keeping low, in rainy, windy and cloudy Weather ; Because in the former, the Pressure of the *Air* is direct uniform and steady ; and in the latter, by the Interposure, or Fluctuation of Clouds and Vapours, broken  
and



and interrupted, and thereby in part diverted and diminish'd.

THAT the Clouds floating in the *Air*, lessen the Weight of it, seems to receive some Illustration at least, if not Proof, from an Experiment or two deliver'd by Mr. *Boyle*.

TAKE a Piece of Sponge, moisten it with as much Water as it will conveniently retain, without dropping. Suspend it with a Weight equivalent to it, in a nice and even Balance. While the Sun shines, and the Sky continues clear, the Scales will hang in *Æquilibrio*: But upon the Approach of any large Cloud towards the *Zenith*, the Water in the Sponge will preponderate, whilst the Cloud is passing. But as soon as the Cloud is gone over, the very same State, or Pressure of the *Air*, being again renew'd, the Scales, in the Consequence of it, will return back to their former *Æquilibrium*.

THIS, I am well aware of, the noble Author incidentally mentions, as a surprising Effect, or sensible Indication of the Humidity, or Moisture of the *Air*, deriv'd from the transient Cloud, and communicated to the Sponge: But may it not seem also to deserve our Attention, whether a real Change in the Weight of the *Air*, does not affect, or produce the Change in the Balance? Because, agreeably to the Laws of Hydrostaticks, where two Bodies of unequal Bulk, are æquiponderant in one Medium,



dium, they will lose their *Equilibrium*, when they come to be weigh'd in another. For if this latter Medium be heavier, the larger Body will be supported in it, and weigh lighter than before ; but if the new Medium be lighter, the more bulky Body will subside in it, and weigh heavier than before. And accordingly the same noble Philosopher, in what he calls his Statical *Baroscope* (consisting of a thin large Glass Bubble, hanging in Counterpoise to a small Glass Weight, in a Balance exquisitely nice and sensible, and plac'd near a *Barometer*) regularly found; that when by any notable Encrease in the Weight of the *Air*, the *Mercury* rose, the Glass Bubble wou'd be buoy'd up, and rise with it: But when, by any considerable Decrease in the Weight of the *Air*, the *Mercury* fell; the Bubble wou'd on the contrary preponderate, and fall with it.

FROM whence it appears, that the superior Weight of the Sponge, in the Instance above-mention'd, seems rather to be deriv'd from a sensible Decrease in the Weight of the *Air*. To those who ascribe it altogether to the Moisture of the *Air*, without admitting any other Cause of it, it will be difficult to account for so odd a Property as that of a Sponge, sucking in Vapours from an approaching Cloud, and releas-



releasing them back, in exactly the same Quantity at the Recess of it.

THE learned Dr. *Wallis* in his farther Sentiments upon this Subject, accounts for the gradual Sinking and Lowness of the *Barometer* in rainy Weather, by the gradual Diminution of the Pressure of the *Air*, growing, as he supposes, lighter and lighter, in Proportion to the Quantity of the falling Rains.

IF this were strictly and generally true; it will seem to follow from thence, that the Glass shou'd stand highest, when the *Air* is fullest of Clouds and Vapours; because, (agreeably to this Opinion) it is then most burden'd: And lowest when the Rains are quite over, because the *Air* is then most lighten'd.

BUT on the contrary, we find by Experience, that the *Mercury* is usually low in cloudy and rainy Weather, because the *Atmosphere* is then lighter: And may be often observ'd to rise for several Hours before the Rains are over; because there is a constant and gradual Accession of new *Air*, pouring in to supply the Place of the descending Clouds and Vapours; and thereby encreasing the Pressure upon the *Barometer*, even whilst the Rains are falling.

I would not here be understood to infer from hence, that this Opinion of Dr. *Wallis* is altogether false; but that it does not, in  
all



all Cases, hold absolutely true. When the Regions above are calm. and at the same time crouded and accumulated with Clouds, discharging themselves in heavy and plentiful Rains, the Quantity falling, will, it is reasonable to imagine, in some Degree, lessen the Pressure of the *Atmosphere*: Because, by the Interposure of large and bulky Clouds, the free Influx of the circumambient *Air*, is, in some measure, and for some time, intercepted and excluded. But when the Communication is open, and the Clouds broken, or dissipated, the free and regular Accession of new *Air*, will add more to the Pressure upon the stagnant *Mercury*, than the falling Rains detract from it.

AND tho' in great and violent Rains, the several Drops of Water, being much heavier than the *Air*, force their Descent with some Degree of Rapidity through it: Yet can their Weight be of no manner of Effect towards raising the *Mercury*; because they act not in one continu'd Stream, or Fall of Water, but in so many distinct and separate Drops; each of which being at the largest not more than one fourth part of an Inch Diameter, bears but a very small Proportion to a Cylinder of *Air*, better than five Miles in Height; and cannot therefore produce any sensible Alteration in it.

10. THE highest Rise and the lowest Fall of the *Mercury* are but seldom observable



able. The Latter ; because it rarely happens, that a Hurricane exerts its Force near enough to a *Barometer* to affect it : And more rarely still, that, during the short Interval of its Action, the Eye of a Spectator is present, and quick and vigilant enough to observe it. And as for the more ordinary Ebb, as low as 28, and sometimes a little below 28 Inches, it is usually observeable, when the *Atmosphere* appears to be crouded with bulky accumulated Clouds ; and those driving low, with a strong Wind and flopping Rains, out of the *South*, or *West*, or *South-West*. But in a dry, cold Wind, unless it be very tempestuous, it is seldom found to sink so low.

THE highest Rise must, in like manner, be ascrib'd to a Concurrence of several Causes, *viz.* To a settled *East* Wind, blowing Cold, to condense the *Air* ; ( which, by the Way, is the Reason of the *Glass* rising and standing higher in the Winter, than in the Summer Season ) to a *West* Wind, blowing at the same time with equal Strength, to accumulate the *Air* ; to a perfect Stillness and Calmness over the Place of Observation, to give the *Atmosphere* its full perpendicular Pressure ; and to the Suspension of the Vapours in the *Air*, lying in misty and hazy Weather, with a still farther additional Weight upon it. And to these we may probably join, what Mr. *Boyle* with Reason suggests, that in very great Droughts, the



subterraneous Steams break out, and rise in greater Quantities through the Chinks and Fissures of the Earth: Many of which, being lodg'd in the lower Regions of the *Air*, may, to a greater Degree, augment the Gravity of it. For as each of these separately acting, are found by Experience to raise the *Mercury*; they must consequently have the greatest Effect, when all of them (as it may sometimes happen) conspire together in encreasing the Pressure of the *Atmosphere*, and elevating the *Mercury* in consequence of it.

II. IN remarking these Extremes, as well as in ascertaining the just and precise Limits to the Rise and Fall of the *Mercury*; the Situation of the Place where the *Barometer* stands, must always with due Care be consider'd and regarded. If it be low, and near the Level of the Sea, it will vary three Inches; because the *Atmosphere* above is of competent Weight and Depth to admit of it: If it be mountainous and far within Land, the *Mercury* will not vary two Inches; because the Cylinders of the *Air* above are proportionably lighter and shorter. And agreeably to this, it is found by Experience in several Places, that the very same *Barometer*, standing at Fair in the Valley below, will, in advancing up to the Top of a Mountain, sink to Stormy, tho' the Weather be exactly the same in both.

FROM



FROM whence we may collect and discover what an egregious Blunder it is in mechanical Philosophy to appropriate the same Scale of the *Barometer*, without Distinction to all Situations. For as the Truth of the Scale depends upon the Proportion it bears to the full Play of the *Mercury*; and that in different Places, varies according to the different Height, or Depth, of the *Atmosphere*: It is certain, that a graduated Plate of three Inches, cannot be commensurate to a Space, or Rise, of two Inches; but must and will be liable to continual Errors, by such an Inconsistency in the Application.

UPON Account of this local Error and Insufficiency in the common upright Tubes, I wou'd recommend the sloping *Barometers*, as more proper and suitable to the midland Countries: Because in them, the Rise and Fall of the *Mercury* may be augmented to any requisite Proportion, tho' the perpendicular Variation be not so much as two Inches.

THE foregoing Pages, grounded in a good measure upon Reason and Experience, seem to be a full Proof of the Truth of the main Propositions there advanc'd, *viz.* That the general Pressure of the *Atmosphere* upon the stagnant *Mercury*, is the real Cause of the Support of the *Mercury* in the Tube; that the several Changes in the Rise and Fall of the *Mercury*, depend upon the va-



rious Changes in the Gravitation of the *Air* ; and those again upon the Quantity of Clouds and Vapours floating above ; and upon the different Quarters, Degrees, Temper and Opposition of the Winds.

AND tho' I dare not say that all the Changes of the *Barometer*, depending upon those of the *Atmosphere*, are clearly accountable for by these Principles ; yet they certainly answer in so many Instances, that a stricter Attention to them, and Application of them, might perhaps go a great way in explaining those few of which, by their seeming Inconsistency, or Irregularity, we find Reason to be diffident.

