A
SURVEY
OF THE
WISDOM OF GOD
IN
THE *CREATION*:
OR, A
COMPENDIUM
OF
NATURAL PHILOSOPHY:
IN FIVE VOLUMES.

THE THIRD EDITION, ENLARGED.

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VOL. III.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!

MILTON.

LONDON:
Printed by J. FRY and Co. in Queen-Street:
And sold at the Foundry, Upper-Moorfields, and by the Booksellers in Town and Country. 1777.

PART the FOURTH.

Of Earth, Water, Fire, Air, and Meteors.

CHAP. I.

Of Earth and Water.

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THE Earth or terraqueous globe is a congeries of many different bodies. It contains ſand, clay, various ſorts of earth, ſtones, ſalts of various kinds, ſulphur, bitumen, metals, minerals, and other fossils almost innumerable. Upon the earth are the waters, and on or near its surface, animals and vegetables of all kinds. But how was this whole mass formed into mountains, valleys, seas, rivers, and islands? Des Cartes advances one hypothesis, Dr. Burnet another, Mr. Hutchinson a third. And each world-builder advances plausible reasons for his own hypothesis. But none of those reasons are demonstrative: higher than probability they cannot go.

That the earth is round, manifestly appears from the eclipses of the moon, in all which the shadow appears circular, which way soever it be projected. The natural cause of its roundness, is the great principle of attraction, which the Creator has stamped on all the matter of the universe, whereby all bodies, and all the parts of bodies continually attract each other. By this means, as all the parts of bodies tend naturally to their center, so they take a globous figure, unless some other more prevalent cause interpose. Hence drops of quicksilver put on a spherical form, the parts strongly attracting each other, drops of water have the same form, when falling in the air, but are only half round, when they lie on a hard body, because their gravity overpowers their attraction. Yet the earth is not exactly round, but swells out towards the equator, and is flatter towards the poles, which is supposed to be occasioned by the diurnal rotation of the earth on its axis. By this means the greater diameter exceeds the less, about 34 miles. What the earth loses of its sphericity by mountains and vales is nothing considerable: the highest eminence being scarce equivalent to the smallest protuberance on the surface of an orange. The diameter of the earth is supposed to be 7967 miles.

In

In the terraqueous globe are 1. The external part, from which vegetables grow, and animals are nourished: 2. The middle part which is possessed by fossils, and extends farther than human labour can penetrate: 3. The internal, which some suppose to be a great Loadstone: some a large mass of fire: some a collection of waters: and others, an hollow space inhabited by animals, which have their sun, moon and all other conveniencies, peculiar to themselves. But indeed of that we know nothing. The deepest cavities natural or artificial, known to us, scarce penetrating a mile below the surface.

In the external part we meet with various Strata, which were doubtless formed by the general deluge. The exterior parts of the earth were then dissolved, and mixed with the waters in one common mass. Afterward they sunk, nearly according to the laws of gravity, the heaviest first, and the lighter in their order. So were these strata formed, with hardening by degrees, have continued ever since. It is probable, these lay more regularly at first, but have been much changed in process of time. and their order disturbed by earthquakes, vulcano's, and divers other causes.

The earth is nearer the sun at Christmas than at Midsummer, as appears both from the sun's apparent diameter being greater in December than June, and from its motion being then swifter. Hence it isthat there are about eight days more in the summer half year from March to September, than in the winter half year from September to March.

That the earth moves round its own axis, not the sun and stars round the earth, may appear from this single consideration. All the planets revolve in more or lefs time, as their orbits are greater or lefs. If then they moved round the earth, they muft revolve in unequal times, according to their orbits; not all in the fame time, in four and twenty hours, as they feem to do. Therefore, they do not move round the earth, but the earth, as the reft, round its own axis.

That it moves alfo round the fun, appears thus. All bodies, which turn round each other, muft gravitate towards each other: confequently if the fun gravitates to the earth, fo muft the earth to the fun. Now it is demonftrable, that when two bodies gravitate to each other, without approaching each other in right lines, they both turn round their common center of gravity. But the earth being no more than a point to the fun, the common center of thefe two bodies, will be within the body of the fun itfelf, and not far from the center of it. The earth therefore turns round a point which is in the fun: confequently round the Sun. Indeed to fuppofe the earth at reft, deftroys all the order and harmony of the univerfe, annuls its laws, and fets every part at variance with the others. It renders the motions of the planets utterly inexplicable, which are otherwife plain and fimple.

Nor is the motion of the earth, whatever is vulgarly fuppofed, contrary to any part of the fcripture. No other ideas are to be affixed to the words of fcripture, than fuch as occur to one who looks at the thing fpoken of. By the fun's rifing therefore when mentioned in fcripture, we are to underftand no more than the fun's appearing again in the horizon, after he had been hid below it: and by his fetting, his ceafing to appear. And when the fun and moon are faid to ftand ſtand ſtill, it means only, that they did not change their ſituation in reſpect of the earth: that the ſun ſtill appeared juſt *over Gibeon*, and the moon *over the valley of Ajalon*. If it be ſaid, " But David ſpeaks of the *Sun running its courſe*," we may anſwer over and above, the word here uſed does not mean the Orb or Body of the ſun, but always his Rays or Beams.

2 It is probable Sand was once the exterior cover of the whole earth. All our northern mountains are, more or leſs, covered with it at this day. And the higher the mountain, the coarſer the ſand. The rivers riſing in the mountains, ſtill daily bring it down in large quantities. And that it has been ſo in all ages, ſince the firſt rains fell on the earth, ſeems highly probable, in that the mouths of rivers, and entrances of harbours are uſually barred with it. And if you pierce deep into the low ground near rivers, you find this mountain-ſand in great quantities: it was the more fit to be the general cover of the earth, becauſe of its great hardneſs, and conſequently durableneſs. Mountain Sand above all other, not being made (as much Sand is) by attrition, ſteadily keeps its original figure and magnitude.

All Sands are either natural or fictitious. Natural Sands are thoſe which have been in the ſame or nearly the ſame ſtate from the creation, diffuſed through all the parts of the earth. Sand viewed in a microſcope, is no more than a parcel of little ſtones; doubtleſs therefore they muſt have begun to exiſt, and been formed by the ſame laws that ſtones were formed by. Now ſtones were formed firſt into hard and ſolid maſſes, in proportion to the quantity of ſimilar materials, and proper cement. Where there was a great quantity of lapideous particles, and few heterogeneous mixtures, there strata, rocks, and large stones were formed. But where the lapideous particles were scattered and disunited by the intervention of other bodies, there small rubble, stones, gravel, grits, and the smallest and most numerous of all stones, Sand, coalesced into minute glebes. This probably was the process in every part of the earth; so that Sand is one of the primæval bodies, concreted at the same time with stones, upon the highest mountains, as well as in the valleys; and at the bottom of the sea, as well as upon dry land.

Besides this natural Sand, there is also a fictitious one, which owes its origin to the fretting of river or sea-water. For water always in motion, preys upon the stones, and grinds them by degres into that stony powder which we call sand: hence it is that the sand of a particular stone, cove or bay, has generally the same colour, and in a microscope the same structure, as the rocks, and stones of the adjacent cliff, and the strata under the sea, upon which the waves are perpetually working, and driving into the sea what they dash off from those strata.

3. We have heard of large Bodies of Sand moving together in the desarts of Arabia. But has any thing of the kind been known in England? There has, and that very lately, It is not a century, says Mr. Wright, since our Sands, near Dewnham, in Suffolk, first broke prison. In a warren near Lakenheath, an impetuous south west wind having broken the Sand of some Sand-hills, the Sand blew upon the adjacent grounds, which being much of the same nature, the thin crust of barren

barren earth was soon rotted and dissolved by this Sand lying upon it, and thereby fitted to bear it company in its strange progress. At its first eruption the whole magazine of Sand could not cover above eight or ten acres of land. But it increased into a thousand acres before the Sand had travelled four miles. Above thirty years since it reached the pounds of this town, where for ten or twelve years it did no considerable mischief: because its course was then down the hill, which sheltered it from the wind that gave it motion. But the valley once past, it went above a mile (up-hill) in two months time. It over-run two hundred acres of good corn that same year. 'Tis now got into the body of this little town, where it has buried several houses. And the remainder have been preserved at more expence than they were worth. At the other end of the town divers houses are buried, and our pastures and meadows destroyed. A branch of the river Ouse, upon which we border for three miles together, is more than half filled up with sand. And had not this interposed to stop its passage into Norfolk, doubtless a considerable part of that county, had e're now been left a desolate trophy of this conquering enemy.

4. One of the most considerable parts of the earth is the Mountains. There is a remarkable irregularity in their figure, and (so far as we can judge) an entire neglect of order in their situation. The far greater part of them are hollow, and contain beds of stone, metals or minerals. And doubtless such there were from the creation, although perhaps not so high, steep, or rugged.

For theſe vaſt maſſes are not, as ſome have ſuppoſed, mere incumbrances of the creation: rude and uſeleſs excreſcences of the globe; but anſwer many excellent purpoſes. They are contrived and ordered by the wiſe Creator, for this grand uſe in particular, to diſpenſe the moſt neceſſary proviſion of water, to all the parts of the earth; without which neither animals could live, plants grow, nor perhaps foſſils receive any increaſe. For was the ſurface of the earth even and level, there could be no deſcent for the waters, but inſtead of gliding along thoſe gentle declivities, quite down to the ſea, they would drown large tracts of land, and then ſtagnate and putrify.

Indeed without hills, as there could be no rivers, ſo neither could there be any ſprings, which we continually find in or near high grounds, very rarely on ſpacious plains. When we do find any there, it is generally at great and inconvenient depths. And even theſe are probably owing to hills, either near, or at ſome diſtance: as we may gather from the impetuous manner wherein theſe ſubterraneous waters break out, when wells are dug in the Lower Auſtria, or in ſeveral parts of Italy. And if there are ſome iſlands, which ſeem void of mountains, and nevertheleſs are well watered, in reality the whole maſs of land is no other than one Mountain, deſcending gently and imperceptibly down, from the midland parts to the ſea.

5. The Benefit of Mountains in general is not only, that vapours driven againſt them are condenſed, ſo as to be precipitated through the chinks of the rocks, but that afterwards in their

bowels

bowels they are preſerved till they form rivulets, and then rivers. Vapours would fall in rain or dew though there were no Mountains, but then they would fall equally, over conſiderable places of the globe at once, and ſo would be ſucked deep in the ground, or make an univerſal puddle; whereas by means of Mountains they are perpetually pouring down in particular places, and treaſuring up a conſtant ſupply to the rivers. Another conſiderable uſe of them is the determination of theſe rivers; for if there could have been rivers without Mountains, yet they could only have run in a ſtrait line, if they had run at all; whereas by theſe eminences, placed up and down, they make innumerable turnings and windings, whereby they enrich, fatten, and water the ſoil of ſeveral different countries in one courſe, and at laſt diſembogue in ſeveral mouths into the ſea. Laſtly, moſt hills are the neſts of metals or minerals. Theſe by the efficacy of ſubterranean heat, converting the adjacent earths into their ſubſtance, grow as truly as animals or vegetables. I juſt mention their uſe for the production, ſhelter, and nouriſhment of ſome ſorts of vegetables and animals, which could not grow or live ſo well any where elſe. But from the whole we may ſee of what advantage theſe unſightly moles (as ſome thought them) are to the accommodations, and even neceſſities of life.

6. The Height of Snowden Hill, ſuppoſed the higheſt in Great Britain, is 1240 yards. But Skiddon Hill in Cumberland is 1760 yards high from the level of the lake beneath. And Conagra, which riſes gradually from the head of the bay at St. Kilda, one of th iſlands of

 cotland,

Scotland, is 1800 yards high; ſo that this may juſtly be ſtiled the Teneriff of Great Britain. The Height of ſeveral Mountains in France is as follows:

		Feet
Bugarach in Languedoc		3888
Le Puy de domme	in Auvergne	4860
Le Courland	in Auvergne	5088
Le Coote	in Auvergne	5106
Le Cantal	in Auvergne	5904
Le Mont d'or	in Auvergne	6180
Le Mont Ventoux in Avignon		6216

The Height of the Pyrenean Mountains is,

St. Barthelemi	7110
La Montagne des Mauſſet	7548
Le Conigoe	8640

Probably theſe Mountains may vie in height with moſt in the known world. Yet above all theſe is the Stella Piz Hail, a ſteep Mountain in the Griſons, which is 9585 Paris feet above the level of the ſea; a Height which the wild goats themſelves ſcarce venture to aſcend.

But Mr. Martel informs us, that the higheſt point of Mont-Blanc is higher even than this: that it is 2076 toiſes above the level of the Rhone, which added to the Height of this above the ſea, makes 13115 Paris feet, or above two Engliſh miles, and two thirds of a mile. If ſo, this is the higheſt Mountain in Europe, and perhaps in all the world: unleſs you except Mount Atlas in Macedonia; which, according to the account of Riccioli, who meaſured it exactly, is 10,000 Italian paces high, carrying its top above the winds and clouds: a clear proof of which is, that whatever is written there in aſhes or light ſand, is found there, juſt as plain as at firſt, after ſeveral months or years.

"But

"But is not the celebrated Mount Atlas in Africa, the wonder of all ages, far higher than this?" One who saw it, and travelled all over it, is beſt able to anſwer this queſtion. He writes thus:

"Barbary is bounded on the ſouth by Biledulgerid, from which it is divided by Atlas, a chain of Mountains, but not of that extraordinary Height or bigneſs, which the antients attributed to it. Thoſe parts of them, ſays Dr. Shaw, which I have ſeen, are rarely, if ever equal to ſome of the Mountains of our own iſland, and cannot any where ſtand in competition with either the Alps or Appenines. Atlas is a number of hills, uſually 4, 5, or 600 yards high, with an eaſy aſcent, and groves of fruit and foreſt trees, riſing up one behind another. Only here and there is ſeen a rocky precipice, of a ſuperior eminence.

The rivers of Indus and Ganges, before they enter the ocean, contain between them a large Peninſula, divided in the middle by a ridge of high hills, which runs from eaſt to weſt, quite to Cape Comorin. On the one ſide is Malabar, on the other Coromondel. On the Malabar ſide it is ſummer from September till April; a clear ſky, and ſcarce any rain. This is winter on the Coromondel ſide, every day and night yielding abundance of rain. So that as you croſs the hills to St. Thomas, in little more than twenty leagues, you aſcend the hill with fair ſummer weather, and deſcend with a ſtormy winter. There is a like ridge of hills in Jamaica running from eaſt to weſt, through the midſt of the iſland. On the ſouth ſide of theſe there is ſummer from November to April, on the northſide, winter, and ſo vice verſa.

Hence it appears, that not the leſſening the gravity of the atmoſphere only, is needful to produce

duce rain, but likewiſe either a change of winds or a ridge of hills, to drive the particles of the vapours together. And hence it is that while the wind blows from north-eaſt in Coromondel, and on the north-ſide of the mountains in Jamaica, there are continual rains, and conſtant fair weather on the ſouth-ſide of the Mountains, and in Malabar. Whereas while it blows from the ſouth-weſt, there are conſtant rains on the ſouth-ſide of the Jamaica Mountains and in Malabar; but conſtant fair weather on the north-ſide of thoſe mountains and in Coromandel.

This alſo may account for the ſingularity of ſeaſons in Peru, which run ſouthward from the line above a thouſand leagues. It is divided into three parts, long and narrow: the Lano's or plains, which run along the ſea-coaſts, the Sierra's, which are hills with vallies intermixed, and the Andes, which are ſteep and craggy Mountains. The Lano's are, ſome ten leagues in breadth, ſome leſs, and ſome more. The Sierra is twenty leagues in breadth, and the Andes the ſame. It is remarkable, 1. That in the Lano's, the ſouth and ſouth-weſt winds continually blow. 2. That they never have any thunder, hail, ſnow, or rain, only ſometimes a ſmall dew. 3. On the Andes it rains almoſt continually. 4. In the Sierra, which lies between, it rains from September to April, and is clear from April to September. The reaſon is plain; the conſtant wind blowing over the Lano's, finds nothing to ſtop it, and drive its vapours into rain. But the Andes continually intercept theſe vapours, and ſo occaſion continual rain. The Sierras being lower, intercept the vapours only from September to April, becauſe then the ſun being nearer the atmoſphere is lighter, and conſequently the vapours ſink lower.

In

In regard to this, there are two or three acts of Divine Providence, which are highly obſervable. One is, that all countries throughout the world ſhould enjoy the great benefit of Mountains placed here and there, at due and proper diſtances. According to the natural courſe of things, when the earth and waters were ſeparated, and ordered to their reſpective places, the earth would have been of one even ſurface. The ſeveral component parts thereof muſt have ſubſided according to their ſpecific gravities, and at laſt have formed a large, even ſpherical ſurface, every where equidiſtant from the center of the globe. But that inſtead of this form, it ſhould jet out every where into hills and dales, is a manifeſt ſign of the ſpecial providence of a wiſe Creator. Another ſign of this is, that throughout the whole earth, the parts fartheſt from the ſea are the higheſt: an admirable contrivance both for ſupplying all places with water, and for carrying off the ſuperfluity of it.

And as the Mountains themſelves are naturally diſpoſed to be drier than the low grounds, ſo nature has provided for them, a more plentiful ſupply of moiſture, unleſs for that very ſmall part of them which aſcends above the clouds and vapours. For beſide the fountains which water them continually, they have more rains and dews than the valleys. They are much more frequently covered by fogs; and by ſtopping and compreſſing the clouds, as well as condenſing them by their greater cold, they procure all the rain they want.

" But how were the Mountains formed after the flood had diſſolved the terraqueous globe?" Probably thus. The ſmaller hills might eaſily be aggregated

aggregated by the mere force of the water. But the Mountains being of a denser substance, seem to have been elevated from beneath, in a convex form, by the violent force of subterraneous wind, water, and fire, heaving them up, and scattering them abroad in so many protuberances. And if this was done before the substance of the stones became fixed and indurated, then it is no wonder that the external wind likewise should leave so manifest tokens of its vehement impetuosity, in the extent and outward figure of them. This gives an easy, natural account, for the innumerable fissures, chasms, and disruptions, whereby so many Mountains are as it were sawn asunder, either across or length-ways. And hence many such apertures in the Mountains, are filled with a slimy matter which was afterwards indurated. In some of the Mountains of Norway, this projects in a range, about an ell in breadth, betwixt the other stony strata, through the whole length or bulk of the Mountain, and from the variety of its colours, makes a very pleasing appearance. Of these veins, some consist of marble or alabaster, some of agate, some white, red, or blue stone, which especially towards the sea, where the rocks are bare, form many curious variegations. Hence likewise there remain on the surface many detached blocks and fragments, scattered not only in the valleys and creeks, but on the tops of the highest Mountains. Many of these are of the bulk of a common house, and consequently too ponderous, to have been raised to such an immense height, by the hands or art of men.

But the largest Mountains may have been formed in the following manner. The sea-waters doubtless remained some time on the earth: and during

during that time the surface of the earth was the bottom of the sea, where every thing passed in the same manner as passes at the present bottom of the sea. Now the sea has always had a flux and reflux, and that most violent under the equator, where likewise the earth's motion causes a greater centrifugal force than any where else. Suppose then the earth was at first quite round, yet its diurnal motion, with the flux and reflux of the sea, would have raised by degrees the parts near the equator, by amassing there shells, mud and earth. And as this is performed daily, the water would carry at each time a small quantity of matter, which afterwards sinks to the bottom, and forms those parallel strata, which are every where found.

Thus in fact. On many shores the flux brings a great number of things along with it, and leaves them there. So that while it insensibly covers some lands, it abandons others, after adding thereto shells, earth and sand, which gradually accumulating, make a part of the continent.

On a coast against which the sea beats violently, it carries a little soil away at each tide. Yea, even where it is bordered with rocks, it wears them away by little and little. These particles the waters carry to a certain distance, where they sink in the form of a sediment, and form the first stratum, which will soon be covered by another, and so with more and more. Hence in time a Mountain will be formed in the bottom of the sea, entirely like what we see on the land.

Such eminences lying in the same direction with the waves that produced them, form by degrees a chain of mountains. "But how come Mountains whose top is composed of rock, to have only earth

earth or ſand for their baſe, which may often be ſeen in the neighbouring plains, to a conſiderable diſtance?" We anſwer, the water firſt tranſported the ſand that formed the firſt layer at the bottom of the ſea. Afterward the more firm and weighty ſubſtances were attacked, and brought by the Waters in an impalpable powder. And this powder of ſtone formed the rocks which now cover theſe eminences.

Theſe cauſes act with more force under the equator, as the winds are there more uniform, and the tides more violent: and accordingly the greateſt chain of mountains is near the equator. Thoſe of Africa and Peru are the higheſt we know, which after traverſing whole continents, ſtretch to very conſiderable diſtances, under the waters of the ocean. The mountains of the north are not equal to theſe. Moreover the number of iſles in the northern ſeas is inconſiderable, while there is a vaſt quantity under the torrid zone: and an iſland is no more than the top of a mountain.

It is then doubtleſs the general flux and reflux of the ſea, which has produced the greateſt mountains. But others we may aſcribe to currents, winds, and other irregular agitation of the ſea, which muſt by their various combinations, infinitely vary the direction of the tides. They are the ſmalleſt of all which owe their riſe to earthquakes, or other accidental cauſes.

But how ſhall we account for the formation of the Iron Mountain, near Taberg, in Sweden? It is ſituated in a mountainous part of the country, covered with ſand, near forty leagues from the ſea. It is an entire maſs of rich iron ore, the perpendicular

perpendicular height whereof is above four hundred feet, and its circumference three English miles. Oppoſite to it is a valley, through which flows a ſmall river. No ore is found beyond the foot of it, nor on the neighbouring plain, ſo that it appears as if the mountain had been artificially laid on the ſand. For it has no roots like other mountains, nor does its ſubſtance penetrate the ground. It has all over, many perpendicular and horizontal fiſſures, filled with pure ſand: in the inner parts whereof bones of ſtags and other animals are found.

No hypotheſis hitherto advanced to account for the formation of mountains, will at all account for this. The bones found therein ſhew it was owing to ſome ruinous cauſe. But what that cauſe was, muſt in all probability ever remain a ſecret.

No leſs unaccountable are ſome of the mountains in Iceland, termed by the natives, Jokeler. From the tops of theſe continually flow large ſtreams of a thick, ſooty, ſtinking water. Theſe occaſion lakes which increaſe in bulk, and again diminiſh, and change their appearance almoſt every day. Hence paths are ſeen in the ſand made by travellers that paſſed the day before. When followed, they lead to a large pond or lake, which obliges them to go two or three miles round, and then they come to the very path oppoſite to that which they were obliged to leave. But in a few days the lake is, as it were vaniſhed, and the uninterrupted path appears again.

7. A body that yields eaſily to the touch, and whoſe parts making but little reſiſtance againſt being

being divided, move among themſelves with great facility, is uſually termed a Fluid. Liquids are a ſort of Fluid which aſſume the figure of the veſſels they are contained in, and always keep their upper ſurface in a plain, parallel to the horizon. Such are Water, oil, mercury, which are diſtinguiſhed from other fluids, by the paralleliſm of their ſurface, in conſequence of their weight, and the inteſtine motion of their parts all manner of ways. That they have ſuch a motion, plainly appears, from their diſſolving hard bodies. Put a piece of copper into a glaſs of Aqua-fortis, and there is firſt an efferveſcenſe, then the copper diminiſhes, and at laſt diſappears. And what ſtrong waters are with regard to metals, other liquids are to other ſubſtances. Each of them is a diſſolvent, more or leſs, according to its component particles. Now it is plain that diſſolution ſuppoſes motion, and is the effect of it. There is therefore in all liquors an inteſtine motion, from which this effect reſults.

Water is a tranſparent liquid, capable of heat and cold, and of being rarefied into vapour. But it is not capable of being condenſed, by any method yet known. It is of itſelf without ſmell or taſte, and liable to putrifaction. It is heavier by many degrees than air, and inſinuates where air cannot enter. Theſe properties do unqueſtionably depend on the figure and texture of its parts. But theſe, after our moſt curious reſearches, it is not poſſible to know with certainty. Dr. Boerhaave ſays, No one ever yet ſaw a drop of pure water. It is never pure from ſalts. For all Water contains air, and all air contains ſalts.

The particles of Water are generally allowed to to be round. This figure indeed is probably inferred from its fluidity. Allowing then the particles of it to be round, fluidity muſt be an eſſential property of all quantities and aſſemblages of it. For take any maſs of round bodies, (bullets for inſtance, pebbles, or the like) they will not cohere or reſt by one another without force, but will flow on every ſide, till they meet with ſuch reſiſtance from external bodies, or their internal gravitation, as ſhall prevent farther motion.

The particles of water are unalterable, for paſſing into ſo many bodies, and through ſuch alternate extremes of heat and cold, if they had not preſerved their eſſential properties conſtantly, moiſture ſince the beginning of the world, muſt have very ſenſibly diminiſhed. But ſeeing no ſuch deficiency appears, and that ſprings, rains, and rivers, are as abundant now as they antiently were (as by the riſing of the Nile for many ages, among other reaſons may appear) we are to conclude, though waters may be tranſplanted, they can neither be tranſmuted nor deſtroyed. And wherever removed they will make their appearance again when at liberty, in the ſame liquid ſtate as they were before.

The particles of water are exceeding ſmall: for they may be ſo divided from each other, that one ſquare inch of common water ſhall when rarified, fill a ſpace of 14000 ſquare inches. And it is computed that at leaſt 13000 particles of Water may be held on the point of a needle. By this it appears, that what we call water is an aſſemblage of ſmall tranſparent globules, which are compoſed again of an infinite number of ſmaller particles or atoms of this elementary liquor.

Water

Water ſeems to be diffuſed every where, and mixed with all bodies. Fire itſelf is not without it. Place ſalt of Tartar near the hotteſt fire, and it will imbibe Water, and thereby in a ſhort time, conſiderably increaſe in weight. So a pewter veſſel with ice in it, brought up from a cold vault into the hotteſt room, in a dry ſummer-day, is immediately covered with little drops of Water, which is gathered from the air, and condenſed by the coldneſs of the ice.

Indeed the quantity of Water which is afforded by the dryeſt bodies is ſurprizing. Oil of vitriol long expoſed to violent fire, to ſeparate it from all its water, by only ſtanding a few minutes in the air, will afford as much as at firſt. Hartſhorn kept forty years, and turned as hard and dry as any metal, ſo as to ſtrike fire with a flint, yet diſtilled in a glaſs veſſel, will yield an eighth part of its quantity in water. Bones dried five and twenty years, and almoſt as hard as iron, have by diſtillation yielded half their weight in water. Yea, the hardeſt ſtones, ground and diſtilled, always afford a portion thereof. All animals and vegetables grow out of water and ſalts, and by putrifaction return to the ſame.

The chief properties of Water are, 1. It is next to fire, the moſt penetrative of all bodies. So that a veſſel through which Water cannot paſs, will contain any thing. Only ſome oils will paſs through thoſe wooden veſſels, which contain water. Not that their particles are more penetrative; but thoſe woods abound with rozin. This the oil diſſolves, and then makes its way through the ſpaces left thereby. Water alſo by degrees makes its way through all wood, and is

only

only retainable by glaſs and metals. It finds its way where air cannot, as through leather, which air cannot penetrate. Again. Air may be retained in a bladder: but water oozes through. Yea, experiments ſhew, it will paſs through pores ten times ſmaller than air will. By this very quality it is fitted to enter into the compoſition of all bodies, animal, vegetable, and foſſile; with this peculiar circumſtance, that by a gentle heat it is ſeparable from them again. By this, joined with its ſmoothneſs, it is fit to convey the nutritive matter of all bodies. Paſſing ſo readily, it never ſtops up the pores, but leaves room for the following ſupplies. And yet 2. Water, which ſo eaſily ſeparates from moſt bodies, firmly coheres with ſome: yea, binds them together in the moſt ſolid maſſes. So mixed with aſhes, it gives the utmoſt firmneſs. The aſhes, for inſtance, of an animal, wrought up with pure water into a paſte, and baked with a ſtrong fire, grows into a coppel, which bears the utmoſt heat of a refiner's furnace. It is in truth, by the glutinous nature of water alone, that our houſes ſtand. For take this out of wood, and it becomes aſhes; out of tiles, and they become duſt.

Indeed all the ſtability and firmneſs in the univerſe, are owing to Water alone. Thus ſtone would be incoherent ſand, did not Water bind it together. And thus of Water and clay we make earthen veſſels, of the utmoſt hardneſs and cloſeneſs. And theſe, though appearing perfectly dry, yield when diſtilled, an incredible quantity of Water. The ſame holds of metals, parings or filings, which by diſtillation, yield water plentifully. Yea, the hardeſt ſtones, ſea-ſalt, nitre, vitriol,

vitriol, are hereby ſhewn to conſiſt chiefly of Water.

Hence we learn, that the component particles of Water are, 1. Infinitely ſmall, whence their penetrative power. 2. Exceeding ſmooth and ſlippery. Hence their fluidity, and eaſy ſeparation from other bodies. 3. Extremely ſolid. 4. Perfectly tranſparent. 5. Hard, rigid, and inflexible: as appears from the abſolute impoſſibility of compreſſing them.

Salts melted in water, do not fill the veſſel in proportion to their bulk. It follows, that there are ſpaces between the particles of Water, to admit thoſe of the ſalt. Hence alſo we gather, that the watry particles are extremely ſolid and inflexible, ſince notwithſtanding thoſe ſpaces, no power can compreſs, or force them nearer each other.

8. When the particles of Nitre that float in the air, wedge the particles of water together, they become Ice. The air lodged in the pores of the water, is then greatly expanded. Hence the water is lighter than before: but at the ſame time it is leſs tranſparent: perhaps becauſe the paſſage of light is hindered by the interpoſal of theſe nitrous particles.

It is obſervable. 1. That all liquids, except oil, dilate in freezing and grow lighter. Nay, even after they are thawed, they are conſiderably lighter than before: 2. That water will not freeze *in vacuo:* 3. That water which has been boiled does not readily freeze: 4. That water covered with oil of olives does not freeze readily; covered with nut oil, not at all: 5. That nut oil, oil of turpentine and ſpirits of wine will not freeze at all: 6. That frozen

frozen water is covered with wrinkles, ſomething like rays drawn from a center to the circumference.

Though fluids are dilated near a tenth of their length, metals are ſhortened by froſt. If veſſels made of metals, however thick and ſtrong, be filled with water, cloſe ſtopped, and expoſed to froſt, the water will burſt the veſſels. A ſtrong barrel of a gun, thus filled and ſtopped, will rend the whole length.

Dr. Plot obſerves, that rivers are always found to freeze firſt at their bottom. The ſame is obſerved by watermen in the Thames, who not only feel it at the bottom with their poles, ſome days before the ſurface is froze over, but ſee it riſe up from the bottom, ſo as to dart up in pieces edgeways, half a foot, ſometimes a foot above the ſurface. In this poſture it continues a little time, and then turning flat upon the water ſwims along the ſtream, till it meets with other pieces, which if the froſt continues, all harden into one, till the river is froze over.

" In a part of the Thames, where there was very little ſtream, I found the water, (ſays Dr. Hale) in a cold morning froze one fifth of an inch thick, under which I ſaw a bed of Ice at the bottom. Breaking away ſome of the upper Ice, I took up ſome of the lower Ice, which was about half an inch thick. It adhered cloſe to the bottom, where the ſtones and ſand were incorporated with it. When it freezes to a conſiderable thickneſs, it will raiſe up with it from the bottom, the fiſhermen's oſier wheels, although they are ſunk down with ſtones or bricks tied to them.

"Standing waters indeed freeze firſt at top, becauſe they are coldeſt there: whereas in a ſtream the upper and lower waters being continually blended together, are equally cold; and the upper water meantime having more motion, cannot freeze ſo ſoon. But here, where the motion of the water was ſo ſmall, its ſurface was froze as well as the bottom, though not ſo thick: whereas the main river, where its motion was greater, was not froze over, though cakes of Ice were continually riſing from the bottom."

It has been commonly ſuppoſed, that fluids not only dilate, but evaporate by cold. And this has long paſſed for an inconteſtible truth. Yet it is altogether a miſtake. From later experiments it undeniably appears, 1. That cold does not increaſe but leſſen the evaporation of water, if it be not expoſed to the agitation of the air: 2. That the evaporation of water depends on an inteſtine motion, which it preſerves as long as it is liquid, and that the air only contributes thereto, by continually tranſporting the particles detached from the ſurface, and thereby giving other particles room to diſengage themſelves: 3. That frozen water does not evaporate at all, if it be kept from the agitation of the air: 4. That the diminution obſerved in Ice expoſed to the open air, is not from any evaporation, but is the effect of a fine raſping by the wind, rubbing againſt it and carrying off its finer particles. And what is thus detached from Ice is only a very fine duſt, not more different from Ice than the duſt of free-ſtone, cut from the ſtone itſelf.

This duſt carried by the wind produces intenſe

cold.

cold. Nor is it always invisible. The air near Hudson's Bay is often filled with particles of Ice, fine as hairs, and sharp as needles; which if they strike against the hands or face, pierce the skin and occasion painful blisters.

The natural state of this globe seems to be in an intermediate degree between heat and cold. And this natural warmth of the earth is what secures many springs from being frozen: the frost in England seldom penetrating the earth, more than fourteen inches below the surface. Even in Sweden bubbling springs do not freeze at all, while the standing waters freeze three ells deep.

In the lakes of Sweden the Ice often cracks, with a rupture nine or ten feet deep, and many leagues long, and with a noise like cannon. Hereby the fishes get air, so that few of them are destroyed. In Moscow the earth is often cleft by the frost, a foot broad and many yards long. In the mountains of Switzerland, there are vast masses of ice, which have lain there for many centuries. At certain times these crack, and by those cracks one may guess at the immense thickness of them: some of the cracks being three or four hundred ells deep, though none of them have ever gone through the whole thickness of the Ice.

We need not then be surprized, at the effects of severe frost on trees and other vegetables. How these are hurt in hard winters is easily understood, if we consider, that water when frozen, takes up more space than it did before: that all trees, especially those that shed their leaves, drink in a large quantity of moisture in summer, and that the vessels of small twigs are larger in proportion than those of the trunk, and consequently contain more moiſture. It follows, that being ſurprized by an hard winter, before their juices are diminiſhed, or changed into a glutinous nature, which does not ſo eaſily freeze: the veſſels of the tree muſt neceſſarily burſt. Conſequently their juice muſt be extravaſated, and ſo cauſe, as in animals, the death of the tree, by a kind of bleeding, which nothing can ſtop.

In the great froſt in 1683, oaks, aſhes and walnut-trees were cleſt in two, and frequently with a terrible noiſe, and not only their bodies, but their branches and roots alſo. In 1708, the froſt was almoſt through all Europe, except Scotland and Ireland. All the orange-trees and olives in Italy, Provence and many other countries periſhed, and all the walnut-trees in France, with an infinity of other trees. In England moſt of the bay-trees, hollies, roſemary, and even furze periſhed. The ſap alſo of wall-trees ſtagnated in the branches, and produced diſorders reſembling chill-blains. And the very buds of the finer trees were quite killed, and turned into a kind of mealy ſubſtance.

• In 1728, toward the end of November, the wind blew exceeding cold, followed by ſo heavy a ſnow, as in one night broke off large arms of many ever-green trees. At this time alſo, there was a great number of large trees diſbarked. Two Weſt-India Plane-trees, in particular, in the phyſic-garden at Chelſea, which were near forty feet high, and a fathom in circumference, were diſbarked almoſt from the bottom to the top, on the weſt ſide of the trees. And it was obſervable, that whatever trees were diſbarked, it was on the weſt or ſouth-weſt ſide.

On

On the fourteenth of December, 1759, there was at Peterſburg, the moſt exceſſive cold weather that ever was known, even to 205 degrees of De Liſle's Thermometer. At that time Profeſſor Braun repeated Fahrenheit's experiments, in order to produce exceſſive cold by means of Spirit of Nitre combined with ſnow. He ſaw with ſurprize, the quickſilver in the other Thermometer deſcend even to 470 degrees: there the quickſilver remained fixed in the open air, for the ſpace of a quarter of an hour, and did not begin to riſe, till it was carried into a warm room. He repeated the ſame experiment, firſt with the ſame, and then with another Thermometer, with the ſame ſucceſs. But as Mr. Braun had not broken the glaſſes, he could only at that time form a conjecture. On the 17th he produced again cold equal to that of the 14th, and communicated his diſcovery at a meeting of the Academy. On the 25th of December in the morning, between nine and ten, De Liſle's Thermometer was at the 199th degree of cold, and Mr. Braun, as well as Profeſſor Æpinus, repeated this experiment. As ſoon as the former obſerved the quickſilver immoveable in the Thermometer, he broke the glaſs, and found the quickſilver frozen, but not entirely: Mr. Æpinus's Thermometer fell with extreme rapidity, almoſt to the 500th degree, and in breaking the glaſs from below, he found the quickſilver contained in it abſolutely frozen. Both the gentlemen found, that the quickſilver, thus rendered ſolid, bore hammering and extenſion, like other metals; but being expoſed to the open air, it recovered its former fluidity in a little time.

Mr.

Mr. Æpinus went farther, to examine the quickſilver when it was made ſolid. He poured quickſilver into a glaſs tube, as thick as one's finger, cloſed at the bottom, but open at top. The quickſilver in this cylinder, which was about one inch and half long, froze in three quarters of a minute; and became ſolid, perfectly reſembling other metals. Mean time it continually contracted, its ſurface, which was at firſt pretty high, ſoon ſunk very low, and the cylinder of frozen quickſilver ſunk to the bottom of the fluid quickſilver. We know the contrary happens to water frozen and other fluids, which extend as they become ſolid, and their ice ſwims in the fluid matter, of which they were produced.

The bodies of Ice in the northern ſeas, near Hudſon's Bay are ſurprizing: ſome of them are immerſed an hundred fathoms or more, under the ſurface of the ocean. They ſtand a fifth or ſixth part above, and are three or four miles in circumference. Theſe floating mountains owe their durable nature, to a cauſe not uſually obſerved; that is, to their not being common ice, but the ice of ſea-water. If a phial of ſea-water be expoſed to the air in froſty weather, till flakes of ice are formed therein, and then ſet in a warm room, ſtill the flakes will remain a long time undiſſolved, and if they are taken out, and expoſed at a ſmall diſtance to the fire, they will not run into water, as common ice would do, but will by degrees evaporate, leaving only a little white ſalt. It is eaſy then to conceive, that the immenſe maſſes of this Ice, found in the Northern Seas, will continue undiſſolved throughout the year, and at the return

of

of the freezing ſeaſon, grow larger and larger every year, by the freezing of more Ice about them.

On the contrary, there are ſome waters, which will not freeze at all. The Lake Neſs in Scotland never freezes, be the winter ever ſo ſevere. Yea, while every thing round is frozen, its water run ſmoking for ſix miles down the river into which they are diſcharged; and from this ſmoke there riſes a ſort of fog, which overſpreads the country, for ſeveral miles. Near the lake is a mountain, on the ſummit of which there is another lake, which is always full, ſummer and winter. Due weſt from the river, there is another lake, two miles long and ſix broad. The middle of this is ſometimes dry, and then plainly appears to have been once an inhabited country. There are many tumuli to be ſeen under water, one of which is acceſſible at low water. And in this urns have been found, which leave no room to doubt of their having been burial places.

There are likewiſe in Scotland other lakes, which freeze only at peculiar ſeaſons. A little lake in Strathérick, never freezes over, be the froſt ever ſo ſharp till February. But after the firſt part of this month, a ſlight froſt will freeze it over in a night's time. There are alſo two other remarkable lakes in the ſame country. The one Loch Monan, which is conſiderably large, obſerves the ſame rule, freezing over in February with a ſlight froſt, but never before, be the ſeaſon ever ſo rigorous. The other in Straglaſh has a contrary quality. It lies between two high hills, and is itſelf conſiderably above the level of the reſt of the country.

This freezes continually, having Ice in the middle, even in the hottest summer months, while the sun by reflection from the hills on each side, gives a very considerable heat. There are many other lakes in the neighbouring country which yet have no such property: so that this, and the property of the two other lakes, must be owing to some peculiar cause. The herbage about the sides of the lake last mentioned, has a kind of perpetual spring, which continues throughout the whole year, and is much esteemed by the country people, for feeding cattle in one month, more than the best land in the country will do in two. The lake is very deep, and the water does not manifest any particular quality.

9. Rain and snow which rise in vapours, both from the earth and waters, descending on hills, sink through the earth, till they meet with a bed of clay or stone. This retains the water and gathers it together, in a larger or smaller bason, till running over the edge, it makes itself a way, and rises in a Fountain. Hence issues a rivulet, many of which joining together, constitute a River, which continues its course, till it empties itself into the grand receptacle of water, the sea.

But it has been asked, "Is there a sufficient quantity of vapours raised, in the ordinary course of nature, to supply the demand of Fountains and Rivers?" We answer, there is abundantly sufficient, from the surface of the sea alone, leaving the earth out of the account. For it has been shewn by clear experiments, 1. That water salted to about the same degree as sea-water, and exposed to a heat equal to that of a summer's day, did

did from a circular ſurface, eight inches in diameter, evaporate ſix ounces in 24 hours. If ſo, the thickneſs of a ſkin of water evaporated in two hours, is the 53d part of an inch. But were it only a 60th, it would exhale the tenth of an inch in two hours. And on this principle every ten ſquare inches of the ſurface of water, yield in vapour a ſquare inch of water daily: each ſquare foot half a pint: every ſpace of four foot ſquare, a gallon: a mile ſquare 6914 tons: a quantity abundantly ſufficient to furniſh, both dews, rains, ſprings, and rivers. So that we need not have recourſe for ſupplies to the great abyſs, whoſe ſurface, at high water, is ſurmounted ſeveral hundred feet, even by ordinary hills: and ſome thouſands, by thoſe vaſt mountains, from whence the largeſt rivers take their courſe.

Nevertheleſs we may allow a different riſe to thoſe ſprings, which ebb and flow with the ſea: as likewiſe to thoſe lakes whoſe water is ſalt, and which have ſea-fiſh in them, although they have no communication with any ſea, by any viſible paſſage.

To explain this a little more at large. It is evident from experience, that a vapour is perpetually riſing from the ſea, rivers, and lakes. The winds carry this vapour through the atmoſphere, in the form of a cloud or miſt. When it meets with a colder air, or is ſtopt by mountains, it condenſes, and falls to the earth. As it falls, it finds ſeveral chinks and crannies, through which it inſinuates into the mountains, and lodges there, till increaſing its ſtore, it burſts out and takes the name of a Fountain.

That this is really the caſe, will eaſily be allowed, by all who ſeriouſly conſider, 1. That the vapours rising from the sea, are more than sufficient to supply both the surface of the earth, and the rivers with water, 2. That the mountains by their particular structure, arrest the vapours that float in the atmosphere, and having collected them in their reservoirs, dismiss them again through their sides, either in perpetual or intermitting currents.

With regard to the first, it has been shewn, that every ten square inches of the surface of the sea, yields a square inch of water daily; every square mile 6914 tons: and pursuing the same proportion, every square degree (or sixty nine English miles,) will yield 33 millions of tons. Now if we suppose the Mediterranean to be 40 degrees long, and 4 broad at a medium, (which is the least we can suppose) its surface will be 160 square degrees: from whence there will in summer evaporate daily 5280 millions of tons.

The Mediterranean receives water, (to say nothing of small and inconsiderable streams) from eight large rivers, the Iberus, the Rhine, the Po, the Danube, the Neister, the Borysthenes, the Tanais and the Nile. Now suppose each of these conveys ten times as much water to the sea as the Thames. The Thames has been shewn to pour daily into the sea 203 millions of tons. Therefore all those rivers will produce 1827 millions of tons. But this is little more than one third of the quantity daily evaporated from the sea. How prodigious a quantity then remains for rains and all other purposes?

Let us observe, Secondly, how the mountains arrest, and collect these vapours, and then discharge them in springs.

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The tops of mountains in general abound with inequalities, cavities, grottos and gaping cells. The floating vapours are ſtopt by theſe and by their pointed ſummits, and being condenſed thereby, precipitate in water, eaſily penetrate through ſand and lighter earth, and gather in baſons of clay or ſtone, till they overflow and work a paſſage through the ſide of the mountain.

And yet we need not deny, that ſome ſprings may ariſe from the ſea, or the great abyſs: thoſe in particular, which at all times afford the ſame quantity of water. Some of theſe are found in almoſt every country. There is one near Upminſter in Eſſex; which in the greateſt droughts, and when all the brooks are dried up, is little, if at all diminiſhed. And in the wetteſt ſeaſons, it is not increaſed, unleſs violent rain falling into it, or running into it from the higher grounds, raiſe it for a day, or a few hours.

As to the manner how the water riſes in ſuch ſprings it may eaſily be repreſented, by putting a ſmall heap of ſand in a baſon, and then pouring in water. Here the ſand will repreſent the dry land, and the water the ſea round about it. And as the water in the baſon riſes, to or near the top of the heap, juſt ſo do the waters of the ſea riſe, to the top of the land with which it communicates,

10. Some think the earth entirely covered the Sea, till at the deluge *the fountains of the great deep were broken up.* And it is highly probable, there is ſtill an abyſs of waters within the earth, which has an uninterrupted communication with ſome part of the outward ſea.