THUS I have sometimes wonder'd at the *Mercury* rising in a warm, moist *Southerly* Wind ; but after a few Hours Suspense, an *East*, or *Northerly* Wind, driving above, has prevail'd over the *South* Wind below, and reconcil'd the Rise of the *Glass*, to the Weight of the *Air*, and the State of the Weather. Sometimes also, in the like Case, when there has been no such apparent Opposition of Winds, I have suspected, either the Spring of the *Air* exerting it self in a more than ordinary manner ; or that the Upper Regions of the *Atmosphere*, being more cold and condens'd, have discharg'd their Weight upon the Lower ; and thereby caus'd the Rise of the *Mercury*, tho' the warm rarefy'd *Air* near the Surface of the Earth,



Earth, seem'd rather to intimate its Falling.

AND here I might with Reason, as it was once my Intention, dismiss the Reader, with this general Theory of the *Barometer*, without descending to Particulars, or engaging in any farther Disquisitions about it: But since the Spring of the *Air*, has, no doubt, a real Share in producing the Effects here accounted for, it wou'd be too material an Omission to pass it over in Silence, without taking a just and proper Notice of it.

As the *Air* is an elastic Fluid, capable (as we above observ'd) of Compression and Dilatation; sometimes yielding and bending beneath the incumbent Pressure, and again rising and expanding itself in proportion to the Abatement of it: So the chief Use and Effect of this elastic Property, seems to be this, *viz.* To preserve the Balance of the *Atmosphere*; and by its occasional Contraction and Expansion, to accommodate itself to the different Degrees of Pressure in the several Parts of it; and thereby, as well to keep the *Air* itself, as the Clouds and Vapours floating in it, as near as may be to an *Æquilibrium*.

To this elastic Force of the *Air*, some Authors (too precipitate in their Conclusions) have entirely ascrib'd the Rise and Fall of the *Mercury* in the *Barometer*; but it is very certain, without any just Premises,  
or



or competent Grounds for it. Because in the regular and ordinary Course of Nature, the Spring of the *Air* acts always in Conjunction with the Weight of the *Air*, and never separately, or distinctly from it: That therefore cannot of itself be the only Cause of an Effect, which requires and admits of another Cause equally coefficient with it. Others therefore, more agreeably to Reason and Experience, divide the Effects of the *Barometer*, betwixt the Spring of the *Air*, and the Weight of the *Air*; and, without rejecting either, admit them both as Causes equally and mutually co-operating in them.

THE Spring of the *Air*, acts, it must be own'd, with incredible Force, where the *Air* is closely pent up and strongly compress'd. But where the *Air* is free, open and unconfined, and has room on all Sides to expand itself, the Spring of it will be proportionably relax'd, and incapable of exerting itself with any notable Strength, or Effect. For the same Reason also, the Spring of the *Air*, near the Surface of the Earth, is very great, because the Weight of the *Air* that keeps it under a State of Compression, is great too: But in the upper Regions of the *Air*, where there is little Weight, and large Expansion, the Spring of the *Air* is so far weaken'd and abated, that in an Ascent of 1300 Yards perpendicular, the *Mercury* in the *Barometer*



ter is found, by Experience, to fall four Inches. Which in Part shews the Connection there is betwixt the Weight of the *Air* and the Spring of the *Air*; and that the Latter depends, in a great measure, upon the Former, as will more fully appear from the following Experiments.

THE most common and obvious Experiment, for proving the Spring of the *Air*, and the Dependance it has upon the Weight of the *Air*, is that of a Bladder, half-blown and carried up to a Mountain, to the perpendicular Height of 700, or 800 Yards: Which, in Proportion as you rise higher, will gradually distend more and more, and be full-blown at the Top. And, in the Descent, it will, in like manner, gradually relax and subside, and grow flaccid at the Bottom of the Hill, as before. The Reason of which is, that the *Air* enclos'd and ty'd up in the Bladder below, is of greater Weight and Density (because more compress'd) than that above. When therefore, in mounting upwards, the Cylinders of the *Air* grow shorter and lighter; that within the Bladder must consequently rarefy and expand itself into a larger Space, that the Attenuation of the *Air* within the Bladder, may be equal to that without. As on the contrary, when in descending downwards the Cylinders of *Air* encrease in Length and Weight, that within the Bladder must consequently shrink and contract within a narrower



rower Compass, that the Density of the *Air* within the Bladder, may be answerable to the Pressure of the *Air* without.

IN the Experiment of the *Barometer* in the *Air* Pump (above recited, Page 20, Line 3.) if, instead of gradually admitting the external *Air*, you suddenly turn the Stop-Cock, and let it all at once into the exhausted Receiver, the Quick-Silver from its lowest Ebb, will immediately dart up with that Degree of Force and Velocity, as even sometimes to break the upper Extremity of the Tube: But if the Tube be strong enough to stand the Shock, and wide enough to give the Quick-Silver Play, it will then, for some little time, vibrate upwards and downwards, 'till it settles to its proper Station. In this case, the sudden Rise of the *Mercury*, as well as the repeated Vibrations of it, above and below the Standard, are plainly produc'd by the Spring of the *Air*; But then, the regular and steady Settlement of the *Mercury* to its proper Standard, is certainly owing to a Cause equally steady and regular; that of the perpendicular Weight and Pressure of the *Air* acting upon it, and by Degrees checking the Vibrations caus'd by the Spring of the *Air*, 'till they come to an *Æquilibrium*.

IF we pursue this Experiment still farther, with a Tube open at both Ends, and suspended in the stagnant *Mercury*; the *Mercury* will remain at the same Height in the Tube,



Tube, and in the Cistern. Then fix a close Cover, as well round the Tube, as over the Top of the Cistern ; and confining there, within the cover'd Space, a small Quantity of common *Air*, ( without any Communication with the external *Air* ) and place the whole *Apparatus*, thus order'd, in the *Air* Pump. The Effect will be this; that by working the Pump, and exhausting the Receiver, the Counter-Pressure of the external *Air* will be quite taken off ; and then, the *Air* enclos'd within the cover'd Cistern, will dilate and expand itself ; and by its elastic Pressure upon the stagnant *Mercury*, will raise and force it up within the Tube, to the Height of  $28\frac{1}{2}$ , or 29 Inches, according to the Standard of the *Barometer* in the open *Air*, but no higher.

FROM hence it is evident ; 1<sup>st</sup>, That the Weight of the *Air*, is here entirely separated from the Spring of the *Air* ; and the whole Effect produc'd by the latter. 2<sup>d</sup>, That the Spring of the *Air* enclos'd, is equal to the Weight of the open *Air*, and acts only in Proportion to it. And 3<sup>d</sup>, That it is only the Confinement of the *Air* within the Cistern, and the Suspension of the outward Pressure, that causes the Spring of the *Air* to exert itself in so peculiar a Manner ; which, in other Cases, acts uniformly with the Pressure of the *Air*, and seldom, or never distinctly from it.

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THE same Effect is equally capable of being produc'd by encreasing the Spring of the *Air* by any natural, or artificial Heat; but then in order to it, it is still necessary that the *Air* so expanding itself, be some way, or other, shut up and confin'd: For if the Communication be open, the circumambient *Air* will rush in, and destroy the Spring acquir'd by such Heat, by restoring the rarefy'd *Air* to its mean Temper and Density.

FROM these, or the like Remarks of the Spring of the *Air* enclos'd, acting in such particular Cases, in Proportion to the Weight of the open *Air*, some unattentive Observers of Nature have credulously receiv'd, and unaccountably form'd this general, but erroneous Conclusion, *viz.* That a *Weather-Glass*, hermetically seal'd at both Ends, with a small Quantity of common *Air* enclos'd in it, will, by its inherent Spring exerting itself, regularly produce the same Changes in the Rise and Fall of the *Mercury*, as are correspondent to those of a *Barometer*, expos'd to the Pressure of the open *Air*.

THE Experiment I have try'd with a slender recurve Tube, turning upwards at the lower End, and there swelling out into a larger Cavity, for the Reception of the common *Air*, and stagnant *Mercury*, enclos'd within; which were nearly equal in Quantity, and might amount to about a cubical  
Inch



Inch of each: But after a full Years Observation, I cou'd never find the Effect to any Degree answerable; nor discover any other Changes in it, than the Rise and Fall of the *Mercury* about one fourth Part of an Inch; which might possibly be occasion'd by the Condensation of the *Air* enclos'd in cold, and the Rarefaction of it in hot Weather. But as for those sudden and greater Changes in serene and calm, in rainy and tempestuous Weather, amounting sometimes in 48 Hours to near three Inches; the seal'd *Glass* (having no Communication with the outward *Air*) appear'd to be insensible of them, and little, or no ways affected by either.

It seems therefore very probable, that the Opinion we are here arguing against, may have taken its Rise from some Inadvertency in sealing the Tube; and that, instead of being perfectly clos'd up, it might possibly have some little unheeded Aperture left in it; through which, the Communication with the external *Air* might be kept open and preserv'd. For, without that, it is scarce possible to conceive, how a cubical Inch of common *Air* (lying under an equal and steady Pressure, having no Communication with the outward *Air* to produce any Change in it, no extraordinary Rarefaction, or Condensation, to encrease its Spring) shou'd of itself exert a Force sufficient to raise and support a cubical Inch of Quick-Silver; whose comparative Density to that



of *Air*, is at the least as 11500 to 1, or as others more accurately state the Proportion, as 14000 to  $1\frac{1}{4}$ .