The immediate cauſe of the deluge, was probably that comet, which (as Mr. Whiſton ſhews) paſſed toward the ſun, juſt before the earth, on the firſt day of the deluge. The conſequence of this muſt be, that when it came below the moon, it would raiſe a vaſt and ſtrong tide, both in the waters that were on the antediluvian earth, and alſo in the great abyſs, which was under the cruſt of the earth. This tide muſt increaſe all the time that the comet was approaching toward the earth; and would be at its greateſt height, when the comet was at the leaſt diſtance from it. By the force of this internal tide, as well as by the attraction of the comet; the abyſs which was nearly round before, would then become oblong. And this muſt immediately extend, and then burſt the incumbent cruſt. And thus, according to the expreſſion of Moſes, *the fountains of the great deep were broken up.*

Again. As the ſame comet for a conſiderable time involved the earth in its atmoſphere, it muſt have loſt a vaſt quantity of its vapours, moſt of which would fall on the earth in violent rain. And thus *the windows of heaven were opened.* To remove this vaſt orb of water, he ſuppoſes a mighty wind to have riſen, which dried up ſome, and forced the reſt into the abyſs again, through the clefts by which it came up. Only part of it ſtayed in the channel of the ocean, now firſt made to receive it, and in the leſſer cavities, placed up and down on the ſurface of the globe.

The preſent diſtribution of the waters and the dry land, though it may ſeem rude and undeſigned to a careleſs view, yet is admirably well adjuſted to the uſe and conveniences of our world. In the firſt place, they are ſo diſtributed all the world over, that there is a juſt æquipoiſe of the whole globe.

globe. The Northern balances the Southern Ocean; the Atlantic, the Pacific Sea. The American dry land is a counterpoiſe to the European, Aſiatic, and African. In the next place, the waters are ſo admirably well placed about the globe, as to afford ſufficient vapours for clouds and rain, to temper the cold of the northern and ſouthern air, to mitigate the heats of the torrid zone, and to ſupply freſh waters to fountains and rivers. Nay, ſo abundant is this great bleſſing, that we have more than a bare ſufficiency, even a ſurpluſage of this uſeful creature: and yet ſo well ordered, as not to drown the earth, not to ſtagnate, putrify or annoy its inhabitants; but to glide gently through convenient channels back again to its grand fountain, the Sea: and many of the rivers through ſuch large tracts of land, and to ſuch prodigious diſtances, that it is a wonder the fountain ſhould be high enough, or the ſea low enough for ſo long a conveyance. Witneſs the Danube and Wolga in Europe, the Nile and Niger in Africa, the Ganges and Euphrates in Aſia, with the Amazon's River and Rio de la Plata in America. No accidental currents or alterations of the waters themſelves, no art or power of man, nothing leſs than the power of the Almighty, could ever have made or found, ſo long and commodious declivities and channels, for the paſſage of thoſe waters.

11. The largeſt Rivers of Aſia, are, the Hoanho, in China, which is eight hundred and fifty leagues in length: the Jeniſca of Tartary, about eight hundred leagues in length, from the Lake Selinga to the Icy Sea: the Oby in Siberia, of near eight hundred leagues, running from the

Lake

Lake of Kila into the Northern Sea: the Amour in Eaſtern Tartary, whoſe courſe is about five hundred and ſeventy-five leagues, from its ſource to its entrance into the Sea of Kamtkatſka: the Kiam in China, five hundred and fifty leagues in length. The Ganges, one of the moſt noted rivers in the world, is about as long as the former: it is viſited annually by ſeveral hundred thouſand pilgrims, who pay their devotions to the river as to a god; for ſavage ſimplicity is always known to miſtake the bleſſings of the Deity for the Deity himſelf. Next to this may be reckoned the celebrated river Euphrates: this riſes from two ſources northward of the city of Erzerum in Turcomania, and unites about three days journey below the ſame; from whence, after performing a courſe of five hundred leagues, it falls into the Gulf of Perſia. The river Indus is extended, from its ſource to its diſcharge into the Arabian Sea, four hundred leagues.

The largeſt rivers of Africa, are, the Senegal, which runs a courſe of eleven hundred leagues: and the celebrated river Nile, ſaid to be nine hundred and ſeventy leagues from its ſource in Upper Ethiopia, to its opening into the Mediterranean Sea.

This river, which the natives call Abava, that is, the Father of Rivers, riſes firſt in Sacala, a province of the kingdom of Goiama, the moſt fruitful in all Abyſſinia. In the eaſtern part of this province, on the declivity of a mountain, are two ſprings, each about two feet diameter, a ſtone's caſt diſtant from each other, which are the real ſource of this celebrated river. Its waters, after the firſt riſe, run eaſt about a muſket-ſhot; then turning to the north, continue hid in the

the graſs and weeds, for about a quarter of a league, and diſcover themſelves for the firſt time among ſome rocks, a pleaſing ſight to thoſe who have read the fabulous accounts of the ancients. It flows thence with a very ſmall ſtream, but ſoon receives ſuch an increaſe from various rivulets, that not above three days journey from its ſource, it is near a mile broad. After running nine or ten leagues farther, it enters the Lake of Dambia. It croſſes this at one end, with ſuch rapidity, that the waters of the Nile may be diſtinguiſhed through the whole paſſage, which is ſix leagues. Fifteen miles farther it ruſhes from the top of an high rock, and forms one of the moſt beautiful caſcades in the world. The fall of this mighty ſtream from ſo vaſt an height, makes a conſiderable noiſe. Yet the neighbouring inhabitants are not deaf, but hear juſt as well as others. After this cataract, the Nile again collects its ſcattered ſtream, and flows on through various nations. Hence we may learn, that it is impoſſible to arrive at the ſource of the Nile, by tracing its channel from the mouth, there being ſo many cataracts in the way, which no veſſel can paſs.

In Abyſſinia from June to September, there is no day without rain. Now the Nile receives in its courſe all the brooks, rivers, and torrents, which flow from the Abyſſian mountains. Theſe neceſſarily ſwell it above the banks, and fill the plain of Egypt with the inundation. This comes regularly in the month of July, that is, three weeks, after the beginning of the rains in Ethiopia.

The water of the Nile is ſo delicious, that the Turks excite themſelves to drink of it by eating ſalt. When the Egyptians leave their country, they ſpeak of nothing but the pleaſure they ſhall

find

find at their return, in drinking the Nile water. All thoſe who have taſted of it, allow, that they never met with the like in any other place. In truth, when one drinks of it the firſt time, it ſeems (ſays Maſerier) to be ſome water prepared by art. It has ſomething in it inexpreſſibly agreeable and pleaſing to the taſte. But to ſome, it appears to have too much ſweetneſs. It is likewiſe ſalutary in the higheſt degree. Drink it in what quantities you will, and it never incommodes you.

It ſeems peculiar to the water of the Thames, that in eight months time it acquires a ſpirituous quality, ſo as to burn like ſpirits of wine. Even when it ſtinks, it is not unwholeſome: men who were obliged to hold their noſes, yet drank of it all the way to the Eaſt-Indies, and found no inconvenience. If you take out the bung from any caſk that ſtinks, and let the air come in, it will be ſweet in twenty-four hours. If you take a broom-ſtick, and ſtir it well, it will be ſweet in four or five hours. It caſts a black lee to the bottom, which remixing with it, cauſes a third or fourth fermentation, after which it ſtinks no more. But though Thames Water does not putrify when it ſtinks, moſt other water does, and is at that time very dangerous to drink.

The Cataracts of the Nile are probably leſs remarkable than that of Niagara, in Canada. The fall of this is about ſix leagues from Fort Niagara. The whole courſe of the river for two leagues and an half below the great fall, is a ſeries of ſmaller falls, one under another. The rocks of the great fall croſs the river in almoſt a ſemicir-

cle.

cle. Above the fall, in the middle of the river, and parallel with the ſides of it, is an iſland above four hundred yards long. The lower end of this iſland is juſt at the perpendicular edge of the fall. On both ſides of this iſland runs all the water that comes from the lakes of Canada, which indeed are rather ſeas than lakes, receiving many large rivers. When the water approaches the iſland, it runs with an amazing ſwiftneſs, and before it comes to the fall, is quite white, and in many places is thrown high into the air. Looking up the river from the fall, you ſee it is exceeding ſteep, reſembling the ſide of an hill. When this vaſt body of water comes to the fall, it throws itſelf down perpendicular. To ſee this ruſh headlong down ſo prodigious a precipice, ſtrikes the beholder in a manner not to be expreſſed.

It falls one hundred and thirty-ſeven feet. When the water is come down to the bottom, it leaps back to a great height in the air: at a little diſtance it is white as ſnow, and boils like a cauldron. The noiſe of it in fair weather is heard fifteen leagues, yea, many times at Niagara. From the place where the water falls, abundance of vapour riſes, reſembling a very thick ſmoke. When it is calm this riſes high in the air. If you go into this vapour, in a few minutes you will be as wet as if you had been under water. In a calm morning, you may ſee it riſing in the air, at the diſtance of many leagues. And a perſon unuſed to it, would be apt to think, that all the foreſts thereabouts were on fire.

But of all parts of the world, America ſupplies the largeſt rivers. The foremoſt of theſe is the great river of Amazons, which from its ſource in the

the Lake of Lauricocha, to its discharge into the Western Ocean, performs a course of more than twelve hundred leagues. The breadth and depth of this river are answerable to its vast length; and where its width is more contracted, its depth is augmented in proportion. Next to this is that of St. Laurence, in Canada, which after a course of nine hundred leagues, pours its collected waters into the Atlantic Ocean. The river Missisippi is more than seven hundred leagues in length. The river Plata is more than eight hundred. The river Oroonoko is seven hundred and fifty-five leagues in length, from its source to its discharge into the Atlantic Ocean.

The glory of other rivers increases in proportion to the length of their course. With the Rhine it is quite the reverse. For some hundred miles it pours on with a vast force. But at Fort Scheneken it divides, and one half of its waters takes the name of Wahall. The Yssel robs it of another part, a little above Arnheim. About twenty miles lower, at the town of Duerstadt, it separates again. Here its principal branch takes a new name, and is called the Leck. The poor, little, stripped rivulet turns to the right, retaining still the old name of Rhine, and passes on to Utrecht, where it is divided a fourth time. There the Vetcht breaks off, and the little thread of water, still called the Rhine, passes quietly to Worden. At length it comes to Leyden, and faintly finishes its course, by losing the small remainder of its waters in two or three canals.

The cause of the Rhine's fate is well known. It was an earthquake which shook the Downs, in the

the ninth century, and filling the mouth of this river, forced it to return, and ſeek a new paſſage. The Leck was then ſcarce worth notice: but the waters of the Rhine, which were driven back, ſwelled and deepened its channel: and the entrance of the ſea has been ever ſince ſhut againſt the ancient courſe of the Rhine. It is ſuppoſed, that Zealand was then divided into the ſeveral iſlands we ſee now: and that thoſe lands, woods, and meadows, which were between Amſterdam and the Texel, were overflowed and covered with the waters ſtill remaining, and known by the name of the Zuyder Sea.

The Lake Baiacal, in Siberia, is the greateſt freſh water lake yet diſcovered. It extends in length above five hundred leagues, and is from twenty-five to eighty leagues in breadth. It is every where deep and navigable. The water is extremely clear, and abounds with fine fiſh. It receives abundance of rivers, but none runs out of it, beſides one, the Angara.

Salt Lakes are common in many parts of Siberia. Some contain a pure, white ſalt, fit for uſe, which in ſummer is chryſtallized by the heat of the ſun, and forms a cruſt on the top of the lake. Springs of ſalt-water ſometimes riſe in the midſt of freſh water. One of theſe riſes through a rock, in the bed of the river Angara. Thirty leagues above this, there is a hill thirty fathom high and two hundred and ten long, conſiſting entirely of rock-ſalt. There are ſome lakes, which were freſh ſome years ſince, but are now ſalt: ſome have by degrees dried up; others appear, where formerly it was dry ground. And ſome

ſome of theſe, which at firſt had no fiſh, are now plentifully ſtocked therewith. The natives ſay, ducks and other birds that live upon fiſh, carry their eggs from one lake to another.

Three leagues eaſt of Damaſcus is a lake ten or twelve leagues long, and five or ſix broad. This continually receives the waters of many rivers; yet never overflows its banks. Above thirty leagues from it, there is a river, which is called the Dog-River. From under a large, vaulted rock, through an opening twelve or fifteen feet high, and twenty or twenty five broad, iſſues continually a vaſt body of water, which gives riſe to this river. And it is the common opinion, that this body of water, comes from the lake, through a ſubterraneous channel: which is the more probable, becauſe the water of the lake and the river have the ſame qualities, and contain the very ſame ſorts of fiſh, (being cold, hard, and remarkably unwholeſome.)

Far different from this, is the water which riſes out of the ground, throughout the vaſt ſandy deſarts of the Mongal Tartars. Wherever you dig, there riſes freſh water. Were it not for this, they muſt have been altogether uninhabited, either by man or beaſt. It ſeems theſe ſprings are produced by the rains and melted ſnow in the ſpring. For the water ſinking in the ſand is thereby prevented from exhaling by the heat of the ſummer ſun, which muſt be very ſcorching in theſe deſerts, wherein there is not the leaſt ſhade to be found.

Beſides the rivers which run upon the ſurface of the earth, there are many which hide themſelves

ſelves in its bowels, and run in ſubterraneous ducts, till they diſcharge themſelves into the ſea. A remarkable one of this kind has been diſcovered on the coaſt of Languedoc. There are alſo ſeveral of this ſort on the coaſt of Croatia, over-againſt Venice.

Thus does the All-wiſe Creator ſhower down his treaſures on the ſummits of the mountains, which afterwards diffuſe their refreſhing ſtreams over the plains below, give life and verdure to the trees and herbs, and beautify and enrich the whole earth. At the ſame time we ſee the communication between thoſe parts of nature, that before ſeemed to have no relation to each other. Indeed all nature is linked together by one law of harmony, which ſufficiently proves it to be the work of one wiſe and gracious Author.

How delightful an object is a large and majeſtic River! How graceful an appearance does it make in the works of nature! Conſider its progreſs. At firſt it is but a vein of water, ſtreaming from ſome hill, and even the ſcattered pebbles interrupt its courſe, till it unites with other kindred ſtreams, and then ruſhes on the plain below. By its fall it hollows the ground, caſting it up on each ſide: then it purſues its courſe, eating a paſſage through every thing that oppoſes it. When it has received the ſupplies of many rivulets, it is dignified with a name. Thus enlarged, it makes the tour of hills and mountains, and at once adorns and enriches the plains.

At the deluge likewiſe the main Iſlands of the globe were formed. But it is certain others have been

been formed in later ages: partly by the casting up of vast heaps of clay, mud and sand, (as that of Isongming in the Chinese province of Nanquin) partly by the violence of the sea, tearing off large provinces from the continent. So the ancients imagined Sicily to have been formed, and even Great Britain and Ireland. It is certain also, that others have emerged out of the sea, as Santorini formerly: and three other islands near it lately. The last of these rose in 1707, from the bottom of the sea, just after a violent earthquake. Indeed earthquakes, storms and inundations, have given rise to many islands: particularly in the East-Indies, where they are very frequent and which abounds in Islands above any part of the world.

12. The entire Bason of the Sea, is of such immense extent, and covered in many places with such an unfathomable depth of water, that it cannot be traced in every part: but from some, we may form a probable judgment of the rest. The materials which compose the bottom of the sea, must in a degree influence the taste of its waters. Its saltness it undoubtedly derives from mountains of salt which are found there: as bitterness from fossil coal and other bituminous substances, which are there in plenty. There may likewise be many other substances, which the plummet does not discover. For the true bottom of the sea is often concealed by another accidental bottom, formed of various substances, mingled together, and covering it to a considerable depth.

The entire gulph of Lyons forms a bank above the surface of the water at the shore, of the exact figure

figure of an arch. And within this there is formed another ſuch arch, making the bottom of the ſea for a great way from ſhore, of different depths in various places, but generally between ſixty and ſeventy fathoms. In general the bed of the main ſea ſinks about as high as the mountain riſe on the land. Near the land in proportion to the height and ſteepneſs of the ſhores, the ſea is deep below. And on the contrary level ſhores denote ſhallow ſeas.

By the ſtrata on the ſhores we may commonly judge of the bottom of the adjacent ſeas. For the veins of ſalt and bitumen doubtleſs run in on the ſame order as we ſee them at land. And the ſtrata of ſtone that ſerve to ſupport the hills and elevated places on ſhore, ſerve alſo in the ſame continued chain, to ſupport the waters of the ſea. Probably the veins of metals and minerals likewiſe, which are found in the neighbouring earth, are in the ſame manner to be found in the bottom of the ſea.

But the natural ſurface of the bottom of the ſea, is greatly changed by ſubterranean currents. As we ſee theſe break out in rivers, on the ſurface of the earth, ſo we may be aſſured they break out at the bottom of the ſea, and empty their freſh waters into the ſalt maſs. In this caſe the continual ruſhing up of the water, makes a roundiſh cavity. And its running on, continues that cavity, 'till by degrees it is loſt. Thus every river that ariſes in the bottom of the ſea, when the water near the ſhore is clear, ſhews the traces of theſe currents, even to the naked eye, and the water taken up from them is more or leſs freſh.

Again. The coral fiſheries give us occaſion to obſerve, that there are many large caverns in the bottom

bottom of the ſea, eſpecially where it is rocky, as alſo in the ſides of perpendicular rocks. Theſe are often of great depth as well as extent, ſome with wide, others with narrow entrances. Nor is it any wonder, that as we daily find vaſt caverns on the land in rocky mountains, ſo we ſhould find them in rocks under the ſea. Nay, we may expect them in theſe the rather, as the rocks at land are in a ſtate of reſt, while thoſe at ſea are continually waſhed by the water, which inſinuates every where, and by its continual agitation, inlarges every cavity it finds.

Upon the whole, it ſeems plain, that the baſon of the ſea was after the flood compoſed of the ſame ſubſtances, as the ſurface of the reſt of the earth, namely, ſtone, clay, ſand, and the like. It is true, the plummet in ſounding uſually brings up a matter compoſed of mud, dead weeds, broken ſhells, and various bodies cemented together by a ſparry or tartareous ſubſtance. But theſe are only an artificial bottom, covering the natural one, ſuch indeed as one might expect where numerous animals and vegetables are produced and decay, and where the quiet waters have time to depoſit their ſtony matter, as our petrifying ſprings do.

There are places however where this adventitious cruſt is found, but the natural bottom appears of the ſame nature with the ſtrata in the body of the earth. But the fine and pure ſand we ſometimes find, ſeems not to be the original bottom, but to have been rather brought into the ſea by the courſe of ſome ſubterraneous river, and to be lodged in one of thoſe particular baſons, which theſe rivers form to themſelves.

In deep water, where the ſurface only is diſturbed by ſtorms and the lower part remains more quiet for ages, the bottom is covered with a great variety of things: ſometimes with pure ſand, ſometimes a ſort of ſand, made of ſhells beat to powder, ſometimes with powdered corals, ſometimes fragments of rocks. But beſide theſe, which might well be expected, the plummet ſometimes brings up ſubſtances, which are of the moſt beautiful colours: of as fine a ſcarlet, purple, or blue, as the fineſt paint could make them. Thoſe of a bright yellow are very common; but the green or ſnow-white more rare. Theſe coloured ſubſtances ſeem ſometimes to make up the whole bottom. But they are more frequently found on other things, as upon mud, corals, or larger pieces of ſhells, in the manner of tartarous cruſts. And their colours are not merely ſo ſuperficial or tranſient, but many of them are ſo permanent, that they may be preſerved in white wax, and when thus examined, they appear equal to paints of the fineſt kind.

There is very little difference between the bottom of the Adriatic Sea, and the ſurface of the neighbouring countries. There are at the bottom of the water, mountains, plains, valleys, and caverns, juſt as upon the land. The ſoil conſiſts of different ſtrata planted one upon another; and for the moſt part correſponds to thoſe of the rock, iſlands, and neighbouring continents. They contain ſtones of different ſorts, minerals, metals, various petrified bodies, pumice-ſtones, and lavas formed by volcanos. Iſtria, Dalmatia, Albania, and other adjacent countries, as well as the rocks, the iſlands, and the bottom of the Adriatic ſea, consist of a mass of white marble, of an uniform grain, and of almost an equal hardness. This vast bed of marble in many places under both the earth and the sea, is interrupted by several other kinds of marble, and covered by a great variety of bodies. The variety of these soils under the sea is remarkable: it is to this are owing the varieties of plants and animals found at the bottom of the sea. Some places are inhabited by a great number of different species of plants and animals, in others only some particular species are found, and in others neither plants nor animals. These observations not only point out to us the resemblance between the surface of the earth, and the bottom of the sea, but likewise one cause of the varieties, which are observed in the distribution of the marine fossils found in the earth.

In that vast mass of marble, which is common to the bottom of the Adriatic, and the neighbouring provinces toward the east, are a multitude of marine bodies petrified; some of which are so united to the stony substance, that they are scarce to be distinguished. Likewise a crust is discovered under the waters in divers places, and for a great extent, which is a composition of crustaceous and testaceous bodies, and beds of Polypi of different kinds, confusedly blended with earth, sand, and gravel.

These different bodies, which enter into the composition of this crust, are at the depth of a foot or more entirely petrified and reduced into marble. At less than the depth of a foot they approach nearer to their natural state. And at the surface of this crust, they are either dead, though extremely well preserved, or still living.

This

This demonſtrates that ſtones may be formed from things petrified, and actually are formed, in great quantities under the water. Cruſtaceous and teſtaceous bodies and Polypi, are every where mingled in the utmoſt confuſion, which ſhews a ſtriking reſemblance between the cruſt diſcovered under the ſea, and the marine bodies petrified in many parts under the earth.

The more theſe cruſtaceous and teſtaceous bodies and beds of Polypi multiply, the more their exuvia, and ſkeletons contribute to inlarge this cruſt. In ſeveral parts it forms very conſiderable banks, and of a very great thickneſs.

It follows that the bottom of the ſea is riſing conſtantly higher and higher. Divers other cauſes contribute to this; ſnow, and rain, and waters that bring down from the mountains, into the ſea, a great quantity of earth and ſtones. The waves, beating againſt the continent and iſlands, detach many maſſes which are ſpread upon the bottom of the ſea. The rivers carry the mud with their waters into the ſea, at the bottom of which that mud depoſits itſelf.

From the riſing of the bottom of the ſea, that of the level of the water naturally follows. So at Venice, in Iſtria, and in Dalmatia, the level of the waters is ſeveral feet higher than it was formerly. This elevation is obſerved only on the northern and eaſtern coaſts of the Adriatic. The ſea ſeems on the contrary, to abandon the weſtern coaſt, that of Italy.

The eye can reach but a ſhort way into the depth of any ſea, and that only when the ſurface is glaſſy and ſerene. In many ſeas it perceives nothing but a bright ſandy plain at bottom, extending for feveral hundred miles. But in others, particularly in the Red Sea, it is very different: the whole bottom of this extenfive bed of water, is a foreft of fubmarine plants, and corals formed by infects for their habitation: fometimes branching out to a great extent; fo that fome have even fuppofed the fea to have taken its name from the colour of its plants below. However, thefe are not peculiar to this fea, as they are found in great quantities in the Perfian gulf, along the coafts of Africa and thofe of Provence and Catalonia.

The bottom of many parts of the fea near America prefents a very different appearance. This is covered with vegetables, which makes it look as green as a meadow; and beneath are feen thoufands of turtles, and other fea animals feeding therein.

Ocean-fhells are frequently found very near the furface, which proves that fuch places formerly have been the fea-fhore. Hence it is clear, that the caufe which tranfported them thither, acted fuddenly, which perfectly agrees with the account of the deluge given by Mofes.

Nay, at Touraine, in France, more than an hundred miles from the fea, there is a plain of about nine leagues long, and as many broad, from whence the peafants of the country fupply themfelves with marle. If they dig deeper than twenty feet, the whole plain is compofed of the fame materials, which are fhells of various kinds, without the fmalleft portion of earth between them. Thefe fhells are in their natural ftate: but they are found alfo petrified and almoft in equal abundance in all the Alffine rocks, in the Pyrennees, in the hills of France, England, and Flanders. Ye, ain all quarters

quarters from whence Marle is dug, if the rock be ſplit perpendicularly down, petrified ſhells, and other marine ſubſtances will be plainly diſcerned. In ſeveral parts of Aſia and Africa, travellers have obſerved theſe ſhells in great abundance. In the mountains of Caſtravan, they quarry out a white ſtone, every part of which contains petrified fiſhes in great numbers, and of ſurprizing diverſity, in ſuch preſervation, that their fins, ſcales, and all the minuteſt diſtentions of their make can be perfectly diſcerned. From all theſe inſtances we may conclude that theſe foſſils are very numerous. And the variety of their kinds is aſtoniſhing. Moſt of the ſea-ſhells which are known, and many others to which we are entirely ſtrangers, are to be ſeen either in their natual ſtate, or in various degrees of petrifaction. But in the place of ſome we have more ſpar, or ſtone exactly expreſſing all the lineaments of animals: forthe ſhells diſſolving by ſlow degrees, and the matter having exactly filled all the cavities within, this matter retains the ſame form which the ſhells were of.

The greateſt depths of the ſea ever yet founded, have been found to be about 3000 fathoms. The ordinary depths are about 150. Though theſe ſhells are to be found in almoſt all the plainer parts of the ſurface of the earth, yet there are certain very large tracts, where ſuch bodies are never found, viz. the mountains, which ſeem to be the remains of the original ſtrata of the earth. It is true that there are many eminences, which have been taken for mountains, where ſea-ſhells of every kind arefound: but theſe hillocks, compared with the large mountains, which may be traced in immenſe chains, without almoſt any difcontinuity, from one continent to another; and from continents to neighbouring and oppofite iflands; infomuch that all thefe chains not only of the old, but likewife of the new world feem connected one with another. In the Alps, Apennine and Pyreneans, no fhells nor marine bodies of any kind are to be found: neither in the large Grampion mountains in Scotland.

The fame is obferved of all the large mountains of Africa, and of Afia, and in the huge chain of Cordilleres in Peru. This kind of mountains (which indeed alone deferve that name) are chiefly compofed of vitrifiable matter; and if they are fometimes found to contain fea-fhells, it is never to great depths, though fuch bodies are found in great abundance in the adjacent valleys.

Potters earth, is found plentifully in moft low grounds and valleys, between mountainous tracts. By expofing common flint ftones to the confined vapour of boiling water, a clay of the very fame kind may be formed, and is no more than a decompofition of flints. Hence it appears that wherever this clay is to be found, there the earth has undergone fome violence by fire; and that this has been effected by earthquakes, foon after the deluge, feems extremely probable. The deluge has given origin to many foffil fubftances, and combinations, which otherwife would not have happened. Chalk is no more than the ruins of fea-fhells, and lime-ftones confift of the fame bodies cemented together by a ftony juice.

13. At fixed times the water of the fea runs for near fix hours from fouth to north, which is called the Flood, at which time it rifes gradually on our

fhores,

ſhores, and in the channels of the rivers. Then after ſtanding at the ſame height for a quarter of an hour, it returns for near ſix hours from north to ſouth, which we term the Ebb; and after a quarter of an hour the water riſes again. The change thereof is twice in twenty-four hours, but begins near fifty minutes later daily. And this is obſerved on all the ſhores of Europe, that are waſhed by the ocean: whereas the Baltic and Mediterranean ſea, as well as the Caſpian, have no tides. The nearer we approach the pole, the more impetuous the tides are. The cauſe of them was wholly concealed from the antients; but it is now well known to every one. They depend entirely on the motion of the moon, with which they exactly correſpond: the flood beginning to riſe juſt at the time when the moon is in the meridian.

There is ſomething remarkable in the manner, wherein the tides riſe, in ſeveral of our rivers. In the river Severn, in particular near Newnham, and 160 miles from Lundy, the head of the flood at ſpring-tides riſe in height like a wall, near nine foot high. Thus it pours on for many miles, uſually overſetting any veſſels that lies in its way. This head-tide they call the Boar; it flows here only two, and ebbs ten hours.

But how ſhall we account for the ebbing and flowing of Lay-well, near Torbay? This ebbs and flows many times in an hour. It uſually performs its flux and reflux in a minute's time. But it ſtands two or three minutes after the ebb: ſo that in the whole it ebbs and flows about ſixteen times in an hour.

14. Currents in the ſea are either natural and general, ariſing from the daily rotation of the earth on its axis, or particular or accidental-cauſed by the waters being driven againſt promontories, or into gulphs and ſtraits, where wanting room to ſpread, they are driven back, and ſo diſturb the ordinary flux of the ſea.

The currents are ſo violent near the line, where the motion of the earth is the greateſt, that they carry veſſels ſwiftly from Africa to America, but prevent their returning the ſame way. So that they run as far as the fortieth degree, to find a paſſage into Europe.

In the Straits of Gibraltar, which are about twenty miles broad, the current almoſt always runs eaſtward. And ſo it uſually does in St. George's Channel. But the moſt violent ſea is in the Straits of Magellan, which is owing to two contrary currents, which meet in thoſe ſtraits.

Sometimes there is an under-current, contrary to that above. So it is in the Baltic Sound. One of the king's frigates being there, they went with their pinnace in the mid ſtream, and were carried violently by the current. Soon after they ſunk a baſket with a large cannon-bullet to a certain depth of water. This checked the motion of the boat. And when they ſunk it lower the boat was driven a head againſt the wind as well as the upper current. And the lower the baſket was let down, the ſtronger the current was found. The upper current appeared by this experiment, not above four or five fathom deep.

And does not the following inſtance ſhew that there is an under current at the mouth of the Mediterranean ſea? In the year 1712, Monſ. l'Aigle, commander of a privateer, chaſing a Dutch ſhip near

near Ceuta Point, came up with her in the Straits between Tariſſa and Tangier, and giving her one broad-ſide ſunk her. A few days after this ſhip with her cargo of brandy and oil aroſe near Tangier, four leagues weſt of that place, where ſhe ſunk, and directly againſt the ſtrength of the current. Certainly then the deep water in the middle of the Strait, ſets outward to the grand ocean. And poſſibly great part of the water, which runs in at the Straits ,may run out again that way.

One of the moſt violent currents in the northern ſeas, runs between two of the weſtern iſles. The ſea begins to boil with the tide of flood, and increaſes gradually, till there are many whirlpools, which form themſelves into a ſort of pyramids, and immediately ſpout out as high as the maſt of a little veſſel. At the ſame time they make a loud report. Theſe white waves run two leagues before they break. The ſea continues theſe motions, till it is more than half flood, and then decreaſes gradually, till it has ebbed half an hour. From that time it boils again, till it is within an hour of low-water. This boiling of the ſea is about a piſtol-ſhot diſtant from the iſle of Scarba. But the ſmalleſt boat may ſafely croſs the gulph, at the laſt hour of the flood or of the ebb.

In like manner, the colliſion of the oppoſite and oblique ſtreams, near the end of the Orkney iſlands, excites a circular motion in the water, and when the ſwiftneſs of the tide is inconſiderable, occaſions whirlpools or cavities in the ſea, in the form of an inverted bell, wide at the mouth, and growing gradually narrower towards the bottom. Their width and depth are in proportion to the rapidity of the ſtreams that cauſe them. Thoſe in Pentland Firth, near the iſlands Storma and

Swona, will with a ſpring-tide, turn any veſſel quite round. There have been inſtances of boats being ſwallowed up in them. The cavity is largeſt when it is firſt formed, and is carried along with the ſtream, diminiſhing gradually as it goes, until it quite diſappears. The ſuction communicated to the water, does not extend farther than the cavity. When fiſhermen are aware of their approach to one of theſe Wells, as they call them; and have time to throw an ore or any other bulky body into it, before they are too near, the ſpiral motion is interrupted, and the continuity of the water broke, which ruſhing in on all ſides, fills up the cavity, and enables them to go over it ſafe.

The Marlſtroon, on the coaſt of Norway, as received from the natives, which ſignifies the Navel of the Sea, ſince they ſuppoſe a great ſhare of the water of the ſea is ſucked up and diſcharged by its vortex. A deſcription of the internal parts is not to be expected, ſince none ever returned thence to bring information, The body of waters that form this whirlpool are extended in a circle about thirteen miles in circumference. In the midſt of this ſtands a rock, againſt which the tide in its ebb is daſhed with inconceivable fury. At this time it inſtantly ſwallows up all things that come within the ſphere of its violence, trees, timber, and ſhipping. No ſkill in the mariners, nor ſtrength in rowing, can work an eſcape: the ſailor at the helm finds the ſhip firſt go in a current oppoſite to his intentions: his veſſel's motion, though ſlow in the beginning, becomes every moment more rapid; and it goes round in circles ſtill narrower and narrower, till at leaſt it is daſhed againſt the rocks, and inſtantly diſappears: nor is it ſeen again for ſix hours; till the tide turning, it is vomitted forth with the ſame violence with which it was drawn in. The noiſe of this vortex increaſes its terror, which with the daſhing of the waters, and the dreadful valley covered by their circulation, makes one of the moſt tremendous objects in nature.

May I be permitted to mention here, a cheap and eaſy way of making ſea-water freſh, "I took, ſays a gentleman, a long glaſs body, and having filled it with ſea-water, put therein ſea-weed with its roots freſh and new gathered. Then I put on a head and a beak, and adapted a receiver thereto, without any lute or cloſing the joints. From the plants diſtilled daily, a ſmall quantity of very ſweet and potable water. And probably there may be found other plants near the ſea, which would yield freſh water in large quantities.

Sea-water ſimply diſtilled affords a water as pure and wholeſome, as that obtained from the beſt ſprings.

From the improvements made by Dr. Hales, it appears that three quarts of water might be procured in five minutes, that is fifty gallons in twelve hours, from a ſmall cylindrical ſtill of Mr. Durand's, by ſetting ſome pewter plates edge-ways in its head. And a ſtill thirty-two inches diameter would give two hundred gallons in twelve hours, with only the expence of a buſhel and half of coals.

When ſea-water is boiled in a cloſe covered veſſel, the ſteam is converted into freſh-water on the

the inside of the cover. And from a pot of thirteen inches diameter, by frequently removing the cover, and pouring off the water collected upon it, a quarter of a pint of fresh water in an hour.

Perhaps yet a better way of making sea-water fresh is the following. Take bees wax, and mould it into the form of an empty hollow vessel; sink the vessel into the sea. The water, in some will work its way through the pores of the wax, and the quantity contained in the vessel will be fresh, and good for use. The same will happen by using a rude earthen vessel, and stopping the aperture: for the water that penetrates is percolated and pure.

But fresh-water may be had in much greater plenty, and more expeditiously, by filling a vessel with river-sand or gravel, and pouring salt-water upon it. The vessel must be perforated at bottom, and by applying a linen strainer the water, after under going a few filtrations, will lose all its brackish taste.

In order to keep fresh-water sweet, take of fine clear, white, pearl ashes, a quarter of a pound of avoirdupoize, and put into one hundred gallons of fresh-water (observing this proportion to a greater or lesser quantity) and stop up your cask as usual till you have occasion to broach it for use. As an instance of its utility and success, Dr. Butler put an ounce of pearl ashes into a twenty-five gallon cask of Thames water, which he stopt up very close, and let it stand for upwards of a year and a half, opening it once in four months, and constantly found in it the same unaltered condition and perfectly sweet and good: afterwards made use of some of it in boiling pease and burgoo, and found that it made

made the peaſe as ſoft, and anſwered for all purpoſes to which he applied it, as well as water freſh drawn out of the river.

To this ſhort ſketch of what is obſervable in the terraqueous globe, I ſubjoin ſome of the beautiful reflections of Mr. Hervey.

" What an admirable ſpecimen have we here, of the Divine ſkill and goodneſs? This globe is intended, not only for an habitation, but for a ſtorehouſe of conveniences. And if we examine the ſeveral apartments of our great abode, we ſhall find reaſon to be charmed with the diſplays both of nice œconomy and boundleſs profuſion.

The Surface of it, the ground, coarſe as it may ſeem, is yet the Laboratory where the moſt exquiſite operations are performed. And though a multitude of generations have been accomodated by it, it ſtill continues inexhauſtible.

The Unevenneſs of the ground, far from being a defect, heightens its beauty and augments its uſefulneſs. Here it is ſcooped into deep and ſheltered vales, almoſt conſtantly covered with verdure, which yields an eaſy couch and agreeable food to the various tribes of cattle. There it extends into a wide, open country, which annually bears a copious harveſt: an harveſt not only of the principal Wheat, which is the ſtaff of our life, but of the appointed Barley, and various other grain, which are food for our animals.

The

The Furrows vary their produce. They bring forth Flax and Hemp, which help us to ſome of the moſt neceſſary accommodations of life. Theſe are wove into ample volumes of cloth, which fixed to the maſt, give wings to our ſhips. It is twiſted into vaſt lengths of cordage, which give nerves to the crane, and ſinews to the pully, or elſe adhering to the anchor, ſecure the veſſel, even amidſt the driving tempeſt. It covers our tables with a graceful elegance, and ſurrounds our bodies with a cheriſhing warmth.

Yonder ariſe the hills, like a grand Amphitheatre! Some are clad with mantling vines, ſome crowned with towering cedars, ſome ragged with miſ-ſhapen rocks, or yawning with ſubterraneous caves. And even thoſe inacceſſible craggs, thoſe gloomy cavities, are not only *a refuge for wild goats*, but ſometimes for *thoſe of whom the world was not worthy*.

At a greater diſtance the mountains penetrate the clouds, with their aſpiring brows. Their ſides *arreſt* and *condenſe* the vapours as they float along. Their caverned bowels *collect* the dripping treaſures, and ſend them gradually abroad by trickling ſprings: and hence the waters increaſing roll down, till they have ſwept through the moſt extenſive climes, and regained their native ſeas.

The Vine requires a ſtrong reflection of the ſunbeams and a large proportion of warmth. How commodiouſly do the hills and mountains miniſter to this purpoſe? May we not call thoſe vaſt declivities the garden-walls of nature? Theſe con-

center

center the ſolar fire, and completely ripen the grape! O that any ſhould turn ſo valuable a gift of God into an inſtrument of ſin!'

What is nature but a ſeries of wonders? That ſuch a variety of fruits ſhould riſe from the inſipid ſordid earth? I take a walk through my garden or orchard in December. There ſtand ſeveral logs of wood on the ground. They have neither ſenſe nor motion; yet in a little time they are beautified with bloſſoms, they are covered with leaves, and at laſt loaded with fruit. I have wondered at the account of thoſe prodigious engines, invented by Archimedes. But what are all the inventions of men, to thoſe nice automata of nature?

The Foreſt rears myriads of maſſy bodies, which though neither gay with bloſſoms, nor rich with fruit, ſupply us with timber of various kinds. But who ſhall cultivate them? The toil were endleſs. See therefore the ever wiſe and gracious ordination of Providence! They have no need of the ſpade or the pruning-knife. They want no help from man.

When ſawed into beams they ſuſtain the roofs of our houſes. They make carriages to convey our heavieſt loads. Their ſubſtance is ſo pliant, that they are eaſily formed into every kind of furniture: yet their texture ſo ſolid, that they compoſe the moſt important parts of the largeſt engines. At the ſame time, their preſſure is ſo light, that they float upon the waters. Thus while they ſerve all the ends of architecture, and beſtow numberleſs coveniences on the family, they con-

ſtitute

ſtitute the very baſis of navigation, and give being to commerce.

If we deſcend from the Ground Floor of our habitation into the ſubterraneous lodgments, we ſhall find there alſo the moſt exquiſite contrivance acting in concert with the moſt profuſe goodneſs. Here are various *minerals* of ſovereign efficacy: beds fraught with *metals* of richeſt value: and mines, which yield a metal of a meaner aſpect, but ſuperior uſefulneſs. Without the aſſiſtance of iron, what would become of all our mechanic ſkill?. without this we could ſcarce either fix the maſt, or drop the faithful anchor. We ſhould ſcarce have any ornament for polite, or utenſil for common life.

Here is an inexhauſtible fund of combuſtible materials. Theſe mollify the moſt ſtubborn bars. They melt even the moſt ſtubborn flint, and make it more ductile than the ſofteſt clay. By this means we are furniſhed with the moſt curious and ſerviceable manufacture in the world; which admits into our houſes the chearing light, yet excludes the wind and rain: which gives new eyes to decripit age, and more enlarged views to philoſophy; bringing near what is immenſely remote, and making viſible what is immenſely ſmall.

Here are quarries ſtocked with ſtones, which do not ſparkle like gems, but are more eminently uſeful. Theſe form houſes for peace, fortifications for war. Theſe conſtitute the arches of the bridge, the arms of the mole or quay, which ſcreen our ſhips from the moſt tempeſtuous ſeas.
Theſe

Theſe are comparatively ſoft in the bowels of the earth, but harden when in the open air. Was this remarkable peculiarity reverſed, what difficulties would attend the labours of the maſon? His materials could not be extracted from their bed, nor faſhioned without infinite toil. And were his work compleated, it could not long withſtand the fury of the elements.

Here are various aſſortments and beds of Clay, which however contemptible in its appearance, is abundantly more beneficial than the rocks of diamond or veins of gold: this is moulded into veſſels of any ſhape and ſize: ſome ſo delicately fine as to ſuit the table of a princeſs; others ſo remarkably cheap, that they miniſter to the convenience of the pooreſt peaſant: all ſo perfectly neat, as to give no diſguſt even to the niceſt palate.

A multiplicity of other valuable ſtores is locked up in theſe ample vaults. But the key of all is given to induſtry, in order to produce each as neceſſity demands.

Which ſhall we moſt admire, the bounty or wiſdom of our great Creator? How admirable is his precaution in removing theſe cumbrous wares from the ſurface, and beſtowing them under the ground in proper repoſitories? Were they ſcattered over the ſurface of the ſoil, it would be embarraſſed with the enormous load. Our roads would be blocked up, and ſcarce any room left for the operations of huſbandry. Were they on the other hand, buried at a great depth, it would coſt us immenſe pains to procure them. Were they

they uniformly ſpread into a pavement for nature, univerſal barrenneſs muſt enſue: whereas at preſent we have a magazine of metallic, without leſſening our vegetable treaſures. Foſſils of every kind enrich the bowels, verdure adorns the face of the earth.

Well then may even the inhabitants of heaven lift up their voice and ſing, *Great and marvellous are thy works, O Lord God Almighty!* And is there not infinite reaſon for us to join this triumphant choir? Since all theſe things are to us, not only a noble ſpectacle, bright with the diſplay of our Creator's wiſdom, but likewiſe an ineſtimable gift, rich with the emanations of his goodneſs? *The earth hath he ſet before* the inhabitants of his glory: but he hath *given it to the children of men.* Has he not then an undoubted right to make that tender demand, "*My ſon, give me thine heart!*"

The Rocks which bound the ſea, are here prodigiouſly high and ſtrong, an everlaſting barrier againſt both winds and waves. Not that the Omnipotent engineer has any need of theſe here. It is true, they intervene, and not only repreſs the rolling billows, but ſpeak the amazing Majeſty of the Maker. But in other places the Creator ſhews, he is confined to no expedient. He bids a bank of deſpicable ſand repel the moſt furious ſhocks of aſſaulting ſeas. And though the waves toſs themſelves, they cannot prevail: though they roar, yet they cannot paſs over.

Nay, is it not remarkable, that Sand is a more effectual barrier againſt the ſea than Rock? Accordingly

cordingly the ſea is continually gaining upon a rocky ſhore: but it is continually loſing on a ſandy ſhore, unleſs where it ſets in with an eddie. Thus it has been gaining from age to age, upon the iſle of Portland and the Land's End in Cornwall, undermining, throwing down, and ſwallowing up one huge rock after another. Meantime the ſandy ſhores both on our ſouthern and weſtern coaſts, gain continually upon the ſea.

Beneath the Rocks frequently lies a ſmooth, level ſand, almoſt as firm as a well-compacted cauſeway: inſomuch that the tread of an horſe ſcarce impreſſes it, and the waters never penetrate it. Without this wiſe contrivance the ſearching waves would inſinuate into the heart of the earth; and the earth itſelf would in ſome places be hollow as an honey-comb, in others bibulous as a ſponge. But this cloſely-cemented pavement is like claying the bottom of the univerſal canal: ſo that the returning tides only conſolidate its ſubſtance, and prevent the ſun from cleaving it with chinks.

Here the Main rolls its ſurges from world to world. What a ſpectacle of magnificence and terror! How it fills the mind and amazes the imagination! It is the moſt auguſt object under the whole heaven. What are all the canals on earth, to this immenſe reſervatory? What are the proudeſt palaces on earth, to yonder concave of the ſkies? What the moſt pompous illuminations, to this ſource of day? They are a ſpark, an atom, a drop. Nay in every ſpark and atom and drop, that proceeds from the hand of the Almighty,

mighty, there is the manifeſtation of a wiſdom and a power abſolutely incomprehenſible.

Let us examine a ſingle drop of water, only ſo much as will adhere to the point of a needle. In this ſpeck an eminent philoſopher computes no leſs than thirteen thouſand globules. And if ſo many thouſands exiſt in ſo ſmall a ſpeck, how many in the unmeaſured extent of the ocean? Who can count them? As well may we graſp the wind in our fiſt, or mete out the univerſe with our ſpan.