To explain the Force of this Argument in a more familiar intelligible Manner; let us, in a Pair of Scales, place a single Feather in Counterpoise to a Pound Weight; let us add afterwards 50 or 100 more to the Tale of Feathers; and it will be ridiculous to expect any sensible Effect, either from the one, or from the other: But if we encrease the Number to Ten, or Twelve Thousand, they will then, perhaps be equivalent to the Weight, or turn the Balance the other way. Agreeably to so great a Disproportion, a Cylinder of Quick-Silver of 30 Inches in Length, requires (as we have prov'd above) a proportionable Cylinder of *Air* of more than 5 Miles in Height; and that too acting jointly with its Spring and Weight upon it, to raise and keep it suspended in *Æquilibrio*; from whence it will consequently follow, that so small a Quantity of *Air* as the Cistern of a *Barometer* ordinarily contains (whether it acts by its Spring, or Weight, or both together) must be a Cause altogether unequal to the same Effect, *i. e.* In other Words, 2 or 3 cubical Inches of common *Air*, acting in a natural Way, cannot be sufficient to produce an Effect, which, in the very same natural Way, is found by Experience to require near 12000 times a greater Quantity to produce it.



IN the marine *Barometer* indeed, where the Spring of the *Air* enclos'd, or rather its Rarefaction and Condensation ( as in a *Thermometer* ) acts only upon the finest volatile Spirits ; the Rise and Fall of the ting'd Liquor in the Tubes, is, it must be own'd, greater than in a common *Weather-Glass* ; because both the *Air* enclos'd, and the Spirits enclos'd, are alike capable of Dilatation and Contraction ; but when the Spring of the *Air* enclos'd is to act upon Quick-Silver, upon a Fluid so vastly superior to it in Weight and Density, the Effect of it, where the Quantities are so nearly equal, as in a seal'd *Barometer*, must be very little, if at all perceivable.

I have dwelt the longer upon this Property of the *Air*, as well to prevent and remove such Objections, as have occasionally fallen in my Way, as to disentangle the intricate Part of this Subject, and place it, as near as I can, in a just and clear Light. In order to which, we may recollect in general, as the Result of the foregoing Paragraphs, that altho' the Spring of the *Air* ( under a State of Confinement ) may be artificially contriv'd so, as to raise the *Mercury* by its own Expansion ; yet the natural, regular and constant Effect of Supporting the *Mercury* at its proper Height ( in the open *Air* ) seems more justly to be ascrib'd to the Weight of it : Or rather, strictly and philosophically Speaking, to the Spring of the *Air*,



*Air*, and the Weight of the *Air*, settling into a mutual *Æquilibrium*, and acting jointly and equally upon the *Barometer*.

It is indeed, with some Art and Difficulty practicable, to disunite these two Properties, and divide them asunder; but in the constant Operations of Nature, they are inseparable: The Spring of the *Air*, acting always in Conjunction with the Weight of the *Air*, and in Proportion to it. For when the *Air* is heavy, its elastic Particles being more compress'd, they will consequently expand themselves with the greater Force; and, by such additional Weight and Spring, will raise the *Mercury* very high. Whereas on the contrary, when the *Air* is light, the Spring of it will be to a greater Degree relax'd and unbent; and consequently, operating with a weaker Force, the *Mercury*, by such a double Abatement of the Pressure upon it, will subside very low. And thus, in Proportion, as the Weight of the *Air* is greater, or lesser, the Spring of the *Air* will be stronger, or weaker; and the Effect (whatever it be) will be jointly and equally the Product of both.

BUT if we strictly consider the particular manner in which the Spring of the *Air* operates; and that it raises and supports the *Mercury* in the Tube, only by exerting a perpendicular Pressure upon the stagnant *Mercury*: it is very certain, that by such a  
direct



direct Pressure, it neither does, nor can act any otherwise than as an elastic Weight incumbent upon it; and consequently, that in this very Case, the Spring of the *Air* is so entirely co-incident with the Weight of the *Air*, as not to be either in Notion, or Fact, distinguishable from it. For which Reason, as well as to avoid any Perplexity in the Argument, I have all along in the main Part of this Discourse, consider'd and assign'd, the general Weight, or Pressure, of the *Air*, as the only Cause of the Elevation and Depression of the *Mercury*, without taking any other than a transient Notice of the Spring of the *Air*, contributing jointly towards it. For tho' it may, and must, in Strictness, be admitted as a partial, or concurrent Cause; yet, since it acts only in Proportion to the Weight of the *Air*, and in Subordination to it; That, in the Balance of Reason, must be adjudg'd and accounted as the more general and superior Cause; by its including, limiting and regulating the other (so far as this Subject is concern'd) in its Effects and Operations. To those who require farther Satisfaction upon this Head; and after what manner the Spring of the *Air* is resolveable into the Weight of the *Air*, and operates by it, I recommend and refer them to *Nieuentyt's Religious Philosopher*, Vol. 1. Pag. 190, to 194. which, besides the good and useful Design of the Book it self, is a very valuable



ble and compleat System of Mathematical, Mechanical and Experimental Philosophy.

BEFORE I dismiss this Article, I must not be so partial to what has been said above, as to conceal from the Reader, that two or three Authors of some Note, have occasionally advanc'd Positions very different from that side of the Question, which I have here undertaken to prove and explain: But as their Notions, upon this Subject, are, in the Main, very obscure and confus'd, and neither rightly consistent, nor intelligible, I shall not trouble the Reader with any Recital, or Refutation of them; but leave the Learned in Speculations of this Kind, to compare and examine, to judge and determine according to what they find most agreeable to the Laws of Nature and Reason; and either to Acquiesce in the plain mechanical Account here given; or, if they dissent from it, to propose and substitute a better in its stead.

THE Account here given, I call plain and mechanical, because a *Barometer*, strictly consider'd, is, in Truth, nothing else but a Philosophical Pair of Scales, wherein (by the artful Contrivance of a *Vacuum*, and the restless Endeavours of Nature to restore and preserve an *Æquilibrium*) a Column of *Air* is continually weighing against a Column of Quick-Silver. And, as for the various Changes in the Gravitation of the *Atmosphere* (whatever Causes they proceed from)



from) they are, in a Philosophical Estimate, to be consider'd no otherwise than as so many volatile Weights; which, to keep the Balance even, the Winds are continually shifting and playing out of one Scale into the other.

FROM hence it readily and naturally follows, that, by taking a precise Estimate of the Weight of the Quick-Silver supported in the Tube, we are enabled to form a Judgment equally true, of the real Weight of a proportionable Cylinder of *Air*, rising and reaching up to the utmost Height of the *Atmosphere*, because they are both suspended in an even Balance, and the one is the exact Counterpoise to the other. From hence also, as well as from the general Purport of this Discourse, neither the Writer, nor Reader, can well avoid drawing one very obvious Conclusion, of near Affinity with this Subject, and capable of undeniable Proof from it, And that is,

IF in a common *Barometer*, the Pressure of the *Air* be equal in Weight to 30 Inches of Quick-Silver; then it will follow, that in Proportion as a Column of *Air* encreases in its Base, or Dimensions, the Weight of it must encrease too: And consequently, as much as an human Body exceeds in Bulk, the Dimensions of a *Weather-Glass*, so much the greater Degree of Pressure, from the incumbent *Atmosphere*, must it sustain.



To reduce this to Calculation. It is found by Experience, that a cubical Inch of Quick-Silver weighs 3580 Grains. Let us then suppose the Body of a Man in an erect Posture, taking one Part with another, to be commensurate to a Square of 12 Inches: And from thence it will follow, that the perpendicular Pressure of such a Column of *Air*, upon the Head, Shoulders, and other prominent Parts of the Body, is equal in Weight to 2685 Pounds.

LET us suppose again the very same Person, lying, or extended upon the Ground; and the superficial Measure of his Body, expos'd to the perpendicular Pressure of the *Air*, to be four square Feet: Then it is evident the Weight will be Quadruple, or Equal to 10, 740 Pounds.

IF we pursue these Computations still farther, by adding the Lateral, or circum-ambient Pressure, which is, at the least, double to the latter Sum; then the whole Amount both of the Lateral and Perpendicular Pressure of the *Air*, upon the Body of a Man of a very moderate Size, will be equal to 21, 480 Pounds Weight.

THIS, and more than all this, were we to be strictly nice in our Calculations, is clearly demonstrable: But then, at the same time, it is equally certain, that whether we stand upright, or lie down, or whatever Situation we may be in, we are not sensible of the least Weight bearing  
upon



upon us, or any Side, or in one Posture more than another.

THE Reason of which is, because the Pressure of the *Atmosphere*, both above us, and below us, and around about us, is exactly balanc'd; and by the Spring, or Elasticity of the *Air*, is continually kept and preserv'd in so just and steady an *Æquilibrium*, that amidst such a dreadful Counterpoise of Weights (sufficient to crush us into Atoms) we move and act with the same Freedom, Ease and Safety, as if we liv'd in a Space void of Matter, incapable of making any Resistance to us, or of exerting any sensible Pressure upon us.

TO make this more easy and intelligible, let us put equal Weights into opposite Scales, so as to keep them suspended in *Æquilibrio*, and then whether the Weights be a Thousand, or Ten Thousand Pounds each, they will be moveable with ease, and manageable at Pleasure: nor can they, whilst they continue thus *Æquiponderant*, affect us with any Degree of Pressure, because their Action, and Re-Action, being equal and opposite, the one will entirely destroy the Effects of the other; and leave no Superiority of Weight, or Motion, in either.

BUT if we destroy the *Æquilibrium*, by diminishing the Weight, or quite emptying one Scale; the other will then instantly descend, and act with a Degree of Force



and Velocity, answerable to the Superiority of Weight in it.

THUS, whatever the Pressure of the *Atmosphere* may be, so long as the Balance of it, on every side, is strictly preserv'd, we feel no Weight, we suffer no Violence, we fear no Danger from it : But if the Equality of its Pressure be destroy'd, as it sometimes is, either by a sudden Flash of Lightning, or Explosion of Gun-powder, the Effects of it then will be surprizingly great and terrible ; and the Weight and Spring of the *Air* ( let loose thereby ) will exert themselves with such incredible Force and Velocity, that nothing can withstand them ; and the strongest Buildings we can raise for our Security, are, in a Moment, liable to be laid level with the Ground by them.

FOR, agreeably to the Calculation above recited, the perpendicular Pressure of the *Air* upon a Room no larger than 12 Feet square, is equal in Weight to 386,640 Pounds. And the lateral Pressure ( considering it only as Quadruple ) is equal to 1,546,560 Pounds. So that whether the one, or the other of these prodigious Weights, acts separately, or both of them together, with a Degree of Velocity, answerable to that of the Spring of the *Air*, suddenly exerting it self, it is very certain, that the Force must be abundantly greater, and the Shock more violent, than any Work of human



human Structure can have Strength, or Firmness, sufficient to sustain.

THESE Computations of the Weight of the *Air*, grounded upon the Weight of a Cubical Inch of Quick-Silver, do, it must be own'd, far exceed others, relating to the same Subject, drawn up in the Sequel of this Discourse ; because herein the Station of the *Barometer* is taken at 30 Inches ; as in the others, at a lower Rate. But if we adhere to the same Height of the *Mercury*, and estimate the Weight of a cubical Foot of Water (as Dr. *Halley* does in his Calculation of the Quantity of Vapours elevated) at 76 Pounds ; the two Accounts will be nearly equal ; and the Difference betwixt them not very material.

FROM these Speculations, it is evident, that the *Air* is very far from being a Body specifically Light, as we are some of us apt to imagine, and the Philosophers, of former Ages, generally held : and that the modern Discoveries of its Gravitation, at the same time that they improve our Knowledge, alarm us of unexpected Danger from it : It being certain ( whether we will believe, or consider it, or not ) that we have every Moment of our Lives, the most formidable Weights hanging over us, and surrounding us on every Side ; Weights, if they were permitted to operate with their full Force, sufficient, not only to destroy us, and every living Creature, but all the Works of human

man



man Art and Industry; all the outward Furniture of the Globe together with them. But then, as the Hand of Providence holds the Balance; and by Laws, peculiar to them, restrains these terrible Powers of the *Air* from breaking out with their natural Force and Strength upon us, we are secure in the midst of the nearest and greatest Dangers: And ought, with Thankfulness, to acknowledge, as we with Safety and Pleasure enjoy the Benefits of so wonderful a Fluid (in Seeing, Hearing, Talking, Moving and Breathing in it) without feeling, or dreading any fatal, or violent Effects from it. Those Persons who are desirous of farther Conviction, or Satisfaction upon this Article, I refer them to the excellent Author above-mention'd, *viz.* Dr. *Nieuentyt's Rel. Philosopher.* Vol. 1. Page 194. &c. to the End of the Section.

To what has been said above, upon the various Streams and Weight of the *Air*, upon the Rise of the Vapours, the Suspension of the Clouds, &c. I shall here, by way of Supplement, add what has occur'd to me in the Course of my farther Speculations upon the same Subjects: To have inserted them sooner, must have interrupted the Thread of my Discourse, and caus'd too large a Digression from it; and not to insert them at all, wou'd in Effect, be to leave the Theory of the *Atmosphere* (upon which the State of the Weather, and the  
Motions



Motions of the *Barometer* so much depend) to a great Degree imperfect without them.

1. As the *Atmosphere*, or Body of grosser *Air* surrounding the Globe, rises and reaches (as we have prov'd above) more than five Miles in Height; and, by a moderate Computation, contains above 2000 Millions of cubical Miles, there is evidently Room, sufficient in so expansive a Fluid, for the Reception and Distribution, for the Diffipation, or Collection, of all Kinds of Vapours and Exhalations, which are rais'd, or forc'd up, either by the solar, or subterranean Heat, from all Parts of the Surface of the Sea, or Earth.

To what Height the Vapours ascend, does, in a great measure, (as we have already in Part intimated) depend upon the Degree of Heat, wherewith they are actuated and distended, and upon the Finesse and Lightness of the Vapours themselves, upon the Density of the *Air* wherein they are buoy'd up; and even sometimes upon the Strength and Force of the Winds wherewith they are impell'd. Some of them are so far subtiliz'd and attenuated, and rise to so great a Height, as not to be distinctly visible; of which Kind, in Sir *Isaac Newton's* Opinion, are those that form by Refraction the blue, or azure Colour of the Sky. Other Vapours of a grosser Kind, being compacted into Clouds, and keeping for some time a fix'd Station in the Regions  
above,



above, have (as Mr. *Boyle* tells us) been ordinarily measur'd to the Height of one fourth, or one third Part of a Mile; and some to half a Mile: But that very few, and those of the whitest, and, in Appearance, the loftiest Clouds, were, upon Tryal, found to be above three Quarters of a Mile in Height.

BUT herein the Accounts of foreign Mathematicians widely differ: Not that the ordinary Floats of Clouds in *France*, or *Italy*, are, in reality, doubly or trebly higher than ours; but that such remarkable Clouds, whose perpendicular Heights were accurately taken and committed to Writing, have some of them, as they tell us, amounted to two, three, or even 4000 Geometrical Paces; but none of them have exceeded 5000 Paces, or five Miles in Height. Tho' in all Appearance, were Observations of this Kind more frequently made, the very same Heights of the Clouds, or perhaps greater, might be sometimes discover'd even here.

THE Day after the great Storm 1703, when all was still and calm below, a Thunder Cloud of unusual Height, and Swiftneſs of Motion, paſs'd over *Oxford*, riſing out of the ſame Quarter, and moving in the ſame Direction with the late Storm: Which was not indeed measur'd by any that I remember; but was adjudg'd, by good Mathematicians upon Sight, to be at the leaſt five Miles in Height.

FOR,



F O R, if the Storm itself (as it was then generally imagin'd) was the remaining Effort of a Hurricane from the Coasts of *America*; if the Force wherewith the Cloud was impell'd, was vastly superior to that of its Gravitation: From thence it will follow, that the farther any such Cloud moves on in a direct Course, or very little declining from a straight Line, the higher must such a Cloud rise in its perpendicular Distance from the convex Surface of the Earth; and the less Resistance it meets with from the upper Regions of the *Atmosphere*, the swifter it will move. But when the protrusive Force of the Wind abates, and that of Gravitation prevails, the Cloud itself will acquire a Degree of Velocity from its extraordinary Height, and fall down, as this was observ'd to do, in violent Rain, or Hail.

A N D this will let us into the natural Reason of a vulgar Observation, *viz.* That in cloudy and stormy Weather, when the Wind falls, it will commonly Rain, because the Clouds are carry'd on by the Strength of the Wind, in a straight Course to a greater Height, than the Density of the superior Regions can support; as soon therefore, as the Horizontal Impulse ceases, the Clouds, by their own natural Gravity, must descend in Rain.

S U C H a moderate Height, as we have here assign'd to such of the Clouds as consist of aqueous Exhalations, is accountable



for in a natural way; but the more extravagant Height, mention'd by Mr. *Boyle*, and cited from *Ricciolus*, seems to be hardly credible. That Author relates, that two skilful Astronomers, in their nocturnal Observations in *France* and *Italy*, viz. *Ab horâ undecimâ usque ad mediam noctem, Lunâ infra Horizontem positâ, viderunt nubeculam quandam lucidam propè meridianum, fere usque ad Zenith diffusam; quæ consideratis omnibus, non poterat nisi a Sole illustrari; ideoque altior esse debuit totâ umbrâ terræ. i. e.* They took notice of a Cloud, which appearing bright at Midnight, and being (as they concluded) enlighten'd by the Rays of the Sun, must, in their Judgment, have been higher, than the projected Shadow of the Earth.

BUT as the Shadow of the Earth (observeable in Eclipses) reaches far beyond the Regions of the Moon, and there only terminates in a Cone, at the Distance of about 300,000 Miles; it is hardly credible, that a Body of so little Firmness and Consistency as a Cloud, shou'd be capable of reflecting and transmitting Light from so immense a Distance: And it seems therefore a more rational Conjecture, that the particular Cloud describ'd above, might rather be one of those luminous Clouds, superior to our *Atmosphere* (which we of late so often see rising out of the *North*, and shining with their own native Light) than that it shou'd be any common, or extraordinary Cloud,



Cloud, detach'd so far from the Body of the Earth, or Moon; and shining with derivative, or borrow'd Light, from the Rays of the Sun.

THESE and the like luminous Clouds (consisting, as they are generally suppos'd, of sulphureous and inflammable Vapours, and from thence deriving a natural Spring, or Levity, exerting itself in mounting upwards; for such Vapours, actuated by Heat, will ascend in *Vacuo Boileano*, without any Medium to support them,) rise to a very great Height, above the common Limits of our *Atmosphere*. And such of these Clouds, as, by their remarkable Appearances in very distant Places, have been reduceable to Calculation, have exceeded the Height of 40, 50, or even 60 Miles. Of which we have an Instance (*Phil. Trans.* Numb. 360. Page 984.) in that extraordinary Meteor of *March 19, 1718*, breaking out from a dusky Cloud, and computed by the learned and accurate Dr. *Halley*, to be in a round Number 69 Miles in perpendicular Height above the Surface of the Earth.