Nor are theſe regions without their proper inhabitants, clothed in exact conformity to the clime: not in ſwelling wool, or buoyant feathers, but with as much compactneſs and as little ſuperfluity as poſſible. They are clad, or rather ſheathed in Scales, which adhere cloſe, and are laid in a kind of natural oil: than which apparel nothing can be more light, and at the ſame time nothing more ſolid. It hinders the fluid from penetrating their fleſh: it prevents the cold from chilling their blood; and enables them to make their way through the waters, with the utmoſt facility. And they have each an air-bladder, a curious inſtrument, by which they riſe to what height, or ſink to what depth they pleaſe.

It is impoſſible to enumerate the ſcaly herds. Here are animals of monſtrous ſhapes, and amazing qualities. The upper jaw of the Sword-fiſh is lengthened into a ſtrong and ſharp ſword, with which (though not above ſixteen feet long) he ſcruples not to engage the Whale himſelf. The Sun-

Sun-fiſh is one round maſs of fleſh; only it has two fins, which act the part of oars. The Polypus, with its numerous feet and claws, ſeems fitted only to crawl. Yet an excreſcence riſing on the back enables it to ſteer a ſteady courſe in the waves. The ſhell of the Nautilus forms a kind of boat, and he unfurls a membrane to the wind for a ſail. He extends alſo two arms, with which as with oars, he rows himſelf along. When he is diſpoſed to dive, he ſtrikes ſail, and at once ſinks to the bottom. When the weather is calm he mounts again, and performs his voyage without either chart or compaſs.

Here are ſholes upon ſholes of every ſize and form. Some lodged in their ſhells, ſeem to have no higher employ, than imbibing nutriment, and are almoſt rooted to the rocks on which they lie: while others ſhoot along the yielding flood, and range the ſpacious regions of the deep. How various is their figure! The ſhells of ſome ſeem to be the rude production of chance, rather than of ſkill or deſign. Yet even in theſe we find the niceſt diſpoſitions. Uncouth as they are, they are exactly ſuited to the exigencies of their reſpective tenants. Some on the other hand are extremely neat. Their ſtructure is all ſymmetry and elegance. No enamel is comparable to their poliſh. Not a room in all the palaces of Europe is ſo adorned as the bedchamber of the little fiſh that dwells in mother of Pearl. Where elſe is ſuch a mixture of red, blue and green, ſo delightfully ſtaining the moſt clear and gliſtering ground?

But what I admire more than all their beauty, is the proviſion made for their Safety. As they have

have no ſpeed to eſcape, ſo they have no dexterity to elude their foe. So that were they naked, they muſt be an eaſy prey to every free-booter. To prevent this, what is only cloathing to other animals, is to them a cloathing, an houſe, and a caſtle. They have a fortification which grows with them, and is a part of themſelves. And by means of this they live ſecure amidſt millions of ravenous jaws.

Here dwell Mackrel, Herring, and various other kinds, which when lean wander up and down the ocean: but when fat they throng our creeks and bays, or haunt the running ſtreams. Who bids theſe creatures leave our ſhores when they become unfit for our ſervice? Who rallies and recalls the undiſciplined vagrants, as ſoon as they are improved into deſirable food? Surely the furlow is ſigned, the ſummons iſſued, and the point of re-union ſettled, by a Providence ever indulgent to mankind, ever loading us with benefits.

Theſe approach, while thoſe of enormous ſize and appearance abandon our ſhores. The latter would fright the valuable fiſh from our coaſts; they are therefore kept in the abyſſes of the ocean: juſt as wild beaſts, impelled by the ſame over-ruling power, hide themſelves in the receſſes of the foreſt.

One circumſtance relating to the natives of the deep is very aſtoniſhing. As they are continually obliged to devour one another for neceſſary ſubſiſtance, without extraordinary recruits, the whole watery race muſt ſoon be totally extinct. Were they

they to bring forth no more at a birth than land animals, the increaſe would be far too ſmall for the conſumption. The weaker ſpecies would ſoon be deſtroyed by the ſtronger, and the ſtronger themſelves muſt ſoon after periſh. Therefore to ſupply millions of animals with their food, and yet not depopulate the watery realms, the iſſue produced by every breeder is almoſt incredible. They ſpawn not by ſcores, but by millions: a ſingle female is pregnant with a nation. Mr. Lewenhoek counted in an ordinary cod 9,384,000 eggs. By this amazing expedient, conſtant reparation is made, proportionable to the immenſe havock.

And as the ſea abounds with animal inhabitants, ſo it does alſo with vegetable productions: ſome ſoft as wool, others hard as ſtone. Some riſe like a leafleſs ſhrub, ſome are expanded in the form of a net: ſome grow with their heads downward, and ſeem rather hanging on, than ſpringing from the juttings of the rocks. But as we know few particulars concerning theſe, I would only offer one remark in general. The herbs and trees on the dry land are fed by the juices that permeate the ſoil, and fluctuate in the air. For this purpoſe they are furniſhed with leaves to collect the one, and with roots to attract the other. Whereas the ſea-plants, having ſufficient nouriſhment in the circumambiant waters, have no need to detach roots into the ground, or forage the earth for ſuſtenance. Inſtead therefore of penetrating, they are but juſt tacked to the bottom, and adhere to ſome ſolid ſubſtance only with ſuch a degree of tenacity, as may ſecure them from being toſt to and fro by the agitation of the waves.

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We ſee from this and numberleſs other inſtances, what diverſity there is in the operations of the great Creator. Yet every alteration is an improvement, and each new pattern has a peculiar fitneſs of its own.

Conſidered in another view, the ſea is that grand Reſervoir, which ſupplies the earth with its fertility: and the air and ſun are the mighty engines, which work without intermiſſion, to raiſe the water from this inexhauſtible ciſtern. The clouds as aqueducts convey the genial ſtores along the atmoſphere, and diſtribute them in ſeaſonable and regular proportions, through all the regions of the globe.

How hardly do we extract a drop of perfectly ſweet water from this vaſt pit of brine? Yet the ſun draws off every moment millions of tons in vaporous exhalations, which being ſecurely lodged in the Bottles of Heaven, are ſent abroad ſweetened and refined, without the leaſt brackiſh tincture, or bituminous ſediment: ſent abroad upon the wings of the wind, to diſtil in dews and rain, to ooze in fountains, to trickle along in rivulet's to roll from the ſides of mountains, to flow in copious ſtreams amidſt burning deſarts and through populous kingdoms, in order to refreſh and fertilize, to beautify and inrich every ſoil in every clime.

How amiable is the goodneſs, how amazing the power, of the world's adorable Maker! How amiable his goodneſs, in diſtributing ſo largely what is ſo extenſively beneficial? That water, without which we can ſcarce perform any buſineſs, or enjoy any comfort, ſhould ſtream by our houſes, ſtart up from the ground, drop down from the clouds. Should come from the ends of the earth, to ſerve

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us, from the extremities of the ocean! How amazing his power! That this boundlefs mafs of fluid falt, fo intolerably naufeous to the tafte, fhould be the original fpring, which quenches the thirft both of man and every animal! Doubtlefs the power by which this is effected, can make *all things work together for* our *good.*

Vaft and various are the advantages which we receive from this liquid element. The waters glide on in fpacious currents, which not only chear the adjacent country, but by giving a brifk motion to the air, prevent the ftagnation of the vapours. They pafs by large cities, and quietly rid them of a thoufand nuifances. But they are alfo fit for more honourable fervices. They enter the gardens of a prince, float in the canal, afcend in the Jet d'Eau, or fall in the grand cafcade. In another kind they ply at our mills, toil inceffantly at the wheel, and by working the largeft engines, take upon them an unknown fhare of our fatigue, and fave us both labour, time, and expence.

So forcibly do they act when collected. And how do they infinuate when detached? They penetrate the minuteft tubes of a plant, and find a paffage through all its meanders. With how much difficulty does the labourer pufh his way up the rounds of a ladder? While thefe carry their load to a much greater height, and climb with the utmoft eafe. They convey nourifhment from the loweft fibres that are plunged in the earth, to the topmoft twigs that wave amidft the clouds. Thus they furnifh the whole vegetable world with neceffary provifion, by means of which *the trees of the Lord are full of fap, even the cedars of Lebanon, which he hath planted.* And notwithftanding their vaft elevation and prodigious diffusion, not a single branch is destitute of leaves, nor a single leaf of moisture.

Besides the salutary and useful circulation of the rivers, the sea has a motion no less advantageous. Daily for five or six hours, it flows toward the land, and for the same time, retires to its inmost caverns. How great is the power that protrudes to the shores such an inconceiveable weight of waters, without any concurrence from the winds, often in direct opposition to them? Which bids the mighty element revolve with the most exact punctuality? Did it advance with a lawless and unlimited swell, it might deluge whole continents. Was it irregular and uncertain in its approaches, navigation would be at a stand. But being constant in its stated period, and never exceeding its appointed bounds, it does no prejudice to the country, and serves all the ends of traffic.

Is the sailor returned from his voyage? The Flux is ready to convey his vessel to the very doors of the owner, without any hazard of striking on the rocks, or of being fastened in the sands. Has the merchant freighted his ship? The Reflux bears it away with the utmost expedition and safety. Behold, O man, how highly thou art favoured by thy Maker! *He hath put all things in subjection under thy feet. All sheep and oxen, all the beasts of the field: the fowls of the air, and the fishes of the sea.* Yea, the surges of the sea are subservient to thee. Even these, wild and impetuous as they are, are ready to receive thy load, and like an indefatigable beast of burden, carry it to the place which thou choosest.

What preserves this vast flood in perpetual purity? It receives the refuse and filth of the whole world. Whatever would defile the land and pollute

lute the air, is tranfmitted to the ocean. How then this receptacle of every nuifance kept clean, kept is from contracting a noifome and peftilential taint? 'tis partly by its inceffant motion, and partly by its faltnefs. By the one it is fecured from any internal principle of corruption; by the other it works itfelf clear of any adventitious defilement.

Confider the fea in another capacity, and it connects the remoteft realms of the univerfe, by facilitating the intercourfe, between their refpective inhabitants. The antients indeed looked on the ocean, as an impaffable gulph. But we find it juft the reverfe; not a bar of feparation, but the great bond of union. For this purpofe it is never exhaufted, though it fupplies the whole earth with rain: nor overflows, though all the rivers in the univerfe are perpetually augmenting its ftores. By means of this we travel farther, than birds of the ftrongeft pinions fly. We crofs the flaming line, vifit the frozen pole, and wing our way even round the globe.

What a multitude of fhips are contiually paffing and repaffing this univerfal thorough-fair! Whole harvefts of corn, and vintages of wine, lodged in volatile ftore-houfes, are wafted by the breath of heaven, to the very ends of the earth: wafted, enormous and unweildy as they are, almoft as fpeedily as the roe bounds over the hills.

Aftonifhing, that an element fo unftable, fhould bear fo immenfe a weight! That the thin air fhould drive on with fuch fpeed thofe vaft bodies, which the ftrength of a legion could fcarce move! That the air and water fhould carry to the diftance of many thoufand miles, what the united force of men and machines could fcarce drag a fingle yard! *Great and marvellous are thy works, O Lord God Almighty!*

How are the mariners conducted through this fluid common, than which nothing is more wide or more wild? Here is no tract, no posts of direction, nor any hut where the traveller may ask his way. Are they guided by a pillar of fire? No, but by a mean, and otherwise worthless fossil. Till this surprising stone was discovered, ships crept timorously along the coasts. But this guides them, when nothing but skies are seen above, and nothing but seas below. This gives intelligence that shines clear in the thickest darkness, and remains steady in the most tempestuous agitations. This emboldens us to launch into the heart of the ocean, and to range from pole to pole.

By this means are imported to our islands the choice productions of every nation under heaven. Every tide conveys into our ports, the treasures of the remotest climes. And almost every private house in the kingdom, is accommodated from the four quarters of the globe. At the same time that the sea adorns the abodes of the rich, it employs the hands of the poor. What a multitude of people acquire a livelihood, by preparing commodities for exportation? And what a multitude by manufacturing the wares imported from abroad? Thus though it is a false supposition, that the waters themselves are strained through subteranean passages into the inland countries, yet it is true, that their effects are transfused into every town, every hamlet and every cottage."

I beg leave to insert here what could not properly come in under any of the preceding articles.

It is a curious remark, which Dr. Cheyne makes concerning

concerning fluids in general. " I take notice, first of the fewness of the original fluids, in respect first of the vast number of compound ones. The primary ones hitherto known are only four, air, water, mercury, and light, three of which are seldom much compounded with others; so that it is water alone, that is the basis of all our mixtures. It is the parts of solid bodies floating in this fluid, that produce all our delightful and useful varieties of liquors: so frugal is nature in principles, and so fruitful in effects and compositions. Take notice, 2dly, Of the great difference between the specific gravities of our fluids, mercury being eight thousand times heavier than air. Now not to mention the many uses of this last fluid in artificers works, had air been as heavy as mercury it had been altogether useless in respiration: it had choaked us immediately. And had there not been a fluid of the same weight with mercury, i. e. a collection of exceeding small, heavy spherules in the present circumstauces of mankind, I do not know what a great part of the world would have done. For the wickedness of mankind, has brought many diseases to that degree of malignity, that a thorough cure could scarce be made of them without this fluid. But by the gravity of this, a remedy is provided for all these maladies, which are more than two or three. But that which is most wonderful in these fluids is, 3dly, That universal property, the direction of their pressure upon the sides of the containing vessel. In all fluids of whatsoever kind or nature this pressure is communicated in lines perpendicular to the sides of the containing vessel. And indeed this property of fluids, which is so uniform, is the necessary consequence of the sphericity of their constituent particles.

Now, could any thing but the almighty power of God, have rounded thoſe infinite numbers of ſmall particles? Or could any thing but his wiſdom have aſſigned them their true dimenſions, their exact weights, and required ſolidities? We ſhall allow him to continue in his infidelity, who can demonſtrate by what laws of mechaniſm, all the particles of water were turned of the ſame diameter ſolidity, and weight; and thoſe of air, mercury, and light turned all of different diameters, ſolidities, and weights from one another; but all of the ſame diameters, ſolidities, and weights among themſelves. And what a beautiful idea of this fluid does Sir Iſaac Newton's later diſcoveries preſent us with; every ray is endowed with its own colour, and its different degree of refrangibility and reflexibility. One ray is violet, another indigo, a third blue, a fourth green, a fifth yellow, a ſixth orange, and the laſt red. And theſe are the primary and original colours from the mixture whereof all the intermediate ones proceed; and white from an equal mixture of the whole; black on the contrary, from the ſmall quantity of any of them being reflected; or all of them in a great meaſure ſuffocated. So that it is not properly bodies that are coloured, but the light that falls upon them; and their colours ariſe from their aptitude, to reflect rays of one colour, and tranſmit all thoſe of another. The prominent little parts, upon their ſurface, according to their different degree of denſity and thinneſs, are apt to reflect back upon our organ rays of one colour, and of one degree of refrangibility and reflexibility, and to let others paſs through their pores, and this one colour too is leſs or more intenſe, according as their prominent parts are of different

different densities. For the first degrees of intenseness, in all the primary colours, seem to arise from the degrees of density and thinness, and the subsequent degrees, from the other different degrees of thickness, or thinness of the prominent little parts of the surfaces of bodies. Light acts upon bodies by heating, dissolving, and putting their parts in a vibrating motion. Bodies act upon light, in drawing its parts to them, and that in lines perpendicular to their surfaces. And as there may be different degrees of attraction in bodies, which produce their different degrees of elasticity and cohesion, so there must be different degrees of attraction in mediums supposed, to account for their different powers, in bringing the refracted rays nearer to, or farther from the perpendicular. For it is well known all mediums have not the same refractive virtue. Now what a beautiful, uniform, and simple theory of light is here! This is so very like the frugal simplicity and yet the manifold variety of nature, that one would be almost tempted to believe it true, were there no experiment to confirm it. We may observe one more instance of the wonderful wisdom of nature, in the propagation of light, viz. That a ray of light in passing from a luminous point, through two differently refracting mediums, to illuminate a given point, spends the least time (the refracting powers of the several mediums considered) possible; and consequently when a ray passes through one medium, from a luminous point to reflect upon a given point, it takes the shortest way possible. This the Geometers have demonstrated. Now is not this an instance of council and design? Is not this like the methods of wisdom, which will not spend more time on a thing than just what is necessary to do the business;

which will not go about but take the ſhorteſt courſe poſſible that will bring it to the place deſigned?

The iſlands of Scilly have been ſo noted among the antients, one might expect to find among the inhabitants ſome conſciouſneſs of their own antiquity, and of their appearance in hiſtory before the other parts of Britain were at all known. But there is nothing of this kind; the inhabitants are all new comers, not an old habitation worth notice, nor any remains of Phœnecian, Grecian, or Roman arts, either in town, caſtle, port, temple, or ſculpture.

We are not to think however but Scilly was inhabited, and was frequently reſorted to antiently, as the old hiſtorians relate. All the iſlands (ſeveral of which are now without inhabitants) by the remains of walls, foundations of many contiguous houſes, and a great number of ſepulchral burrows, ſhew, that they have been fully cultivated and inhabited.

That they were inhabited by Britons, is paſt all doubt, not only from their neighbourhood to England, but from the Druid monuments. Several rude ſtone pillars, circles of ſtone erect, rock-baſons: all monuments common in Cornwall and Wales, are equal evidences of the antiquity, religion, and original of the old inhabitants.

How came theſe antient inhabitants then (it may be aſked) to vaniſh, ſo as that the preſent have no pretenſions of any affinity of any kind with them, either in blood, language, or cuſtoms? How came they to diſappear, and leave ſo few traces of plenty, or arts, and no poſterity behind them? From two cauſes, the manifeſt encroachments of the ſea, and as manifeſt a ſubſidence of ſome parts of the land.

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The ſea is the inſatiable monſter which devours iſlands, gorges itſelf with the earth, ſand, clay, and all the yielding parts, and leaves nothing where it can reach, but the ſkeleton, the bared rock. The continual advances, which the ſea makes upon the low lands, are plain to all people of obſervation. What we ſee happening every day may aſſure us of what has happened in former times; and from the banks of ſand and earth giving way to the ſea, and the breaches becoming ſtill more open, and irrecoverable: it appears, that repeated tempeſts have occaſioned a gradual diſſolution of the ſolids for many ages.

Again, the flats which ſtretch from one iſland to the other, are plain evidences of a former union between many now diſtinct iſlands. The flats between ſome of them are quite dry at a ſpring-tide, and men eaſily paſs dry ſhod from one iſland to the other, over ſand-banks where, upon the ſhifting the ſands, walls and ruins are diſcovered frequently upon which at full ſea there are ten and twelve feet of water.

All ſtrong arguments that theſe iſlands were once one continued tract of land, though now as to their low lands over-run with the ſea and ſand. Hiſtory confirms their former union "The iſles Caſſiterides (ſays Strabo) are ten in number, cloſe to one another; one of them is deſert and unpeopled, the reſt are inhabited." But ſee how the ſea has multiplied theſe iſlands! There are now reckoned one hundred and forty. Into ſo many fragments are they divided, and yet there are left ſix inhabited. But no circumſtance can ſhew the great alterations, which have happened in the number and extent of theſe iſlands, more than this, viz. that the iſle of Scilly, from which the little cluſter takes its name, is no more at preſent than a high rock, of about a furlong over, whoſe cliffs hardly any thing but birds can mount, and whoſe barrenneſs could never ſuffer any thing but ſea-birds to inhabit it. How then came all theſe iſlands to have their general name from ſuch a ſmall and uſeleſs plot?

Doubtleſs Scilly, which is now a bare rock, and ſeparate from the lands of Guel and Brehar by a narrow frith, was formerly joined to them by low necks of lands, being the rocky promontory of one large iſland now broke into ſeven. This promontory (at preſent called Scilly iſland) lying weſtermoſt of all the high lands, was the firſt land of all the iſlands diſcerned by the traders from the Mediterranean and Spaniſh coaſts, and, as ſoon as diſcovered was ſaid to be Scilly, nothing being more uſual with ſailors, upon their firſt ſeeing land, than to call the part by the name of the whole. But when this conſiderable iſland called Scilly was broken to pieces, the greateſt portions became inhabited, and had firſt Britiſh names, as Brehar, Treſcaw, Enmor; but afterwards were called according to the religion of the times, after the names of particular ſaints. The chief diviſion was intitled St. Mary's, the others dedicated to St. Nicholas, St. Martin, St. Theon, and ſo on; but this remarkable promontory being in no wiſe fit for habitation or devotion, was dedicated to no ſaint, but left to enjoy its ancient name; and notwithſtanding the modern Chriſtian dedications, ſailors went on in their old way. This high land is ſtill called Scilly, and the iſlands in general are ſtill denominated Scilly iſles.

It muſt have been a diſpiriting circumſtance to the old inhabitants, to ſee the ocean ſo continually

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eating away their low-lands, in which they had their treaſures of tin, their houſes and ports: but this gradual decay was not the only misfortune which attended them. From the iſland of Sampſon, one may ſee the foundations of ſtone-fences running on in a ſtrait line croſs the Firth, towards Treſcaw iſle, till they are hid in the ſand; which ſand, when it is full tide, has from ten to twelve feet water on it. Now we cannot ſuppoſe that the foundation of theſe fences was laid as low as high water mark, (for who could build fences upon ſo dangerous a level?) At a medium we may ſuppoſe them to have been laid ſix feet above the full tide.

Here then we have the foundations, which were ſix feet above the high-water mark, now ten feet under, which together make a difference as to the level of ſixteen feet.

Here then was a great ſubſidence, which muſt have been followed by a ſudden inundation, and this inundation is likely not only to have deſtroyed a great part of the inhabitants, but to have terrified others who ſurvived into a total deſertion of their ſhattered iſtands. By this means that conſiderable people, who were the Aborigines, and carried on the tin trade with the Phœnecians, Greeks, and Romans, were reduced to the laſt gaſp. The few poor remains of this deſolation by their neceſſary attention to food and raiment, muſt ſoon have loſt ſight of their ancient proſperity, and the faint remembrance that was left of what the iſlands had been before, expired of itſelf in an age or two, through the indigence of the inhabitants.

That ſuch an inundation has happened here, is ſtill more plain, becauſe theſe iſlands are no longer what they were antiently, fertile in tin: nor are there any remains of so many antient workings as could maintain a trade so greedily coveted by the antients. But what is become of those mines? How shall this question be answered, but by confessing that the land, in which they were, is now sunk, and buried under the sea?

I am not fond of introducing earthquakes; but where there has been evidently a great subsidence of the earth's surface, can it be accounted for at all without a previous concussion of the earth? And what nature declares in this case, tradition seems to confirm; there being a strong persuasion in the Western parts of Cornwall, that formerly there existed a large country between the Land's-End and Scilly, now laid many fathoms under water. Indeed there are no evidences of any ancient connexion of the Land's-End and Scilly. Yet that the cause of that inundation, which destroyed much of these islands, might reach also to the Cornish shores, is extremely probable; there being several evidences of a like subsidence of the land in Mount's-Bay. The principal anchoring-place, called a lake, is now a haven or open harbour. The mount from its Cornish name, we must conclude to have stood formerly in a wood; but now at full tide, it is half a mile in the sea, and not a tree near it; and in the sandy beach betwixt the Mount and Penzance, when the sands have been dispersed by violent high tides, there have been seen the trunks of several large trees in their natural position, the surface of their section worn smooth by the agitation of the water, sand, and gravel, as if cut with an axe, upon which at every full tide, there must be twelve feet water; so that the shores in Scilly, and the neighbouring shores of of Cornwall are concurrent evidences of ſuch a ſubſidence, and the memory of the inundations, which were the neceſſary conſequences of it, is preſerved in tradition: though like other traditions, in proportion to their age, obſcured by fable.

That there has been ſuch a ſubſidence of the lands, belonging to theſe iſlands, the preſent ruins of the iſlands teſtify. And this ſubſidence reached even to Mount's Bay, and laid under water a great part of the low-lands then woody, there being now ten feet water, ſo that the ſhores in Scilly and the ſhores in Cornwall, are equal proofs of ſuch an inundation. When this inundation happened, we know not; but two pieces of hiſtory poſſibly may lead us near the time. In the time of Strabo and Diodorus Siculus, their commerce was in full vigour. "Abundance of tin was carried in carts, ſay Diodorus Siculus." "But ten iſlands in all (ſays Strabo) and nine of thoſe inhabited." The deſtruction therefore of Scilly muſt be placed after the time of theſe authors; that is, after the Auguſtan age.

Now Plutarch hints, that the iſlands round Britain were generally unpeopled in his time. If he includes Scilly among them, then this deſolation muſt have happened between the reign of Trajan, and that of Auguſtus.

15. At the mouth of the river Neſs, near Burges, in Flanders, at the depth of fifty feet, are found great quantities of trees lying as cloſe to each other, as they do in a wood; the trunks, the branches, and the leaves are in ſuch perfect preſervation, that the particular kind of each tree may be known. About five hundred years ago this very ground was known to have been cover-

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ed with the ſea; nor is there any hiſtory of its having been dry ground, which no doubt muſt have been the caſe. Thus we ſee a country flouriſhing in verdure, producing large torrents, and trees of various kinds, overwhelmed by the ſea. We ſee this element depoſiting its ſediment to an height of fifty feet; and its waters muſt, therefore have riſen much higher. We ſee the ſame after it has thus overwhelmed, and ſunk the land ſo deep beneath its ſlime, capriciouſly retiring from the ſame coaſts, and leaving it habitable once more. All this is wonderful, and perhaps inſtead of attempting to enquire after the cauſe, it will beſt become us to reſt ſatisfied with admiration.

At the city of Modena in Italy, and about four miles round it, whenever they dig, when the workmen arrive at the depth of ſixty-three feet, they come to a bed of chaulk, which they bore with an augre five feet deep. They then withdraw from the pit, before the augre is removed, and upon its extraction, the waters burſt up through the aperture with great violence. That which is moſt remarkable in the operation is the layers of earth, as we deſcend. At the depth of fourteen feet are found the ruins of an ancient city, paved ſtreets, houſes, floors, and different pieces of Moſaic. Under this is found a ſolid earth, that one would imagine had never been removed; however, under it is found a ſoft oozy earth, made up of vegetables; and at twenty-ſix feet deep, large trees entire, ſuch as walnut-trees, with the walnuts ſtill ſticking on the ſtem, and their leaves and branches in exact preſervation. At twenty-eight feet deeper a ſoft chalk is found mixed with a vaſt quantity of ſhells, and this bed is eleven feet

thick.

thick. Under this vegetables are found again with leaves and branches of trees as before; and thus alternately chalk and vegetable earth, to the depth of ſixty-three feet. Theſe are the layers whenever the workmen bore; while in many of them they alſo find pieces of charcoal, bones, and bits of iron. From this deſcription it appears, that this country has been alternately overflowed and deſerted by the ſea, one age after another: nor were theſe overflowings and retirings of trifling depths, or of ſhort continuance. When the ſea burſt in, it muſt have been a long time in overflowing the branches of the fallen foreſt with its ſediment; and ſtill longer in forming a regular bed of ſhells, eleven feet thick over them. It muſt have therefore taken an age, at leaſt to make any one of them layers; and we may conclude, that it muſt have been many ages employed in the production of them all. The land alſo, upon being deſerted, muſt have had time to grow compact, and to be drain'd of its waters before it could be diſpoſed to vegetation.

Likewiſe in cutting a channel for the canal of Newry, in Ireland, a great multitude of fallen trees was diſcovered, lying near two miles in length, and in many places, ſix or eight feet deep. Many of theſe are very large, and are tumbled down one over another, ſome lying in ſtrait lines, and others in an oblique or tranſverſe poſition. If trees thus found had been felled by the deluge, (as undoubtedly others were) they would all lie in one poſition. But this is not the caſe. We muſt therefore ſeek for other cauſes. And one cauſe ſeems to have been this. If water flowing either from ſprings or ſtreams be ſtopt, it naturally

naturally softens and loosens the earth; and in a course of time, even to the roots of trees, which are then subject to be overturned by any violent storm. This doubtless was the case with most of those trees, that are fonnd in bogs with the roots adhering to them. Trees thus falling sink into the yielding soil, and cause a farther stoppage in the course of the waters. Hence the loose earth is increased, by a yearly accession of scurf, moss, grass, and weeds. Add to this, that the higher lands being gradually dissolved by repeated rains, and washed down by floods, in a long course of years, cover the lower grounds with fresh layers of earth. This being so, it is not strange to find trees buried eight or ten feet under the earth.

Another cause may be this. Various colonies from time to time arriving in the then uncultivated country of Ireland, would naturally make room for tillage and pasture, by clearing the ground of its forests. This was certainly the case, where we find in bogs, trees partly burned, and others bearing the mark of the axe. But sometimes these colonies were driven by the natives from their intended settlements, leaving the trees they had felled strewed over the plain, which stopping the waters, of course created bogs, that in process of time covered those trees to a considerable depth. Nay, as late as 1561 Tyrone and O'Donnél marching toward Kinsale, through Connaught, and laying the country waste, there is a great tract of ground, now a bog, which was then ploughed land.

That bogs in general grow but slowly may be gatherèd from a lump of coins of Edward IV. (probably lost in a purse which rotted away) taken up in a bog in Yorkshire, eighteen feet deep.

This

This was about 300 years before. So the bog had grown about a foot in eleven years, that is, ſomewhat above an inch in a year: although ſome ſeem to grow much faſter.

Much more antient is the Great Level, or fenny ground, which contains about 300,000 acres, lying in the counties of Norfolk, Suffolk, Cambridge, the Iſle of Ely, Huntingdon, Northampton, and Lincoln. This was once firm land. There have been found therein ſtones, bricks, and other materials for building. In ſetting down a ſluice, there was found ſixteen feet deep, a ſmith's forge, and all the tools thereunto belonging. William of Malmſbury, who lived 1200 years ago, ſays that in his time, "The trees which grew there, ſmooth and ſtrait, were ſo tall that they ſeemed to touch the ſtars. A plain there is, as even as the ſea, which with the green glaſs, allures the eye; and there is not the leaſt parcel of ground that lies waſte and void. Here you ſee plantations of fruit-trees; there a field ſet with vines, part creeping on the ground, part mounting on high poles." But how came it to be reduced to ſo very different a ſtate? It ſeems the ocean broke in upon it, with ſuch reſiſtleſs violence, that the buildings throughout the whole ſpace were overturned, and the trees torn up by the roots. The amazing quantity of ſilt thrown up at the ſame time, covered the whole country, even to the verge of the Highlands, ſeven, eight, or even ten feet deep. Hence a few years ſince in digging a pool, there was found at the upper ſkirts of the level, the ſkeleton of a large fiſh, near twenty feet long, lodged in ſilt above ſix feet below the ſurface of the ground. Yet how or when this inundation was, we are not able to determine.

mine. Whenever it was, it was probably occasioned by a violent earthquake.

A late writer gives the following account of the natural origin of Bogs in Ireland. Some of these have vast quantities of timber under them: others have very little. But the surface of all is covered with a short, thick, and matted kind of heath. This as it grows and thickens at the top, vegetates at the bottom into a close texture, which being replete with moisture, throws out annual growths of this ramified heath, part of which dies every winter, and moulders at the bottom, where it forms another stratum, from which at spring comes a new crop of heath. And thus as these strata of mouldered heath are annually repeated, the roots increase, and at once extend higher, and are more consolidated at the bottom. Hence the turf is ever found of a closer texture, as we descend deeper in the Bog.

The turf itself is only a closely concreted combination of the roots of this heath, which universally grows on the surface of these bogs; not the produce of the trees which are at the bottom. Wherever these were thrown down, some earth would be washed down upon them from the adjacent grounds, the surface of which every where produces this heath. And this being now supplied with constant moisture, would throw out a more plentiful growth.

The same cause produces these bogs on the sides or even tops of mountains. But it is ever in wet grounds, or in flats on the side of hills where the water settles, and supplies them with moisture.

There seems indeed to be a spungy quality in this heath, which prevents the moistures sinking away

away from it, by an attraction of the fluids, by an infinite number of capillary fibres, which are the very substance of it. At the bottom of these Mountain-Bogs, no trees are found. And very few in the largest bogs, unless on the skirts of them.

The turf then from top to bottom is entirely the produce of a vegetation from itself. And the reason why Ireland produces so many turf-bogs, is because it so abounds with the seeds of this heath, which is every where found where the land is uncultivated, and forms bogs, wherever it has proper moisture.

Our marle is found only in the bottom of low Bogs, at the depth of seven, eight or nine feet. For three feet is a spungy sort of earth, then gravel for about half a foot. For about three feet more is a spongy earth, mixed with timber, but so rotten, that it cuts like earth. Next this for the depth of three inches we find leaves, that are fair to the eye, but will not bear a touch. With these are sometimes mixed heaps of seed, which seem to be broom or furz seed: nay, in one place what seemed to be gooseberries and currants, was found, and sea-weed in others. Under this was blue clay half a foot thick, throughly mixed with shells, as was also the marle, which lay next, three or four feet deep. They are shells of periwinkles: and among these are large horns and bones answerable thereto. But it is not only in Bogs that subterraneous trees are found; nor in Ireland only, but in many parts of England. At Youle, about twelve miles from York, near the place where the Dun empties itself into the Humber, abundance of them have been dug up from time to time; all of which are a species of fir.

In

In the iſle of Axholme in Lincolnſhire, not firs only, but abundance of oaks are found in the Moor, whereof ſome are five yards in compaſs, with quantities of acorns near them. The Firs lie ſomewhat deeper than the oaks; one of them was thirty-ſix yards long. The adjoining levels (about 180000 acres) were half of them yearly covered with water, till King Charles I. ſold them to Sir Cornelius Vermuyden, who drained them at the charge of above 400,000l. In the ſoil of all this land, through all Marſhland, and on the ſkirts of all the Lincolnſhire and Yorkſhire wolds, are found millions of roots and bodies of trees, firs, oaks, birch, beech, yew, willow, and aſh. The roots ſtand in their natural poſtures, as thick as ever they could grow. The bodies of moſt of the great trees, lie all their length about a yard from their roots with their tops north-eaſt. The ſmaller lie acroſs in every direction, ſome under, ſome above them. Some of the oaks are thirty, ſome thirty five yards long, yet wanting ſome yards at the ſmall ends. They are firm, laſting, and as black as ebony. Many of them have been burnt, ſome quite through, ſome on one ſide. Some have been found chopped and ſquared, ſome bored through; ſome half cleft with great wooden wedges in them, and broken axe heads, ſhaped not unlike the ſacrificing axes. And all theſe were in ſuch places, and at ſuch depths, as could not have been opened, from the time the foreſt was deſtroyed until the ground was drained. Near a great root in the Pariſh of Hatfield, were found eight or nine Roman Coins: and at the bottom of a new drain, were found trees ſquared and cut, rails, bars, a kind of battle axe, and two or three coins of the Emperor Veſpaſian. Nay, the ground

ground at the bottom of the river was found to lie in ridge and furrow, manifeſting that it had been ploughed. In an old drain, an oak was found forty yards long, four yards in diameter, at the great end: three yards and a foot in the middle, two yards at the ſmall end, ſo that by a moderate computation, it ſeems to have been as long again. Yea, about fifty years ago, there was found ſeveral feet deep, a man lying at his full length, with his head upon his arm as aſleep. His ſkin, tanned as it were, by the moor-water, preſerved his ſhape entire; but his fleſh and moſt of his bones were conſumed.

Theſe ſtately trees formerly compoſed one of the moſt beautiful foreſts in the world. But how came it to be deſtroyed? When the Romans purſued the Britons, they always fled into the woods. On this the Roman Generals ordered them to be cut down; this vaſt foreſt in particular. The trees falling croſs the rivers which ran through the country, ſoon dammed them up, turned the ground into a lake, and gave riſe to the Moors, that increaſed continually, by earthly matter waſhed down, the conſumption of rotting branches and leaves, and the growth of water-moſs, which wonderfully flouriſhes on rotten grounds. Hence it is, that ſo many Roman Coins have been found at the bottom of theſe levels; that ſo many trees are found burnt or chopped; and that the ſoil of the country in general is two, three or more yards higher than formerly.

Some ſimilar alteration ſeems to have happened many centuries ago, to that whole tract of land, near Newbury in Oxfordſhire, out of which they dig

dig their Peat. There is a ſtratum of this ſeveral miles, which lies many feet under the ſurface.

The beſt peat has very little (if any) earth in it, but is a compoſition of wood, branches, twigs, leaves, and roots of trees, with graſs, ſtraw, plants, and weeds. The colour is of a blackiſh brown: and if it be chewed between the teeth it is ſoft, and has no gritty matter in it. It is indeed of a different conſiſtence in different places, ſome being ſofter and ſome harder; which may ariſe perhaps from the different ſorts of trees it is compoſed of. Great numbers of trees are viſible in the true peat, lying irregularly one upon another, and ſometimes even cart-loads of them have been taken out: but the nearer theſe trees lie to the ſurface, the leſs ſound is the wood; and ſometimes the ſmall twigs which lie at the bottom, are ſo firm as not to be eaſily cut through: theſe trees are generally oaks, alders, willows, and firs, beſides ſome others not eaſily known. The ſmall roots are generally periſhed, but yet have ſufficient ſigns to ſhew that the trees were torn up by the roots, and were not cut down; there being no ſign of the axe or ſaw, which had they been felled, would have been plainly viſible. A great many horns, heads, and bones of ſeveral kinds of deer, horns of the antelope, heads and tuſks of boars, and heads of beavers, are alſo found in it, and ſome human bones.

Before we diſmiſs this ſubject, it may not be improper to ſubjoin as ſtrange an account as any age can parellel. June 7, 1697, near Charleville in Ireland, a great rumbling was heard in the earth. Soon after, in the bog of Kapanihane, ſtretching

ſtretching north and ſouth, ſome meadow and paſture land, that lay on the ſide of the bog, ſeparated by a large ditch, and other land on the further ſide adjoining to it, began to move: and a little hill in the middle of the bog, ſunk down.

This was at ſeven in the evening, the ground fluctuating in its motion, like the waves of the ſea. The paſture-land then roſe up, over-ran the ground beneath, and moved upon its ſurface, rolling on with great violence, till it had covered the meadow ſixteen feet deep. It drew after it the body of the bog, part of it lying on the place where the paſture-land was before, leaving great breaches behind it, and currents of water, which caſt up noiſome vapours. There are ſtill cracks and chaſms through the whole ſurface of the bog, which contains forty acres.

But we have a later incident of the ſame kind. On Saturday, January 26, 1745, a part of Pilling-Moſs, lying near Heſcomb-houſes, was obſerved to riſe to a ſurpriſing height. After a ſhort time it ſunk as much below the level, and moved ſlowly toward the ſouth-ſide. In half an hour it covered twenty acres of land. The improved land, adjoining to that part of the bog, is a concave circle, containing near an hundred acres, which is well nigh filled up with bog and water. In ſome parts, it is thought to be five yards deep.

An intenſe froſt retards its progreſs for the preſent, but it is likely to ſpoil a great deal more land. That part of the Moſs, which is ſunk like the bed of the river, runs north and ſouth. It is above a mile in length, and near half a mile in breadth.

Perhaps

Perhaps ſome Moraſſes have been ever ſince the deluge. In ſome of theſe are found, many feet deep, whole foreſts of timber, and frequently of ſuch ſorts as have not grown in thoſe countries for many ages.

But ſome Moraſſes are only of late date. Lord Cromartie gives a remarkable account, of what he himſelf obſerved with regard to the generation of ſuch a Moraſs. In the pariſh of Lockburn he ſaw, near the top of a very high hill, a plain about a mile over. It was then covered with a ſtanding wood, but ſo old, that the trees had neither leaves nor bark left. When he came by the place fifteen years after, he obſerved all the trees were fallen. A few years after that, they were quite covered over with a ſoft, ſpongy earth, which formed a proper Bog or Moraſs. Many have been formed the ſame way.

The diſcovery of the Bones of Elephants at the bottom of ſome of our Engliſh Bogs, ſeems a convincing proof, that the earth has undergone ſome very extraordinary alterations. For the remains of animals of quite different climates, which in the preſent ſituation of the world, could never poſſibly come over thither, muſt imply, their having been originally here, or that England was once joined to the continent. But ſince we find theſe creatures only in the very hot countries, it is highly probable, they were not originally here, unleſs we ſuppoſe the temperature of our climate to have been greatly altered. And without ſuch a ſuppoſition, we cannot ſuppoſe they would have wandered hither, though all parts of the globe had been contiguous. But what changes have happened to our earth, no human wiſdom can find out. Suppoſe only the axis thereof to have been

been ſhifted at any time but a few degrees, what convulſions in nature, what an univerſal change in the face of things muſt have enſued? What inundations of water, bearing every thing before them? What breaches in the earth, what hurricanes and tempeſts, muſt have attended ſuch an event? For the waters muſt have rolled along, till an equipoiſe was produced. And all parts of the world muſt acquire different degrees of heat and cold from what they had before. Seas would be formed, where continents had been; continents torn in pieces, or ſplit into iſlands. Such would have been the fate of inanimate things. And as to living creatures, they muſt have been deſtroyed and buried in the ruins of the world, as perhaps theſe elephants were.

CHAP. II.

34. *Air*

34. *Air capable of immense expansion.* 35. *Difference between fix'd & common air.*

1. THE Effects of Fire are various. It heats, it ſhines, it expands, it diſſolves other bodies, either by melting or reducing them to aſhes or a calx. Moſt of theſe argue a vehement motion of its particles, which tears aſunder whatever it ſeizes. It ſeems to be a moſt ſubtle matter, diſperſed throughout the univerſe. Yet this, even when collected ſoon ſcatters again, unleſs it be detained by ſome inflammable matter. Not that Fire will ſpring from every motion: it muſt be circular, as well as rapid. For if particles move ever ſo ſwift in a ſtraight line, no Fire will follow.

Heat ſeems to be nothing but motion: but this motion has ſome peculiar circumſtances. 1. It is expanſive motion, whereby a body endeavours to dilate itſelf. 2. This motion is upward, and toward the circumference: 3. it is not an equable motion of the whole, but only of the ſmaller particles of the body: 4. it is a rapid motion. Heat may therefore be defined, an expanſive, undulatory motion in the minute particles of a body, whereby they rapidly tend to the circumference, and at the ſame time upward.

Yet Fire has ſome effect on moſt bodies, even in an exhauſted receiver. One placed a black ribbon therein, and then applied a burning-glaſs. Abundance of ſmoke iſſued out of it, which fell by little and little, and the ribbon appeared not at all changed. But when it was touched, after the re-admiſſion of the air, it preſently fell into aſhes.

The glaſs being applied to gun-powder ſo incloſed, it burnt grain by grain, but none of the grains kindled. Another time, when the ſun had leſs force, they would not burn, but only boiled and emitted ſmoke. This ſmoke falling on the board on which the powder lay, was of the colour of brimſtone. The powder that remained, being put on coals, burned like ſaltpetre, inaſmuch as the brimſtone had exhaled.

Tin and Copper melted together weigh more than both bodies did before. Yea, Orpin being mixed with ſalt of Tartar, is heavier by a fifth part.

To account for this, it has been commonly ſuppoſed, that fire adds to the weight of bodies. But fire has itſelf no weight at all: therefore it can give none. Pure Fire, as Dr. Hillary obſerves, is a body without gravity, and has no more tendency to any one part of ſpace, than to any other.

Is not then this alteration of weight rather owing to an alteration of the inward texture of the particles in the body calcined? The lighter particles being removed by exhalation, do not thoſe remaining approach nearer each other? And muſt not then the weight, which is always as the ſolidity, increaſe accordingly?

It ſeems ſtrange, to talk of heating cold liquors with ice. Yet it may eaſily be done thus. Out of a baſon of cold water, wherein ſeveral fragments of ice are ſwimming, take one or two, and plunge them into a wide-mouthed glaſs of ſtrong oil of vitriol: this quickly melts the ice, and by

two

two or three ſhakes, the liquor grows ſo hot, that frequently you cannot endure to hold the phial in your hand.

It may ſeem as ſtrange, that thoſe parts of the earth, which are neareſt the ſun ſhould be intenſely cold. Yet ſo it is. For the higher you aſcend on mountains, the colder is the air. And the tops of the higheſt mountains in the moſt ſultry countries are eternally cloathed with ſnow. This is partly owing to the thinneſs of the air, partly to the little ſurface of earth there, to reflect the ſolar rays.

Thus very different degrees of heat, obtain in the ſame latitude, on the different ſides of the South American Continent: which ſhews that the temperature of a place depends much more upon other circumſtances, than upon its diſtance from the pole, or nearneſs to the equinoctial. Thus though the Coaſt of Brazil is extremely ſultry, yet the coaſt of the South Seas in the ſame latitude is quite temperate, and in ranging along it, one does not meet with ſo warm weather, as is frequent in a ſummer's day in England; which is the more extraordinary, as there never falls any rain to refreſh and cool the air. On the coaſt of Peru, even under the line, every thing contributes to make the day agreeable. In other countries, the ſcorching ſun in ſummer, makes the day unfit either for labour or amuſement: and the rains are no leſs troubleſome, in the cooler parts of the year. But in this delightful climate, the ſun rarely appears; for there is conſtantly a grey, chearful ſky, juſt ſufficient to ſcreen the ſun, without obſcuring the air. Thus all parts of the day are proper for labour, while the coolneſs produced elſewhere by rains, is here brought about by freſh breezes, from the cooler regions.