BUT as these bright and light Clouds make no Difference in the Weight of the *Air*, nor produce any Change in the *Barometer*, I shall pass them by, as Foreign to our Purpose, (as well as that more remarkable Cloud, observeable in the *Southern Hemisphere*, and keeping a fix'd Station and



Appearance near the *South* Pole ; which seems to be one of the Wonders, or Mysteries of Nature, lying without the Reach of human Imagination to form any rational, or even probable Conjecture about it ) and return back to what bears a more immediate Relation to this Subject.

2. THE *Atmosphere* being ( as we have remark'd above ) of so great Depth and Extent, and resting with its whole incumbent Weight upon the Surface of the Earth, the general Pressure resulting from it, must be great in Proportion. Let us suppose a cubical Foot of Water, taking it at the lowest, to weigh 63 ( tho' some of our *English* Authors have rated it at 76 ) Pounds ; and that the Weight of the *Air*, as is evident in a Pump, ordinarily supports a Column of Water 33 Feet in Height. From thence it will follow, that the general Pressure of the *Atmosphere*, is equal to that of an Ocean of Water surrounding the Globe 33 Feet in Depth. And consequently that the *Atmosphere* impendent over *England* ( computing it in superficial measure to be 39 Millions of Acres ) amounts to more than Fifteen Hundred Thousand Millions of Tuns Weight, *viz.* 1,576,735,875,000 Tuns.

AND since it is the Property of all Fluids, to raise and buoy up, all such Bodies, which, Bulk for Bulk, are lighter than themselves, lighter than the Medium in which



which they float : From hence also it will farther follow, that in an Ocean of *Air* of such intrinsic Weight, there must be a Counterpoise more than sufficient, to support a far greater Quantity of Clouds and Vapours, Rain, or Snow, &c. than the *Atmosphere* ordinarily contains ; and abundantly more, than at any one Time appears to be discharg'd from it.

By the celebrated Dr. *Halley's* Calculations, the *Mediterranean* Sea, in a Summer's Day, exhales in Vapours at the least 5280 Millions of Tuns ; and the drying Winds, he farther adds, are sometimes observ'd, to lick up an equal, or greater Quantity of Vapours from the Surface of the Water, than is exhal'd by the Heat of the Sun. If therefore we suppose two or three such drying Days to pass, without any Fall of Dew, or Rain, to diminish the Quantity, there will be evidently rais'd up in Vapours, and supported at one time in the neighbouring Regions of the *Atmosphere*, above Thirty Thousand Millions of Tuns of Water.

AND, by this means, it is possible for some Parts of the *Atmosphere*, to be sometimes even saturated, or over-charg'd with Vapours ; which, as they afterwards happen, either to be driven and dispers'd, or collected and accumulated by the Winds, will accordingly produce moderate, or plentiful Supplies of Rain, upon some Parts  
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of the Continent, or excessive Quantities in others.

AND from hence, in Appearance, are deriv'd, as well the wet Seasons, peculiar to some foreign Climates, as the greatest Gluts of Rain, sometimes incident to our own; which proceed always from such a copious Exhalation of Vapours, and generally from such a previous Confluence of Clouds, and Opposition of Winds, (as we have already in Part intimated) the latter, *viz.* the opposite, or contrary Winds, still driving on, and bringing up fresh Supplies of Clouds and Vapours rang'd on either Side; where (being check'd in their farther horizontal Progress, and heap'd up in greater Quantities than the *Air* can support) they must consequently stop, and, successively condensing, fall; much after the same manner, and in such like Streams of Rain, as we sometimes see pendent from the Clouds, and reaching down in continu'd Streaks, or Lines, towards the Surface of the Earth; which are always very violent, under, or near the Place of Concourse, but seldom extend to any wide Circuit, or Tracts of Land.

THE Reader will, I doubt not, readily excuse a short Digression here, in taking notice of such a mutual Approach, and dreadful Congress of two Thunder Clouds, as it is nobly imagin'd and describ'd by *Milton*;

— As



——— *As when two black Clouds* [on  
*With Heav'n's Artill'ry fraught, come ratt'ling*  
*Over the Caspian; then stand, front to front*  
*Hov'ring a-while, 'till Winds the Signal blow*  
*To join their dark Encounter in mid Air.*

Especially since these admirable Lines are here inserted, not altogether for the Sake and Pertinence of the Description, but with a View of grounding something Philosophical upon the same Thought, farther pursu'd. Let us then suppose these two Thunder Clouds, thus moving in direct Opposition, to be very great, full charg'd with Vapours, and just upon the Point of falling: Let us farther imagine them to be driven with equal Strength by contrary Winds (as Thunder Clouds are commonly observ'd to rise against the Wind; which, by the way, is the Reason of their first Appearance, being always Mountainous) and accordingly to meet and mix, to be blended and confus'd together; the very same Winds still continuing to press them forwards towards the Place of their mutual Concourse and Dissolution: Let us once more suppose the subjacent Country to lie shelving, with a general, or double Declivity; and that, leading into a single Valley, or Channel: From such a real, or even partial Concurrence of Causes and Circumstances, it is  
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incredible to imagine, how great a Quantity of Rain such a Concourse of Clouds will appear to discharge, and what a prodigious Inundation it will raise; when the Waters falling thus within the Compass of such a Declivity, are all collected together into one single Current, and that confin'd within one narrow Passage, or Channel? And how impracticable it is, for any common Buildings, such as Men raise for Convenience, rather than Strength, to bear up against a Torrent of Waters, rowling down all at once, with such impetuous Weight and Force.

FROM these Premises, or something of the like Nature, we may in a very probable manner, account for those terrible Storms, as well as for those great and sudden Inundations, happening lately at *Sheffield* in 1729, at *Ripponden* in 1723, and another near *Madrid* in *Spain*, in 1725, or 1726; more tragical in the Number and Quality of the Persons surpriz'd and drown'd in it, than either of the former: Towards which, such a peculiar Confluence of Clouds, and unhappy Situation of the several Places, might, in all Appearance, contribute more, than any imaginary Land-Spouts, or Cataracts of Water pouring from above: which are usually talk'd of, and sometimes receiv'd as Matters of Fact, upon these Occasions; tho' they are seldom, or never seen, or known



known in any inland Country, at so remote a Distance from the Sea.

3. IT is frequently observ'd by Sailors in several Parts of the Ocean, that the upper, or visible Current of the Waters drives one Way, at the same time, that an under Current runs another Way ; and sometimes in Courses directly contrary. Agreeably to which, as the Parts of the *Atmosphere* are more easily separable, than those of Water, more capable of receiving any Impression, and of propagating and continuing any Motion produc'd in them : It is certain that in so great a Depth of *Air*, as we have above assign'd to it ; there may, and must be often Variety of Streams, or Currents of *Air*, driving different Ways, in higher, or lower Regions of the *Atmosphere* ; sometimes at so great a Distance asunder, as to move freely without Interruption ; and sometimes in, or near the same Level, or Horizontal Planes, crossing and interfering with each other in several different Courses and Directions.

LET us, for Instance, allow  $\frac{1}{2}$  or  $\frac{1}{3}$  Part of a perpendicular Mile, for the under Current of *Air* ; and to the superior Regions, and Streams of *Air* driving through them, allot the same Proportion. It is no uncommon Thing, to find and feel a very strong Wind below, whilst the Clouds remain fix'd and immoveable in their Station above or, on the contrary, to see the Clouds driving with great Swiftnefs above, when all is

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calm and still below. Sometimes we may discover two distinct Squadrons of Clouds, floating at different Heights, in Streams of *Air* directly contrary; sometimes an intermediate Wind arising, by its superior Strength, controuls and carries each of the other Currents along with it; or if they happen to be nearly equal, and neither of them extinguish'd, we may often, in such a Case, observe the Clouds to meet and mix, and to encrease all of a sudden in Bulk and Quantity; being driven and collected together by such a Complication of Winds blowing towards the same Regions of the *Atmosphere* from different Quarters. And agreeably to this Purpose, in the very worst of Weather, when it runs into either Extreme of Rains, or Snow, it is reasonable to imagine that there is always the greatest Confusion in the Streams of *Air*, and Confluence of Clouds and Vapours above, when, by the Thickness of the *Atmosphere*, we can discern the least of it from below.

SINCE therefore the *Atmosphere* is thus actually separable into various Horizontal Planes; and those (as it often happens) with different Streams of *Air*, and Squadrons of Clouds floating through them: From thence it will seemingly follow, not only that the Weight and Temper of it must be liable to frequent and sudden Alterations; but that no regular, or certain Judgment can be form'd of the general State and Quality of  
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the *Atmosphere*, without taking in the full Extent of it. Because the Upper Regions of the *Air*, may be very different from the Lower in their Effects and Indications; nor can any Change of the Weather be lasting, where there is not a suitable Tendency in the whole *Atmosphere* to support and confirm it.

AND, upon this Account, as the Weight of the *Atmosphere* runs through the whole Extent of it; and is, in Truth, the chief Property concern'd, as well in supporting the Clouds and Vapours, as in giving way upon any Abatement, to their Descent in Rain: So the Motions of the *Barometer* depending, in like manner, upon the Weight of the whole *Atmosphere* (rising with the Encrease, and falling upon the Diminution of it) must be a more likely and reasonable Prefage of the State of the Weather, than any of the common *Hygrosopes*, or *Weather Houses*; which depend altogether upon the Moisture, or Dryness of the *Air* near the Surface of the Earth, and (how mysterious, or ludicrous soever some of them appear) consist ordinarily of a twisted Cord, or Gut; in damp Weather, swelling in Bulk, and thereby contracting in Length; or, on the contrary, when the *Air* is dry, shrinking in Bulk, and thereby extending in Length.

IF therefore we suppose, as it sometimes happens, the lower Region of the *Air* to be moist, when all above has a Tendency to



be fair and dry ; or the lower Region to be dry, when all above has a Tendency to wet Weather: It is certain, that no Conjecture, taken from Part of the *Atmosphere*, can be so well grounded, as what is deriv'd from the more general and prevailing Quality of the Whole.

N O T that even in this latter Case, we can form any certain Judgment of a Thing so mutable as the succeeding State of the Weather: Because the sudden Changes and Oppositions of Winds, and Confusion in the Streams of *Air* and Vapours driving above, are usually attended with Changes equally sudden and irregular, as well in the Motions of the *Barometer*, as in the Temper and Quality of the Weather. Within the short Compass of 48 Hours, I have observ'd these following (and it rarely happens, but that the like, or greater Changes in the Winter Season may be equally observable) *viz.* 1<sup>st</sup>, A warm Wind and Rain out of the *South*, the *Glass* near Stormy. 2<sup>d</sup>, A cold *North* Wind, the *Air* clear and frosty ; the *Glass* betwixt Rain and Changeable. 3<sup>d</sup>, A cold *Southerly* Wind and Rain for six, or eight Hours ; the *Glass* advancing still towards Fair. 4<sup>th</sup>, A *West* Wind rising gently, and after some little Time blowing stronger, and clearing the *Hemisphere*, the *Glass* in the Beginning at fair, and afterwards sinking to changeable.



THE two former Articles are above accounted for ; in the two latter (where the Difficulty and Irregularity lie) it seems very probable, that the very same Opposition of Winds, which in the lower Regions, by mixing and jumbling together the Clouds and Vapours, precipitated them in Rains, might, by heaping up and accumulating the *Air* above, cause a gradual Addition to the Weight of it ; and thereby keep the *Barometer* rising, even whilst the Rains were falling. And as the *West* Wind, at its first setting in with a gentle Gale, seems also to have added to the Accumulation, by the *Glass* standing at Fair ; so after it prevail'd over the other Winds, and drove off the accumulated *Air* from the Place of Observation ; the *Mercury* (by such a Diminution of the Pressure upon it) settled to Changeable.

FROM these, or the like inconsistent Effects and Appearances, it is obvious to remark, that a real Distinction may, and ought to be made, betwixt the *Barometer* and the *Weather-Glass* ; the former always going right, as it is an Indication of the Weight of the *Air* ; because it is a regular and even Counterpoise to it, in the several Degrees and Changes of its Gravitation : But that the latter may, and does sometimes remarkably err (as in the Instance above-mention'd) in the Indication of the Weather.

BUT



BUT then, as these extraordinary Oppositions of Winds, and Irregularities flowing from them, happen but seldom, and never last very long; they will not hinder, but that the Rise and Fall of the *Mercury*, will, generally speaking, be an useful Monitor and serviceable Direction to us, in other more regular, leisurely and settled Alterations of the Weather.

FROM what has been here said in Addition to the Theory of the *Atmosphere*, it appears, that the Sun daily and actually raises from the Surface of the Ocean, a prodigious Quantity of watry Bubbles and Exhalations; which the lower Regions of the *Air*, by their Density receive, and transmitting upwards, sustain at their proper Height. These the Winds, or Streams of *Air*, moving above, variously tumble and toss about; sometimes scattering and dispersing them in Regions far remote: And at other times, collecting and amassing them together in greater Quantities, than the *Atmosphere* can support. And if to these Premises, we farther add, with the ingenious and learned Mr. *Derham*, the Coldness of the superior Regions (condensing and thickening the Coats of these watry Bubbles; and either freezing them above, or compacting them into solid Drops, and thereby encreasing their Weight, and giving them a Tendency towards falling) from these and the foregoing Principles, and the different



rent Action and Combination of these natural Causes ; the various Changes in the Temper of the *Air*, the Unsteadiness of the Weather, and the Irregularity of the Seasons, are deriv'd ; and may, in a reasonable manner, be deduc'd and explain'd.

4. THAT the Upper Regions of the *Atmosphere* are actually cold, or comparatively colder than the Lower, was the receiv'd Opinion of *Aristotle* and the Naturalists of his Age ; and seems to have been grounded upon the common and obvious Observation of Snow and Ice melting at the Foot and Sides of the highest Mountains, but lying undissolv'd, through all the Seasons of the Year, at, or near the Tops of them. But from whence this Coldness of the superior Regions proceeds, may deserve our Enquiry.

As there are plenty of sulphureous and inflammable Exhalations extracted by the Heat of the Sun from the Juices of Plants and Minerals ; which (being rais'd up to a very great Height, and, by that natural Principle of Attraction, whereby Things of a similar Nature run together, there collected in great Quantities, pent up within the Clouds, and fir'd by Fermentation) discharge themselves in Lightning and Thunder : So on the contrary, it is equally certain, by Experience, that there are other volatile Particles, as well as several mineral Extractions and Compositions, of a Nature intensely cold ; which, where-ever they exert



or extend their Effects, produce natural, or artificial Freezing.

Mr. *BOYLE* observes, that a Solution of Gunpowder in a due Proportion of Water, will produce a great and sensible Degree of Cold: And as Lightening in its Nature and Effects, bears the nearest Resemblance to Gunpowder; so it seems very probable, that the very same nitrous and sulphureous Particles, which, when collected and compress'd together in greater Quantities, break out into Flashes of Lightening; when they are more scatter'd and dispers'd, and mix'd, or dissolv'd in aqueous Exhalations, may produce the same Degree of Cold above, as they are, by Experience, found to cause below. From hence however, in hot sultry Weather, we may account for that agreeable refreshing Coolness observable in the *Air*, after a Storm of Thunder and Lightening, *viz.* From the Solution of the nitrous and sulphureous Vapours, whereof the Lightening consists; many of which (being fir'd at every Flash, and quench'd in their Descent through the Drops of Rain) remain floating in the lower Regions of the *Air*, and produce that grateful Refrigeration in the Lungs and Blood, of which we are most sensible, immediately after the Ceasing of the Storm. To this also may in Part be ascrib'd the peculiar Chilness and Coldness of some of the Summer Winds and Rains; and even in the Winter Season, the nitrous  
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Particles floating in the *Air* in frosty Weather, are by *Gassendus*, and other Philosophers, held, to make the most sensible Addition to the Sharpness of it.

THIS, in Appearance, seems to be a partial Cause, contributing, in some measure towards the Coldness of the middle Regions of the *Air*; but can by no means be admitted as an adequate, or sufficient Cause for it. Let us therefore, beside this, farther consider, that as well under the *Southern*, as the *Northern* Pole; there are vast Tracts both of Sea and Land, cover'd with fix'd, or floating Mountains of Ice, or unfathomable Depths of Snow; which have lain undissolv'd there for many Centuries; and, by the Observation of Sailors to *Greenland*, seem, in some Places at least, by the different Strata of Snow, to receive a yearly Encrease.

THESE then, as Cold naturally produces Cold, seem to be the great Magazines of Nature, from whence that Quality of the superior Regions is deriv'd and supply'd: But how, or by what means, the Communication is carry'd on, will admit only of present Conjectures, 'till Time and Philosophy make way for future Discoveries. Whether the Winds may contribute towards it, by blowing from the *North* and *South*, with greater Steadiness and Constancy in the Regions above, than in those below? Whether the Sun, keeping always within

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the Tropics, may not so far heat and attenuate the Tropical *Air*, as to draw in continual Supplies of colder and more condens'd *Air* from the polar Regions, to preserve the Balance? Or whether the Moon, may not have the same Influence in raising a Tide, and continuing the Circulation of it, through the vast Ocean of *Air* above, as she is found by Experience to cause in the several Oceans of Water here below? Or lastly, whether the Communication betwixt the polar Regions, may not depend upon other Causes unknown to us; and as it is certain from the common Effects and Operations of the Load-Stone, that there is a continual Stream of magnetic Particles, flowing near the Surface of the Earth, and passing from Pole to Pole: So, whether there may not, in like manner, be something analagous to it, passing through the middle Regions of the *Atmosphere*, in a Stream of Vapours, or Particles, intensely cold, and thereby answering the great Ends of Nature, in cooling the upper Regions of the *Air*, in giving a Check to the Rise of the Vapours, in condensing and precipitating many of them in Dews, or Rains, in forming the several Kinds of Meteors, in actuating and giving Force and Strength to the Winds, which, besides other Causes, seem to depend, as well upon the frequent and sudden Condensations of the *Air* by Cold, as upon the Rarefaction of it by Heat; and



to require the mutual and alternate Action and Re-action of both. (As Mr. *Derham* *Physico Theology*, Note p. 15, 16. in part confirms and observes.)