This is chiefly owing to the Andes, which running not far from, and nearly parallel with the ſhore, and riſing immenſely higher than any other mountains in America, form on their ſides a prodigious tract of land, where according to their different heights, all kinds of climates may be found, at all ſeaſons of the year. Theſe mountains intercept great part of the eaſtern winds, which generally blow on the continent of America, cool that part of the air which comes over their tops, and keep it cool by the ſnows, with which they are always covered. Thus by ſpreading the influence of their frozen creſts, to the neighbouring coaſts and ſeas, they cauſe the temperature and equability which conſtantly prevail there. But when they leave theſe mountains, they experience in a ſhort time an entire change of climate, and in two or three days paſs from the temperate air of Peru, to the ſultry atmoſphere of the Weſt Indies.

The ſparks which appear on ſtriking Fire with a flint and ſteel, are diſcovered by the microſcope, to be ſo many ſpherical balls of iron, detached by the blow from the maſs. They are then red hot. After they cool, they are a ſort of ſcoriæ or droſs.

2. Fire is Generated chiefly, either by collecting the ſun-beams by a glaſs, or by rubbing hard bodies againſt each other. Either way the ſubtle matter is collected from all ſides, and put into a rapid, circular motion. This continues together, as long as it is ſupplied with inflammable ſubſtances. The

The particles of these being divided by the Fire, are scattered hither and thither, and the fire goes out unless fresh fuel be brought: as it does if air be wanting. For as that subtle matter is dissipating continually, it soon fails, unless recruited from the air. If water or dust be thrown upon Fire, it is likewise quickly extinguished. For these interrupt that internal motion, which is essential to it.

That fuel cannot consume without air is clearly proved by an easy experiment. Let a strong hollow cylinder of iron, be fitted with a firm screw at each end. Inclose in this a piece of charcoal: then screw up both ends, and place it in a strong fire. Let it stay there as long as you will. Open it when cool, and the charcoal is no way diminished, It is plain from this, that the consumption of fuel depends on the rarefaction and agitation of its parts by fresh air. And hence we have the reason of the known method, of extinguishing Fires by smothering them.

3. The watry part of the fuel being rarefied by the heat, ascends in the form of Smoke, carrying with it many of the lighter particles, which adhere as soot to the chimney. The grosser and more compact, the contexture whereof the Fire cannot wholly destroy, remain and constitute ashes, which are of consequence extremely porous, all that was combustible in it being consumed.

To enlarge a little on this subject. Fire is a body, and a body in motion. It is in motion; for it expands the air, which can no otherwise be done, than by communicating motion to it. And that it is a body appears hence. Pure mercury inclosed in a phial, and kept in a gentle heat for

 a year,

a year, is reduced into a ſolid. And its weight is conſiderably increaſed, which can only ſpring from the acceſſion of fire.

Fire is the inſtrument of all the motion in the univerſe. Without it all bodies would become immoveable. Men would harden into ſtatues: and not only water, but air cohere into a firm, rigid maſs.

As it is in itſelf, it is termed *Elementary Fire*: joined with other bodies it is called *Culinary*. The minute particles of this, joining with thoſe of the pure Fire, conſtitute what is termed Flame. Pure Fire, ſuch as is collected by a burning glaſs, yields no flame, ſmoke, or aſhes. In itſelf it is imperceptible, but is diſcovered by its *effects*. The firſt of theſe is *heat*, which ariſes wholly from Fire, and the meaſure of heat is always as the meaſure of Fire. The ſecond is, *dilatation* in all ſolid, and *rarefaction* in all fluid bodies. So an iron rod, the more it is heated, increaſes the more in all its dimenſions. And by the ſame degrees that it cools, it contracts, till it ſhrink to its firſt magnitude. So gold, when fuſed takes up more ſpace than it did before. And mercury aſcends in an hollow tube over the fire, to above thirty times its former height. The ſame degree of heat rarefies fluids ſooner, and in a greater degree than it does ſolids. And the lighter the fluid, the more it is dilated. Thus air, the lighteſt of all fluids, expands the moſt. The third effect of Fire is *motion*: for in dilating bodies, it muſt needs move their parts. All motion ſprings from it. Only take Fire away, and all nature would grow into one concrete, ſolid as gold, and hard as diamond.

Pure Fire needs no air to ſuſtain it. Put calx of tin into an exhauſted receiver, and if you apply a burning

burning glaſs, the calx will be ſo vehemently dilated, as to break the receiver into a thouſand pieces.

All the effects of elementary Fire may be increaſed. 1. By rubbing one body againſt another. And the more hard and ſolid the bodies are, the more heat is produced. So ſponges rubbed together acquire little or no heat: but two pieces of iron, an intenſe heat. 2. By mixing certain bodies together. So ſteel-filings mixed with oil of cloves or ſpirit of nitre grow exceeding hot; yea, burſt into a violent flame.

Yet it does not appear that any new Fire is generated in any of theſe ways. Friction does not create Fire, but only collect what was before diſperſed. It is preſent every where, in all bodies, in all ſpace, at all times, and that in equal quantities. Go where you will, to the higheſt mountain, or the deepeſt cavern, by one or other of theſe ways Fire may be collected. Yea, there is no place in the world, where the attrition of two ſticks will not make it ſenſible.

But in what manner ſoever Fire is collected, if the collecting cauſe ceaſe, it diſappears again, unleſs it be ſupplied with fuel, and then it becomes Culinary Fire. By fuel we mean whatever receives and retains Fire, and is conſumed thereby. The only fuel in nature is oil or ſulphur, and bodies are only fuel, as containing oil. Hence 1. All vegetables, not too moiſt or too dry, afford fuel, particularly thoſe which contain much oil, as balſamic and reſinous woods. 2. All vegetable and animal coals, being thoſe parts which have exhaled their water and ſalt, and retained the oil alone inhering in the earth. 3. All bituminous earth. 4. All mineral ſulphur, whether pure or joined with other things. 5. The fat and dung of animals: and 6. Chymical oil and spirits.

On the removal of air, this Fire goes out. Yet it does not immediately bear the air, but repels it, and by that means forms a kind of vault, which by its weight and the pressure of the incumbent air, confines the particles that would otherwise escape, and applies them to the combustible matter. Hence the heavier the air, the fiercer the Fire; which therefore is fiercest in still, cold weather.

The Fire in burning combustible matter, affords a shining fire or flame, or both: and frequently too, smoke, soot and ashes. Shining Fire seems to be elementary Fire, so strongly attracted toward the particles of the fuel, as to whirl, divide, attenuate them, and thus render them volatile, and just fit to be expelled. Flame seems to be the most volatile part of the fuel, greatly rarefied and heated red hot. Soot is a sort of coal, consisting of a thick sulphur, and an attenuated oil, with earth and salt. Smoke is the earthy and watry particles of the fuel, so rarefied as to break through into the atmosphere. Ashes are the earth and salt, which the fire leaves unchanged.

Fire increases the weight of some bodies. Thus if antimony be placed under a burning-glass, the greatest part of it will seem to evaporate in fumes, and yet if it is weighed, it will be found to have gained in weight.

But beside the solar, there is a subterraneous Fire. The earth is only cold to the depth of forty or fifty feet. Then it begins to grow warmer; and at a great depth it is so hot as to destroy respiration. Hence we learn that there is another source of Fire, or as it were another sun in the bosom of the earth.

Upon

Upon the application of Fire to water, it boils: that is, the particles of Fire, paſſing through the pores of the veſſel, ſtrike on the loweſt particles of the water, impel them upwards, and render them lighter than before, both by inflating them into little veſicles, and by breaking and ſeparating their ſpherules. There will of conſequence be a conſtant flux of water, from the bottom of the veſſel to the top. And hence we ſee, why the water is hot at the top, ſooner than at the bottom.

Farther, the air contained in the interſtices of the water being dilated, and its ſpring increaſed by the heat, it aſcends through the water into the air, carrying with it the contiguous particles of water. And by this means much of the water will be heaved up, and let fall alternately, as the air has no power to carry away into the atmoſphere more than that ſmall part that riſes in the ſteam.

4. That this ſubtle matter is plentifully collected in the bowels of the earth, appears from Burning Mountains. It is obſerved, that there is always in the neighbourhood of theſe, plenty of ſulphur or bitumen, the ſtench whereof ſpreads far and near, eſpecially before any great eruption. This feeds the Fire, which may be kindled by various means, ſo as to continue for many centuries. Ætna and Veſuvius have burned for above 2000 years, and probably will till the end of time.

5. Mount Ætna is divided into three diſtinct regions, called La Regione Culta: the Fertile Region: La Regione Sylvoſa, the Woody Region; and La Regione Deſerta, the Barren Region.

The three are as different, both in climate and productions, as the three zones of the earth: and perhaps with equal propriety might have been ſtiled the torrid, the temperate, and the frigid zone. The firſt region ſurrounds the foot of the mountain, and conſtitutes the moſt fertile country in the world on all ſides of it, to the extent of about fourteen or fifteen miles, where the woody region begins. It is compoſed almoſt entirely of lava, which, after a number of ages, is at laſt converted into the moſt fertile of all ſoils.

Every eruption generally forms a new mountain. As the great crater of Ætna itſelf is raiſed to ſuch an enormous height above the lower regions of the mountain, it is not poſſible that the internal fire raging for vent, even round the baſe, and no doubt vaſtly below it, ſhould be carried to the height of twelve or thirteen thouſand feet, from the ſummit of Ætna. It has therefore generally happened, that after ſhaking the mountain and its neighbourhood for ſome time, it at laſt burſts open its ſide. At firſt it only ſends forth a thick ſmoke, and ſhowers of aſhes, that lay waſte the adjacent country: theſe are ſoon followed by red-hot ſtones, and rocks of a great ſize, thrown to an immenſe height in the air. The fall of theſe ſtones, together with the quantity of aſhes diſcharged at the ſame time, at leaſt form one of theſe ſpherical and conical mountains. Sometimes this proceſs is finiſhed in the courſe of a few days: ſometimes it laſts for months, which was the caſe in the eruption in 1669. In that caſe the mountains formed are of a great ſize; ſome of them are not leſs than ſeven or eight miles round, and upwards of one thouſand feet in perpendicular height: others are not more than two or three miles round, and three or four hundred feet high.

After

After the new mountain is formed, the Lava generally bursts out from its lower side; and bearing away every thing before it, is for the most part terminated by the sea. This is the common progress of an eruption; however, it sometimes happens, though rarely, that the lava bursts at once from the side of the mountain, without all these attending circumstances; and this is commonly the case with the eruption of Vesuvius, where the elevation being so much smaller, the melted matter is generally carried up into the crater of the mountain, which then discharges showers of stones and ashes from the mouth of the volcano, without forming any new mountain, but only adding considerably to the height of the old one; till at last the lava, rising near the summit, bursts the side of the crater, and the eruption is declared. This has been the case with two eruptions lately; but Ætna is upon a much larger scale, and one crater is not enough to give vent to such oceans of liquid fire.

Recupero saw in an eruption of that mountain, large rocks of fire discharged to the height of some thousand feet, with a noise more terrible than that of thunder. He measured from the time of their greatest elevation, till they reached the ground, and found they took twenty-one seconds to descend, which (the spaces being as the squares of the times) amounting to upwards of 7000 feet.

After contemplating these objects for some time, says a late traveller, we set off, and soon after arrived at the foot of the great crater of Ætna. This is of an exact conical figure, and rises equally on all sides. It is composed solely of ashes, and other burnt materials, discharged from the

the mouth of the volcano, which is in its center. This conical mountain is of a very large ſize: its circumference cannot be leſs than ten miles. Here we took a ſecond reſt, as the greateſt part of our fatigue ſtill remained. The mercury had fallen to 20 4½. We found this mountain exceſſively ſteep; and although it had appeared black, yet it was likewiſe covered with ſnow, but the ſurface (luckily for us) was ſpread over with a pretty thick layer of aſhes, thrown from the crater. Had it not been for this, we never ſhould have been able to get to the top.

The circumference of this zone or great circle on Ætna is not leſs than ſeventy or eighty miles. It is every where ſucceeded by the vineyards, orchards and corn-fields that compoſe the Regione Culta, or the Fertile Region. The laſt zone is much broader than the others, and extends on all ſides to the foot of the mountain. Its whole circumference, according to Recupero, is 183 miles.

The preſent crater of this immenſe volcano is a circle of about three miles and a half in circumference. It goes ſhelving down on each ſide, and forms a regular hollow, like a vaſt amphitheatre. From many places of this ſpace, iſſue volumes of ſulphureous ſmoke, which being much heavier than the circumambient air, inſtead of riſing in it, as ſmoke generally does, immediately on its getting out of the crater, rolls down the ſide of the mountain like a torrent, till coming to that part of the atmoſphere of the ſpecific gravity with itſelf, it ſhoots off horizontally; and forms a large tract in the air, acccording to the direction of the wind; which happily for us, carried it exactly to the ſide oppoſite to that where we were placed.

placed. The crater is ſo hot that it is very dangerous, if not impoſſible, to go down into it: beſides, the ſmoke is very incommodious, and in many places the ſurface is ſo ſoft, there have been inſtances of people ſinking down into it and paying for their temerity with their lives. Near the center of the crater is the great mouth of the volcano. That tremendous gulph ſo celebrated in all ages. We beheld it with awe, and with horror, and were not ſurpriſed that it had been conſidered as the place of the damned. When we reflect on the immenſity of its depth, the vaſt cells and caverns whence ſo many lavas have iſſued; the boiling of the matter, the ſhaking of the mountain, the exploſion of flaming rocks, we muſt allow that the livelieſt imagination hardly ever formed an idea of hell more dreadful.

Kircher pretends to have meaſured it, and to have found it four thouſand French toiſes in height; which is more than any of the Andes are. The Italian Mathematicians are ſtill more abſurd. Some of them make it eight miles, ſome ſix, and ſome four. Arnici, the laſt, and I believe the beſt who has made this attempt, reduces it to three miles, two hundred and ſixty-four paces; but even this muſt be exceedingly erroneous, and probably the perpendicular height of Ætna is little more than two miles.

It is a curious conſideration that this mountain ſhould re-unite every beauty and every horror; and in ſhort, all the moſt oppoſite and diſſimular objects in nature. Here you obſerve a gulf, that formerly threw out torrents of fire now covered with the moſt luxurient vegetation; and from an object of horror becomes one of de-

light

light. Here you gather the moſt delicious fruits, riſing from what was lately a black and barren rock. Here the ground is covered with every flower; and we wonder over theſe beauties, and contemplate this wilderneſs of ſweets without conſidering that hell and all its terrors, is immediately under our feet, and that but few yards ſeparates us from lakes of liquid fire and brimſtone.

But our aſtoniſhment ſtill increaſes, on caſting our eyes on the higher regions of the mountain. There we behold in perpetual union, the two elements that are at perpetual war; an immenſe gulph of fire, for ever exiſting in the midſt of ſnows, which it has not power to melt; and immenſe fields of ſnow and ice for ever ſurrounding this gulph of fire, which they have not power to extinguiſh.

The quantity of matter diſcharged from Ætna, is ſuppoſed upon a moderate computation to exceed twenty times the original bulk of the mountain. The greateſt part of Sicily ſeems covered with its eruptions. The inhabitants of Catanea have found at the diſtance of ſeveral miles, ſtreets and houſes, ſixty feet deep, overwhelmed by the lava or matter it has diſcharged: nay the walls of theſe very houſes have been built of materials evidently thrown up by the mountain. The inference is obvious: that the matter thus exploded cannot belong to the mountain itſelf: otherwiſe it would have been quickly conſumed: it cannot be derived from moderate depths: ſince its amazing quantity evinces that all the places near the bottom, muſt have long ſince been exhauſted: it muſt therefore be ſupplied from the deeper regions of the earth; theſe undiſcovered tracts,

where

where the Deity performs his wonders in ſolitude.

An eruption of Mount Ætna in 1669 was preceded for eighteen days, with a dark, thick ſky, thunder, lightening, and frequent tremblings of the earth. The place of eruption was twenty miles from the old mouth: the matter of it was a ſtream of melted minerals, boiling up and guſhing out, as water does at the head of a great river. Having run thus for more than a ſtone's caſt, the extremities began to cruſt, and turn into porous ſtones, reſembling huge cakes of ſea coal, full of a fierce fire. Theſe came rolling over one another, and where any thing oppoſed, filled up the ſpace and rolled over. But they bore down any common building, and burnt up all that was combuſtible. This inundation went on about a furlong a day, for nineteen or twenty days. It overwhelmed fourteen towns and villages. The noiſe of the eruption was heard ſixty miles.

On Sunday, March 9, 1755, about noon, Mount Ætna began to caſt from its mouth a great quantity of flame and ſmoke, with a moſt horrible noiſe. At four o'clock the air became quite dark and covered with black clouds. At ſix a ſhower of ſtones, each weighing about three ounces, began to fall over all the city of Maſcali and its territories. This ſhower laſted till a quarter paſt ſeven; and was ſucceeded all night by a ſhower of black ſand. On Monday morning at eight, there ſprang from the bottom of the mountain a river of ſcalding-hot water, which in half a quarter of an hour, overflowed all the rugged land that is near the foot of the hill, and ſuddenly going off, left the whole a large plain of ſand. The ſtones and ſand which remain wherever this water reached, differ

differ in nothing from the ſtones and ſand of the ſea; and have even the ſame ſaltneſs. After the water was gone there ſprang from the ſame opening a ſmall ſtream of fire, which continued for four and twenty hours. On Tueſday about a mile below this opening, there aroſe another ſtream of fire, which being in breadth about four hundred feet, overflowed all the adjacent country.

6. On the 3d of December, 1754, a ſtream of liquid Fire, began to run down the ſide of mount Veſuvius, from an opening on the eaſt ſide. But it ſoon ceaſed running from this orifice, and burſt out from a much larger one, about two hundred yards below it. Afterward it burſt out from a third orifice, and having ran ſome ſpace with great fury, the ſurface then began to cool and incruſt; as it ran over gently-declining ground, till it came within about ten yards of the top of a ſteep declivity. Here the Fire collected, as in a reſervoir, to ſupply a caſcade, which ruſhed down from thence in a channel of more than twenty feet wide, and about two hundred yards in length, with a fall of at leaſt fifty feet. After this the ſtream was leſs rapid, but grew wider, and ſpread ſeveral miles from its ſource. It now preſented a very different ſcene from what it afforded before. The caſcade (ſays an eye-witneſs) looks like melted gold, and tears off large bodies of old Lava (ſo they term the incruſtation) which float down the ſtream, till the intenſeneſs of the heat lifts them from the bottom. But in the lower country, it divides into ſmaller ſtreams, running with leſs rapidity: and yet with ſuch violence, that it drives the ſtrongeſt ſtone fences before it, and

and lighting the trees, like torches, affords a most extraordinary, though dismal spectacle.

On December 23, 1760, about two in the morning, a violent shock of an earthquake was felt, near Mount Vesuvius. Some time after, some countrymen being at work, four or five miles from it, perceived the ground near them on a sudden heave and gape, like dough that is rising. At the same time they observed smoke issuing from the clefts. They immediately fled, till they thought they were out of danger. And then looking back, saw the water of a cistern, near which they had been at work, spout out to a great height. This was succeeded by a large discharge of fiery matter from the mouth of the cistern, and from four other openings, attended with a dreadful noise and explosion of burning stones. On a sudden all the fiery streams united in one, flowed impetuously down the mountain, and gliding quick as lightening, presently covered all the adjacent lands. Mean time the whole mountain shook greatly, and a fixed pillar of smoke issued out of the main aperture, which rising to a certain height, then dissolved into ashes, and fell like rain all over the mountain. At the same time an immense quantity of burning stones was thrown out.

The fiery stream continued running down the mountain, the whole night between the 23d and 24th. Houses, Gardens, and every thing in its way, were consumed. And ashes were still thrown out, which lay deep on the ground for several miles about, and reached as far as the sea-coast.

On the 25th also there was an eruption of liquid fire, with a shower of stones, and a huge noise. In several parts this stream was fifty spans deep

deep. The mountain mean time continued to roar, and thick ashes fell like rain over the whole country.

On the 26th both the mountain itself and the hills lately produced, sent forth stones and ashes. the bellowings were still heard, but with intermissions: and out of the five apertures, two only continued to emit stones, ashes, and fire.

On the 27th only one fiery stream remained, and that began to cool, and to lose its brightness, appearing more dusky, like burning coals ready to go out. On the 28th the stream ran much slower, and no more burning stones were cast out. The height of the chief hill raised thereby was about two hundred spans; and its circumference about two hundred paces. The motion of the Lava in front was very slow; it gained ground only on the sides. The hill, where the last aperture was, burst, and Fire issued from all the fissures.

On the 29th, the Lava having ceased, appeared to have reached about a mile in breadth and four miles in length. The new-raised hills were now quiet: but the top of Vesuvius still cast out ashes and smoke and some showers of stones. About eight at night the new hill was overturned with a great crack, and on the 30th emitted nothing. But from the mouth of Vesuvius clouds and ashes came in great abundance. From the whole it appears, that the inflammatory contents take Fire at a great depth in the cavern, and it is highly probable, it is the sea-water which feeds this subterraneous fire, by means of some communications which the Volcano has with the Mediterranean.

Although the fiery eruptions of mount Vesuvius strike the neighbourhood with horror; yet as even noxious things bring some advantage with them; so this mountain by the sulphureous and nitrous

nitrous particles with which it manures the ground, and the heat of its ſubterraneous paſſages, much contributes to its uncommon fertility. And whereever theſe inflammable ſubſtances abound, it is better they ſhould have a vent than not. So experience ſhews, that this country has had fewer earthquakes, and thoſe leſs fatal in their effects, ſince the eruption of the ſubterraneous matter, through the mouth of Veſuvius. And the inhabitants are not much alarmed, at ſeeing the uſual vernal exploſions.

The diſtance from Naples to the foot of Veſuvius, is five Italian miles, from whence to the top is near three miles further. It properly conſiſts of two hills, though one of them only, emits Fire and ſmoke. The valley between them is about a mile long, and extremely fertile. The burning ſummit, which is the loweſt of the two, is eleven hundred fathoms above the ſurface of the ſea. From Reſina, the aſcent grows ſteeper, and many ſtones are ſcattered about, as memorials of its former devaſtations. It is aſtoniſhing to think of the force, by which ſuch huge bulks of four or five hundred weight have been thrown ſeveral miles from the hill.