AND agreeably to this Observation, the temperate Zones, being, by their Situation, liable to different Degrees and frequent Vicissitudes of Heat and Cold, are, by Experience, found to be the chief and only Seat of the variable Winds: Whereas in the torrid and frigid Zones, the Degrees of Heat and Cold being more equal, constant and regular, the Winds blowing within their respective Limits are so too.

By the daily Revolution of the Earth upon its own Axis, the *Air* within the Tropics passing daily under the meridian Heat of the Sun, is to a great Degree rarefy'd and attenuated by it: In the Consequence of which, the more cool and heavy *Air* pressing in, to preserve the Balance; and following the apparent Motion of the Sun towards the *West*, causes a general *East* Wind to blow round the Globe on each side of the *Æquator*; which, being at all Seasons of the Year nearly equal and constant, can produce little Alteration, either in the Weight of the *Air*, or the Rise, or Fall, of the *Mercury* within the Tropics.

THE very same Effect (of little or no Variation in the Height of the *Mercury*) equally follows from the intense and settled



Coldness of the polar Regions, whereby the *Air* above is to such a Degree condens'd and continu'd in a State of Density, as even to resist the Impression of the Winds, and thereby prevent any notable Changes in its Gravitation. And agreeably to this Purpose, Mr. *Boyle*, from the Voyages to *Greenland*, &c. remarks ; that the Mountains of Ice in those *Northern* Climates, by the extraordinary Weight, or Resistance of the *Air* resting upon them, give a certain and gradual Check to any such distant Winds, as blow directly upon them ; so as either to becalm the Ships, or render their Approaches very slow and leisurely towards them.

BUT then, on the other side, when any of these large Mountains, or Islands of Ice, are loosen'd from their Foundations, and sail with the Current from the polar Regions, towards the Tropic ; they are generally follow'd with a strong *North*, or *East-erly* Wind, driving them forward ; and as some of these are describ'd by Travellers, as rising in Height, and sinking in Depth, from 50 to 140 Fathoms, and extending in Bulk and Circumference several Miles : it is certain, that such a prodigious Accretion of Snow and Ice (advancing still with its broad Basis out of the Ocean, in Proportion as the upper Parts melt and dissolve) must be attended with very great and sensible Effects upon the *Air* and Vapours of warmer



warmer Climates; and often cause those unseasonable bleak Winds, and Storms of Hail in the Summer Months, which some Philosophers have with Reason ascrib'd to them.

As the polar Regions are the inexhaustible Stores and Magazines of Cold, I shall only add, what *Dampier* and other Travellers confirm; that in the *Southern* Latitudes beyond the Tropic, the *South* Wind is as remarkable for being Cold, and the *North* Wind for bringing Heat and Thunder-Storms, as the contrary are with us. So that on each side of the Globe, at equal Distances from the Line, the very same Estimate may be reasonably made, both of the Temper of the Winds, of the State and Weight of the *Atmosphere*, and of the Quality of the Weather: And the same general Rules and Observations upon the *Barometer*, will consequently (*mutatis mutandis*) hold good in one *Hemisphere*, as well as in the other.

To make the Changes in the Gravitation of the *Air* more discernable, several Instruments have been contriv'd, and Additions made to the *Barometer*. The first, was by affixing to it, a circular Plate of Brass, divided into equal Parts, and figur'd, with a Pulley in the Centre, and a Weight suspended, turning a moveable Hand backwards and forwards, according to the Rise, or Fall, of the *Mercury*; and thereby discovering



covering and pointing out, upon the figur'd Plate, any the least Change, or Variation in the Weight of the *Air*. But this Instrument was found to have this Inconvenience, that in some measure defeated the Truth and Exactness of it, *viz.* The Cord, or String to which the Weight, moving the Pully, hung, wou'd in damp Weather be contracted, and in dry Weather be extended; and by such Contraction, or Extension, turn the Hand, tho', in the mean Time, the *Mercury* had neither risen, nor fallen.

To remedy this, another *Barometer* was contriv'd, with that Part of the Tube, where the Quick-Silver rises and falls, of a larger Base; and a slender Pipe (immersed in Oyl of *Tartar* swimming upon the Quick-Silver) rising from it to the Height of 36, or 40 Inches; and each so proportion'd, that for every Inch the *Mercury* ascended in the larger Tube, the Oyl of *Tartar*, in the slender Pipe, might rise 10 Inches. But this also was attended with much the same Inconvenience as the Wheel *Barometer*. For as the Weather grows Hot, or Cold, the Oyl will rarefy, or condense, and, by Consequence, rise or fall, when the *Mercury* is no ways alter'd in its Situation.

SINCE therefore the *Mercury* will always rise in Proportion to the Weight of the *Air*, and remain at the same perpendicular Height, however the Tube be inclin'd:



clin'd: The best and most convenient Contrivance for a *Barometer*, seems to be that of a sloping Tube, rising upright from the stagnant *Mercury* to the Height of 28 Inches; and then reclining and running off in an Angle, to the Length of 12 Inches, and to the perpendicular Height of 3 Inches; according to which Frame, for every Inch that the *Mercury* rises in the perpendicular Tube, it will rise in the sloping Tube 4 Inches; and thereby make any Changes in the Gravitation of the *Air* more discernable.

BESIDES these, there are other *Barometers* of a more modern Invention, contriv'd so as to increase the Rise and Fall of the *Mercury* to 30, 60, or even to 100 Inches; but then as they are more nice and accurate in their Construction, and difficult in their Management, they are fitter for the Closets and Speculations of Philosophers, than to be introduc'd into common Use, or accommodated to the ordinary Capacities of Mankind.

BUT whatever Use they are design'd for, or how different soever their Effects and Appearances may be; they are all of them to be accounted for upon the same Philosophical Principles, *viz.* by the Weight, or Spring of the *Air*, or both together, acting in a Manner suitable to the daily Alterations liable to be produc'd in them.



AT the Close of this Account of the *Barometer*, it may not be improper to add an Abstract of such Observations as have been made upon it, by Persons of unquestionable Skill and Authority. Those of the celebrated Dr. *Halley* (which are the main Grounds of this Discourse, and to which most of the Observations since made, are in some Degree, referable) are as follow.

1. THAT in calm Weather, when the *Air* is inclin'd to Rain, the *Mercury* is commonly low.

2. THAT it is generally high in good, serene, settled, fair Weather.

3. THAT it sinks lowest of all on very great Winds, tho' they are not accompanied with Rain, according to the Point of the Compass from whence they blow.

4. THAT, *cæteris paribus*, the greatest Height of the *Mercury* is found, when an *Easterly*, or *North-Easterly* Wind blows; if it be not too strong.

5. THAT in calm frosty Weather, the *Mercury* is generally high.

6. THAT



6. THAT after very great Storms of Wind, when the *Mercury* has been low, it usually rises very fast,

7. THAT in the Latitude of  $45^{\circ}$  and about Ten Degrees on each side (being the Seat of the variable Winds) is the greatest Variation of the Height of the *Mercury*; the Rise and Fall of it gradually decreasing towards the *Æquator*, and *Poles*; so as within the Tropics, and near the Polar Circles, to stand at near the same Height in all Weathers.

FOR the Satisfaction of the Curious, I shall here insert, as I find it stated by a learned Author, the general Scale of the *Barometer* in all Latitudes, viz. near, or under the Line, the *Mercury* is observ'd to rise, or fall, about Two or Three Tenths of an Inch. At 15 Degrees Latitude, either *North*, or *South*, one Inch. At 30 Degrees 2 Inches. At 45 Degrees, 3 Inches. At 60 Degrees, the Rise, or Fall, diminishes again to 2 Inches. At 75 Degrees, to 1 Inch. And in 81 Degrees, to less than a fourth Part of an Inch. And as for the intermediate Spaces betwixt the Numbers specify'd, the Rise, or Declension of the *Mercury*, is gradual, in Proportion as the Latitude approaches nearer to, or recedes from the 45th Degree; tho' according to Dr. *Halley* from 35, to 55 Degrees (upon

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Account of the different Temper, Changeableness, and frequent Opposition of the Winds, within those Latitudes) the *Mercury*, taking its highest Rise and lowest Fall, varies little from the stated Height of 3 Inches.

THIS general Estimate, we must here remark, is settled chiefly with regard to the ordinary Course of the Weather; for in violent Storms and Hurricanes, which sometimes happen within the Tropics, the Depression of the *Mercury* is much lower than the Proportion here allotted to it. And to this I shall farther add, that the Station and Height of the *Barometer* must also be taken upon, or near the Sea-Coasts; because within the Continent, in Proportion to the Height of the Land above the Level of the Sea, the Scale of the *Barometer* diminishes in all Latitudes.

THE following Rules whereby to judge of the Weather, are deliver'd by Dr. *Harris*, as the Result of Mr. *Patrick's* long Observation and Experience.

1. IN the *Barometer* of common Form, the Motion of the *Mercury* does not exceed 3 Inches in its Rising, or Falling.

2. THAT its least Alterations are to be minded, in order to the judging rightly of the Weather by it.

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3. THE Rising of the *Mercury* presages, in general, fair Weather ; and its Falling, foul Weather ; as Rain, Snow, high Winds and Storms.

4. IN very hot Weather, the Falling of the *Mercury* fore-shews Thunder.

5. IN Winter, the Rising presages Frost ; and in frosty Weather, if the *Mercury* falls three or four Divisions, there will certainly follow a Thaw. But in a continu'd Frost, if the *Mercury* rises, it will certainly Snow.

6. WHEN foul Weather happens soon after the Falling of the *Mercury*, expect but little of it. And on the contrary, expect but little fair Weather, when it proves fair, shortly after the *Mercury* has risen.

7. IN foul Weather, When the *Mercury* rises much and high, and so continues for two or three Days before the foul Weather is quite over, then expect a Continuance of fair Weather to follow.

8. IN fair Weather, when the *Mercury* falls much and low, and thus continues for two or three Days before the Rain comes ; then expect a great deal of Wet, and probably high Winds.



9. THE unfettled Motion of the *Mercury* denotes uncertain and changeable Weather.

10. YOU are not fo ftrictly to obferve the Words engraven on the Plates (tho' for the moft Part it will agree with them) as the *Mercury's* Rifing and Falling: For if it ftands at much Rain, and then rifes up to Changeable, it prefages fair Weather; altho' not to continue fo long, as it wou'd have done, if the *Mercury* were higher: And fo on the contrary, if the *Mercury* ftood at Fair, and falls to Changeable, it prefages foul Weather; tho' not fo much of it, as if it had funk down lower. *Vide Harris's Lexicon*, under *Barometer*, where Dr. *Halley's* Obfervations, with the Reafons of them, are alfo inferted.

IT wou'd be often of great Confequence to form a probable Judgment fome few Hours before hand, of the enfuing State of the Weather; whether it may be likely to continue, or liable to a fudden Alteration: But altho' in fuch an Enquiry (by the peculiar Situation and Uncertainty of our Climate) we can arrive at little more than bare Conjectures; yet even here, a good *Barometer* will be of Service to us, in giving us fome little Light and Intimation. But then, in this Cafe, we muft confine our Infpection wholly to the Surface of the *Mer-*  
*cury*



*cury* within the Tube ; and examine the particular Figure and Appearance of it, with great Strictness and Attention.

1. IF in a common upright *Barometer*, the Surface of the *Mercury* appears perfectly plain and level, the Pressure of the *Air* is equal and steady ; and the Weather will generally continue for some Hours, much the same, as about the Time of Observation.

2. IF in wet Weather, it appears round, or convex, rising higher in the middle of the Tube, than at the Sides, the Pressure of the *Air* is encreasing, and an Interval of fair Weather will commonly follow soon after.

3. IF in changeable, or fair Weather, the Surface of the *Mercury* appears to be concave, or depress'd more in the middle, than at the Sides of the Tube ; the Pressure of the *Air* is decreasing, and the Weather will, in a few Hours, become cloudy, and sometimes rainy or windy. (These Observations, it must be added, require a clear Tube of near half an Inch in Diameter, the purest Quick-Silver, and a strong Side-light to make them distinct and visible ; but if the Tube be small, the Light weak, and at a Distance, or the *Mercury* foul and drossy, the different Appearances of the Surface, will



will be scarce distinguishable, or ascertain'd to any Truth, or Exactness.)

4. IN all Judgments form'd of the ensuing Weather, it is a main *Postulatum*, that the Wind continues in the same State and Quarter; for if there be a sudden Change, Encrease, or Opposition of Winds, the Weather, for the Reasons above given, will commonly change, and take a different Turn with them.

AFTER so large and full an Account of the Nature, Reasons and Uses of the common Sort of *Barometers*, it may perhaps be in some measure serviceable, or entertaining to several of my Readers, to add two or three easy Rules for trying and judging of the Goodness and Sufficiency of them, as well as for amending such Defects as are ordinarily found in some of them. As,

IN a *Barometer* adjusted to a Situation and Scale of three Inches, observe the Distance from the Surface of the stagnant *Mercury*, to the lowest Line upon the graduated Plate (when that within the Tube stands at changeable) that it be exactly 28 Inches; if it be more, the Quick-Silver can never rise to settled Fair; if it be less, it can never sink to Stormy. In the former Case, shorten the Tube, by grinding, or filing, and then either add to the *Mercury*, or  
raise



raise the Cistern higher ; In the latter Case, sink the Vertex of the Tube, and the Cistern lower.

2. LAY your Finger, with a gentle Depression, upon the stagnant *Mercury* ; and if it immediately rises and vibrates in the Tube above ; it is to a just Degree sensible of the Changes in the Gravitation of the *Air* ; but if it produces no correspondent Motion in the *Mercury* within the Tube, it is a certain Indication, that the Cavity of the Tube is too narrow, and not allowing sufficient Room for the free Play of the Quick-Silver, you must change the Tube for one of a wider Bore, and place it in its Stead.

A small Tube will, it is evident, save Quick-Silver, but be of little Use in judging of the Weather ; because by the Cohæsion of the Parts of the *Mercury* in so slender a Cylinder, by the Resistance and Opposition of the Sides of the Tube ; or, perhaps, by some little Asperities within the Motion produc'd in it will be so very slow and dilatory, that I have often observ'd the *Mercury* not to begin to fall, 'till the Day after a Glut of Rain ; nor to rise to its proper Height, 'till two or three Days after the Setting in of fair Weather. So, that in this Respect, a slender Tube, not unlike the *Ladies Almanack*, gives no notice of the  
Changes



Changes of the Weather, 'till they are actually past.

3. THE common Sort of Quick-Silver, after it has stood in a *Barometer* several Years, becomes less sensible of the Impressions of the *Air*, less capable of answering, by a correspondent Motion, the different Changes in its Gravitation.

THIS may be caus'd, either by the droffy Parts of the Quick-Silver, rising to the Top, and adhering to the Sides of the Tube ; or by some imperceptible Bubbles of *Air* disengaging and expanding themselves in the Vertex of the Tube ; which, we have observ'd above, ought to be void of *Air*.

FOR, if (according to Mr. *Boyle's* Calculation, when the Pressure of the *Atmosphere* is taken off) a cubical Inch of common *Air*, will extend it self above 10,000 times its natural Dimensions ; it is certain that two or three Bubbles of *Air*, expanded in such a Proportion, will be more than sufficient to fill up the Vertex of the Tube ; and thereby obstruct the Rising or Force of the Descent of the *Mercury*, below its proper Standard.

IN this latter Case, apply a live Coal, or hot Iron, to the upper Extremity of the Tube ; and the Rarefaction of the *Air* (if there be any) when encreas'd by the Heat, will



will immediately discover itself in the Depression of the *Mercury*.

BUT the Remedy in both Cases is the same, *viz.* to take out the Tube and the Quick-Silver, and after cleaning the Tube well within, and clearing off the droffy Parts of the Quick-Silver with great Care and Exactness, fill the Tube, with a competent Addition of fresh *Mercury*, and fix it up again.

4. IF the Tube be thin, and the Bore wide, you must tie it to a pliable Stick, or Whalebone, of equal length, before you fill, or invert the Tube: Otherwise, the Weight of the Quick-Silver will endanger the Breaking of the Tube.

IT is also of some Consequence, when the Tube is large, and the Bore wide, to have the Cistern large in Proportion, and entring so far into the back Part of the Frame, as to admit of the Suspension of the Tube, in, or near the Centre, and thereby allowing a circular Column of *Air* free Play in acting upon the stagnant *Mercury*: By which means, as the Weight, or Pressure of the *Air*, will be more equal, steady and uniform; so the Rise and Fall of the *Mercury* will be more entire, regular and sensible.

IN short, the finer and purer the Quick-Silver is, the larger the Tube, and the more exactly smooth and cylindrical the



Cavity within; with so much the greater Freedom and Facility will the *Mercury* play, and consequently more plainly and sensibly shew any notable Change in the Gravitation of the *Air*.

By a moderate Attention to what has been deliver'd upon this Subject, even People of ordinary Capacities, may rightly apprehend, and competently understand, the Nature and Use of the *Weather-Glass*; and find it of real Service to them, in the proper Direction and Accommodation of their rural Affairs: There being no remarkable Change, or lasting Interval of any Sort of Weather, but what the *Barometer*, to a careful and skilful Observer, gives sure and previous Notice, both of the Setting in, the Continuance, and Determination of it, so as not to leave such as attend to it, altogether under the same Uncertainty with those who judge at random, without any natural Grounds, or Presages, to support their Conjectures.

BUT then, in order to form from thence a probable Judgment of the State of the Weather, the *Barometers* we consult must be good in their Kind, and nicely sensible of the Impressions of the *Atmosphere*: And all such Persons as wou'd be curious in them, and well assur'd of the Truth and Exactness of those Instruments, upon which they ground their Observations, must not  
grudge



grudge the Expence of purchasing from the very best Hands.

As for such *Weather-Glasses*, as have been lately hawk'd about the Country, by needy Foreigners, or pedling Philosophers, it may not be improper to caution my Readers, that they are, generally speaking, very great Cheats and Impositions upon those, who, for the Sake of the Meanness of the Price, are persuaded to buy them : The Cavity of the Tube, being, in many of them, scarce large enough to receive an ordinary Pin ; and the Quantity of Quick-Silver being consequently too small, either to force the *Air* out of the Tube, at the first ; or to be regularly affected by it afterwards, according to the Difference of its Gravitation.

I shall only add, by way of Advertisement. That it may perhaps, be an Inducement to some of the Gentlemen of *Lincolnshire*, to deal with Mr. *Jonathan Sisson*, Mathematical Instrument Maker, at the Corner of *Beaufort Buildings*, in the *Strand, London* ; that he is their Country-Man, and eminent for his great Skill, Accuracy and Fidelity, both in the Construction of his *Barometers*, and in whatever other Works he undertakes, or delivers out of his Hands.

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