This being ſteep, and covered with black aſhes, the aſcent is very difficult. From the mouth frequently iſſues a flood of Lava, or compoſition, of ſulphur, metals, and minerals. This ejected matter lies ſtill one layer above another, with large ſtones projecting above the ſurface, which in their courſe along the fiery river, were ſtopped by their inequalities, and fixing in the melted matter, gradually hardened. Theſe ſtreams are not thrown up from the mountain, like the ſtones, but pour down as from an inclined veſſel, proceeding, it ſeems

ſeems, from the whole cavity, which is then full of melted ſubſtances.

About half way up the mountain (ſays Mr. Keyſter) we met with ſtones above of an hundred weight, glowing hot, which when broken had exactly the appearance of red hot iron. As we went on, we heard a moſt horrid noiſe, reſembling the diſcharge of a whole battery of cannon, and under our feet we perceived a rumbling, like the boiling of a large caldron. At laſt we reached the place where the largeſt volcano was formerly ſituated. But it is now not only choaked up but covered with a round pile of aſhes and lava. Thirty years ſince there was a plain of about three thouſand yards to croſs, before you came to the ſkirts of this new mountain. But it is now ſo inlarged, that in moſt places, the plain is but about thirty yards broad. Probably in a few years it will be quite filled up, and the two mountains joined in one. Here the increaſe of heat was very ſenſible, eſpecially at every exploſion, when the aſhes flew ſo ſtrongly in our faces, that we were obliged to cover our eyes. The ground alſo was ſo hot under our feet, that it burnt the ſoles of our ſhoes. Every eruption was attended with a whizzing noiſe, like that of many rockets thrown up at once. The clouds of ſmoke, and the multitude of ſtones thrown into the air, totally obſcured the ſky. Moſt of the ſtones, (eſpecially if large) fell again into the abyſs from which they were projected. Great quantities however fell on the ſides of the mountain, and rolled down with a hideous noiſe.

Even when all is ſtill, the bottom of the cavity is ſeldom ſeen, by reaſon of the ſmoke. When it is, it is ſubject to great variation. Sometimes it is of a proa prodigious depth; at other times hardly more than an hundred feet, according to the rising or falling of the melted matter, since the last eruption, by the hardening of which, this bottom is formed.

Since the birth of Christ, there are recorded upwards of twety memorable eruptions of Vesuvius. One of the most violent was, that which happened in the reign of Titus Vespasian, and destroyed the cities Herculaneum, Stabice and Pompeii, which then stood near Naples. During that eruption the ashes were driven as far as Africa, Syria, and Egypt, and even at Rome, the sun was darkened by them. These cities were partly swallowed up, partly buried in the burning lava, so that not the least remains of them were to be seen.

But within a few years many things have been dug out of Herculaneum, near Portici, the King of Naples' palace. Among these are many paintings done in Stucco, in water colours in Fresco. They have been taken from the walls of an amphitheatre, a temple, and several houses, and are in great variety, some perfectly well preserved.

Four capital pieces are so extremely well executed that Don Francesco de la Vega, a painter, whom the king of Naples sent for from Rome, to take draughts of these paintings, said, "If Raphael were alive, he would be glad to study these drawings, and perhaps take lessons from them." Nothing can be more just and correct. The muscles are exactly and softly drawn, every one in its own place, without any of that preternatural swelling seen in the works of some of the best Italian masters. And it is surprising to see how fresh the colours are, considering they have been under

under the ground above ſixteen hundred and fifty years.

The matter thrown out of Veſuvius, ſhews whence its fiery eruptions ariſe. For, pour water on ſulphur, mixed with filings of iron, and it ſoon breaks out into a flame, That abundance of ſulphur and iron is contained in Veſuvius, appears not only from what is ejected, but alſo from the mineral water, iſſuing from the foot of the mountain. The neighbouring ſea both ſupplies moiſture to theſe inflammable ſubſtances, and alſo ſalt andbitumen. That Veſuvius has a communication with the ſea, experience ſhews, the waters being ſurpriſingly abſorbed, in 1681, before the eruption, ſo that the ſeveral veſſels before afloat were left dry. Likewiſe in 1698, the ſea ſuddenly ebbed twelve paces and the mountain diſcharged a torrent of bituminous matter. When the diſcharge ceaſed, and the ſea returned to its former height, great quantities of ſhells, half burnt, and emitting a ſulphurous ſmell, were found along the ſhore. In another violent eruption, not only ſhells, but ſea-weeds, and hot ſea-water were ejected.

This volcano, however, affords ſeveral freſh ſprings, ſome of which are conveyed to Naples, by a beautiful aqueduct. Theſe waters have not the leaſt heat in them. Nay, a cold wind is left to blow, from ſeveral fiſſures and chaſms of the mountain.

The whole country for twenty miles or more round Naples, is the product of ſubterraneous fires. Probably the ſea reached the mountains that lie behind Capua and Caſerta. Theſe fires ſeem to have worked under the bottom of the ſea, as moles in a field, throwing up here and there

there a hillock. And the matter thrown out of ſome of theſe hillocks formed into ſettled volcanos, filling up the ſpace between them, has compoſed this part of the continent, and many of the iſlands adjoining.

Were the matter carefully examined, it would be found (juſt contrary to the common opinion) that moſt mountains which are or have been volcanos, owe their exiſtence to ſubterraneous fires.

It cannot be denied that Herculaneum and Pompei once ſtood above the ground, though now the latter is buried ten or twelve feet deep; the former in no part leſs than ſeventy, in ſome parts an hundred and twelve. As theſe were buried by an eruption of Veſuvius, A. D. 79, it muſt be allowed, that whatever matter lies between them and the ſurface of the earth over them, muſt have been produced ſince this time.

Pompei being farther off, felt the effects of a ſingle eruption only. It is covered with white pumice ſtones, mixed with fragments of lava and burnt matter. Over this there is a ſtratum of good mould, about two feet thick. The ſhower of pumice ſtones covered alſo the town of Stabiæ, with a tract of country thirty miles in circumference. It is obſervable, the pavement of the ſtreets of Pompei is of lava: nay, under the foundation of the town, there is a deep ſtratum of lava and burnt matter: hence it is clear, there have been eruptions before that of 79, the firſt which is recorded in hiſtory.

The matter which covers Herculaneum, is not the produce of one eruption only. From the ſtrata of mould intermixed it appears, that five or ſix eruptions have taken their courſe over that which lies immediately above the town, with which the theatre, and moſt of the houſes are filled. This is not vitrified lava, but a ſort of ſoft ſtone, compoſed of pumice, aſhes, and burnt matter. It is of the ſame nature with what the Italians call Tufa, and is in general uſe for building, and is met with only in thoſe countries that have been ſubject to ſubterraneous fires. As water frequently attends eruptions of fire, doubtleſs the firſt matter that iſſued from Veſuvius, and covered Herculaneum, was in the ſtate of liquid mud.

Bracini deſcended into the crater (or hollow on the top) of Veſuvius, a little before the eruption in 1631. He obſerves, it was then five miles in circumference, and about 1000 paces deep. Its ſides were covered with bruſh wood, and at the bottom there was a plain on which cattle grazed. In the midſt of this plain was a narrow paſſage, through which by a winding path he deſcended among rocks and ſtones into a more ſpacious plain, covered with aſhes. In this were three little pools, one of hot water, bitter and corroſive beyond meaſure, another of water ſalter than that of the ſea; the third, hot but taſteleſs.

The great increaſe of the cone of Veſuvius, from that time to this, naturally induces one to think, that the whole cone was raiſed in like manner, as was alſo that part of it now called Somma. It ſeems, that this was what the ancients termed Veſuvius, and that the conical mountain at preſent called by that name, has been raiſed by the ſucceeding eruptions.

From repeated obſervations, it appears, that all the ſoil in the neighbourhood of Veſuvius, is compoſed

poſed of different ſtrata of erupted matter, to a great depth below the level of the ſea. And undoubtedly this volcano took its riſe from the bottom of the ſea. The ſoil from Capriæ to Naples is of the ſame ſort. And that on which Naples ſtands, has been evidently produced by exploſions, ſome of them on the very ſpot whereon the city is built. All the high grounds round it, with the iſlands of Prochyta and Iſchia, appear likewiſe to have been raiſed in the ſame manner.

Such wonderful operations of nature, are certainly intended for ſome great purpoſe. They are not confined to one country; volcanos exiſt in the four quarters of the globe. We ſee the fertility of the ſoil occaſioned thereby, in what was thence called Compania felix. The ſame is evident in Sicily, juſtly eſteemed one of the moſt fertile ſpots in the world. May not ſubterraneous fire be conſidered as the great plough (if we may be allowed the expreſſion) which nature makes uſe of to turn up the bowels of the earth, and afford us freſh fields to work upon, when the former are exhauſted? Perhaps likewiſe many precious minerals might have remained unknown to us, had it not been for theſe operations of nature.

There is great reaſon to believe that the whole Iſland of Madeira was at ſome remote period thrown up by the exploſion of ſubterraneous fire, as every ſtone, whether whole or in fragments, that is ſeen upon it appeared to have been burnt; and even the ſand itſelf to be nothing more than aſhes. And it is certain, that part of the country near the ſea is a very exact ſpecimen of the reſt

7. Near Puzzuolo lies Monte Secco, which is Vesuvius in miniature. Its summit, formerly a cone, is now sunk into a concave oval, whose shortest diameter is about one thousand feet, the longest one thousand two hundred and forty-six. It is generally known by the name of Solfatara. Though Vesuvius is twelve miles distant, yet they have a communication with each other. Hence the subterraneous Fire is quiet at Solfatara, when it has a vent at Vesuvius: whereas the heat at the former increases, when the latter is at rest.

On this mountain are many cracks emitting smoke; the heat issuing from them is sometimes insupportable. Hold a piece of iron over one of these cracks, and a sweetish fluid will drop from it: but a piece of paper, instead of being moistened, grows quite dry and stiff. The stones near these cracks are in continual motion; and small stones dropped into them are ejected to the height of twelve feet, like the ponderous masses from Vesuvius. In some places the sand by the force of the vapours, springs up and down, like the sparkling of cyder.

Out of Solfatara they extract beside sulphur, blue vitriol, and the best kind of allum. The large leaden kettles used therein, are not heated by a culinary fire, but by the natural heat, issuing through holes in the ground, over which the vessels are placed.

8. Not far from Puzzuolo is Monte Nuovo, which rose suddenly in the night, between the 19th and 20th of September, 1636. During a dreadful earthquake, that laid the whole neighbourhood in ruins, the subterraneous Fire, opening a large chasm in the ground, threw out such quantities of stones, ashes, bitumen, and sand,

ſand, as in twenty-four hours formed this mountain. Its perpendicular height is 400 rods, its circuit three miles. The edge of the firſt aperture is ſtill viſible, a mile in circuit, though it is now entirely filled up.

9. An event ſimilar to this occured more lately. After a ſhock of the earth, there was ſeen from Santorini (an iſland in the Archipelago, on the coaſt of Natolia) on the 23d of May, 1707, as it were a floating rock. Some were ſo bold, as to go down upon it, even while it was riſing under their feet. The earth of it was very light, and contained a ſmall quantity of Potters Clay. It increaſed daily, till it was half a mile in circumference, and twenty or twenty-five feet high. At this time a great ridge of rocks, dark and black, roſe out of the ſea, and joined to the new iſland. Then there iſſued out of it a thick ſmoke, with a noiſe like conſtant thundering, or a diſcharge of many cannon at once. The ſea-water continually bubbled up; and in a ſhort time the new land preſented nothing to view for whole nights, but a great number of ſtoves, which caſt forth flames, with ſhowers of aſhes, and innumerable ſmall ſtones, red hot. Rocks were alſo darted out of theſe burning furnaces, which mounted up like bombs. This continued till November.

There is likewiſe an iſland among the Azores, which had the ſame original. On the night between the 7th and 8th of December, 1720, there was felt a ſhock of an earthquake at Tercera: and preſently after an Iſland roſe, from the midſt of boiling hot water. It was nearly round, and high enough to be ſeen ſeven or eight leagues off. But after a little while it ſunk, till it became level with the water.

10. On June 4th, 1693, the mountain on the iſland Torca in the Eaſt-Indies, began about day-break, to caſt out more Fire than uſual, which continued five or ſix days, till at laſt it poured forth, not only a prodigious flame, but likewiſe ſuch a black and ſulphureous vapour, that the inhabitants of Hiſlo (a village in the weſtern part of the iſland, and neareſt to the opening) were wholly covered by it. Quickly followed a ſtream of burning brimſtone, which conſumed many that could not eſcape. Afterwards the inhabitants perceived, a great part of the mountain was ſunk down. Another part ſunk three or four days after, and ſo from time to time, till the burning lake covered near half the iſland. Wherefore they went on board their boats: from whence they perceived huge pieces of the mountain fall into the fiery lake, with a prodigious noiſe, as if a whole battery of cannon was diſcharged. The inhabitants of another town on the eaſt ſide of the iſland, not thinking themſelves in ſo great danger, remained a month longer. But the fiery lake approaching nearer and nearer, ſo that there was no doubt but it would ſwallow up the whole iſland, they too fled for their lives, and arrived at Amboyna, July the 18th, 1693.

In the Mountains of Ternata, a terrible noiſe is continually heard. The fire frequently caſts out ſtones, and lies exceeding deep. Probably the burning mountains in the Molucca Iſlands are conſumed beneath by the ſame Fire.

Manilla

Manilla is one of the largest of the Philippine Islands. The city is much larger than Oxford, is an university, and is inhabited only by Spaniards. The houses are large, and built very strong. The lower walls are stone, and of a prodigious thickness. All above is wood, and every piece of timber has a connexion with the others, and all are jointed together, that the earthquakes which are very frequent may not throw them down. In 1750, they had an earthquake with almost continual tremblings for three months. Then followed an eruption in a small island, surrounded by a large lake, which is unfathomable. The third day after the eruption began, there arose in the lake four more small islands all burning. About a mile from one of these, there is a fire rising continually out of the water, in a part where there is no ground for above an hundred fathom.

11. A particular account of a journey to Mount Hecla, is given by a late author. We travelled, says he, two days in rugged and unfrequented roads. Then we came within six miles of the mountain, and perceived the ground strewed with ashes and pumice stone, over which we passed to the foot of it. The weather being serene and calm, and no flames issuing out of the volcano, we resolved to go to the top; till being informed by our guides, that if we went any further, we should be in danger of falling into pits, where we might be suffocated by the fumes rising out of the earth, all my company declined it. I told them, if they would stay for me, I would go alone, They promised they would. So I alighted and and prepared to go up, when one of them offered to go up with me.

Having given our horses to our guides, who stayed

ſtayed with the reſt of our company, we ventured forward, reſolving to reach the top, and in a ſhort time ſaw a large flight of crows and vultures, that had their neſt in the top of the mountain. Having aſcended about half a league, we felt the ground ſhake under us, and heard a terrible noiſe in the bowels of the earth, juſt as if it was going to burſt open. At the ſame time there appeared on all ſides chinks, out of which iſſued bluiſh flames, with a ſtrong ſuffocating ſmell. This made us turn back, for fear of being burnt to aſhes. But we had ſcarce proceeded thirty yards back, before a black cloud of ſmoke aſcended out of the mountain, obſcured the light of the ſun, and covered us ſo thick, that we could not ſee each other. Our fears increaſed every ſtep we took; for behind us came flames of fire, with ſhowers of aſhes and pumice ſtones, which fell as thick as hail. This dreadful ſtorm was attended with horrible noiſes, and we expected every moment, the earth would open and ſwallow us up. This added wings to our flight, ſo that in a quarter of an hour we got to the bottom of the mountain.

12. There are volcanos likewiſe in many of the American iſlands: and a very eminent one in Guadaloupe. The ſummit of this conſtantly emits ſmoke, and ſometimes flames. It riſes very high, in the form of a cone, above the chain of mountains, that occupy the center of the iſland. Near the foot of it are three ſprings, the waters of which are ſo hot as to boil eggs in three minutes. The neighbouring ground ſmokes and is full of brown earth, like the droſs of iron. But the chief place where the ſmoke iſſues out, is higher up, at the foot of a ſteep bank, about fifty yards in breadth.

Here

Here no grafs is to be feen; nothing but fulphur and calcined earth. The ground is full of deep cracks, which emit much fmoke, and where you may hear the fulphur boil. But the ftench of it is intolerable. The ground is loofe, fo that you may thruft a cane up to the head. And when you draw it up, it will be as hot as if you had plunged it into flaking lime.

On the plain top of the hill is another funnel, that opened fome years fince, and emits nothing but fmoke. Here are abundance of large and deep chinks, which doubtlefs burned in former times. In the middle of this plain is a very deep abyfs. It is faid there was once a great earthquake in the ifland, and that the Brimftone Hill (fo they call it) then took fire. It was probably then this abyfs was opened. It is between two crags that rife above the mountain, and on the north fide anfwers to the great cleft, which goes down above a thoufand feet perpendicular, is more than twenty feet broad, and penetrates above an hundred paces in the flat. So that in this place the mountain is fairly fplit, from the top down to the bafis of the cone.

On this plain you may fee the clouds gather below, and hear the thunder rumble under your feet. The great cavern is under the cleft, and was doubtlefs formed by the fame earthquake that fplit the mountain into two parts nearly equal. The parting goes north and fouth. To the north is the cleft and cavern, in the middle the abyfs, and to the fouth the burning gulph. The cavern is above twenty-five feet wide, as much in height, and about fixty paces deep. Within this is a fecond cave, about fixty feet in length, as much in breadth, and forty in height. Here the heat is moderate: but there is a third cave within this, where it is ſo hot, that a torch will give no light therein, and a man can ſcarce fetch breath. Yet on the left is a great hollow, which is ſufficiently cool. And the ſpace of one fathom makes the difference. It ſeems ſtrange, that in the ſame cave, three hundred feet under ground, it ſhould be ſo hot on one ſide, and ſo cool on the other. Perhaps the cool ſide has ſome vent into the great cleft, and receives freſh air thereby.

13. Another ſurpriſing eminence, which may be ranked among burning mountains, is the Pike of Teneriffe. On the ſummit of it is an hollow twelve or fourteen feet deep: the ſides ſloping down to the bottom, form a cavity like a truncated cone, with its baſe uppermoſt. This cavity is nearly circular, about forty fathoms acroſs. The ground is very hot, and from near twenty veins, iſſues a ſmoke of a ſtrong ſulphureous ſmell. The whole ſoil ſeems powdered with brimſtone, which forms a beautifully coloured ſurface. Almoſt all the ſtones thereabouts are of a greeniſh colour, ſparkling with a yellow, like gold. On the midddle of one of the rocks is an hole, about two inches in diameter. Hence proceeds a noiſe like that of a great body of liquors boiling very ſtrongly. And ſo hot a ſteam comes from it, as will burn the hand, even at a quarter of a yard's diſtance.

A ſmall part of the ſugar-loaf is white like lime; another ſmall part is covered with ſalt. But the far greateſt part is covered with ſnow, almoſt throughout the year.

The accounts given of its height are exceeding various. But a gentleman ſome years ago, who meaſured

measured it exactly, found the perpendicular height to be two thousand, five hundred and sixty six fathoms.

14. When it happens that any inflammable substance takes fire in the caverns of the earth, the air contained therein is rarefied and exploded with an immense force. Hereby not only the arch which covers it, but the whole body of incumbent earth is shaken. And this is one species of earthquakes. In this case, the deeper the cavern is, and the larger the quantity of matter which takes fire, the more extensive and the more violent the earthquake. If the cavern is near the surface of the earth, the fire often issues out of it: and the lower parts being eaten away, the ground sinks in, and swallows up houses or whole cities.

But, to consider this point a little more minutely. As some earthquakes are owing to fire, so are some to air, others to water, and others to earth itself. 1. The earth itself may be the occasion of its own shaking, when the root or basis of some large mass being worn away, that mass sinks in by its own weight, and causes a concussion of all the neighbouring parts. 2. Subterraneous waters wash away the foundations of hills, and eat far under the earth. By this means many earthquakes have been occasioned, and whole cities swallowed up. This was undoubtedly the cause of the great earthquake at Port Royal, and of that which swallowed up Lima. 3. Air pent up in the bowels of the earth, if it be at any time rarefied and expanded, will struggle for vent with incredible force, and thereby both shake and tear the earth. 4. But the usual cause of the most violent earthquakes is sulphur, or some other inflammable matter, taking fire in the cavities of the earth, and bursting through whatever opposes.

There are ſcarce any countries that are much ſubject to earthquakes, which have not ſome burning mountain. And whenever any earthquake happens, this is conſtantly in flames. Indeed were it not that theſe vents thus diſgorge the fire, it would make far greater havock than it does; probably it would make the whole country for a vaſt ſpace round quite uninhabitable. Yea, ſo beneficial are theſe, that we do not want inſtances of countries frequently annoyed by earthquakes, which upon the breaking out of a volcano, have been wholly delivered from them.

Perhaps what cauſes moſt earthquakes of this kind is the Pyrites, or Iron-ſtone, which will take fire of itſelf. The earth, we know, abounds in cavities, which are at certain times full of inflammable vapours. This the damps in mines ſhew, which being fired, do every thing as in an earthquake, only in a leſs degree. And the Pyrites only, of all known minerals, yields this inflammable vapour. Nor is any mineral or ore whatever, ſulphureous, but what is more or leſs mixed with the Pyrites. But probably the Pyrites of the burning mountains, is more ſulphureous than ours. It is likewiſe in far greater quantities in all the countries round the Mediterranean than in England: a plain reaſon why earthquakes are ſo much more frequent and more violent there.

An artificial earthquake may be made thus. Add twenty pounds of ſulphur to twenty of iron-filings. Mix and temper theſe with water, ſo as to form a maſs of the conſiſtence of a firm paſte. Bury this three or four feet under ground. In ſix or ſeven hours time, the earth will begin to tremble, crack and ſmoke, and fire and flame will burſt through. So that there only wants a ſuffi-

cient

cient quantity of this matter, to produce a true Ætna. If it were ſuppoſed to burſt out under the ſea, it might occaſion a new iſland.

To explain this point a little farther. This globe of earth is bored through with infinite cavities, which branching out like the veins, arteries, and nerves in our bodies, paſs under the very bottom of the ſea. Some of them ſerve to convey water, others a more unctuous ſubſtance, others an igneous matter, that gives motion to the whole frame.

Thus the exterior ſea communicates with the inmoſt abyſs, and paſſes to the roots of the hills and mountains. Mean time a conſtant air or wind forces the water into the dark caverns, and receives and keeps alive a perpetual fire.

Have we not indubitable examples of theſe things? Does not the vaſt river Wolga, pour ſuch a quantity of water into the Caſpian, within the ſpace of one year, as would be ſufficient, were there not ſome inviſible out-let, to cover the whole earth. This inviſible out-let is an huge cavern, that paſſes under Mount Caucaſus into the Euxine ſea. Hereby the waters of the one ſea, diſcharge themſelves into the other. And the whole kingdoms of Georgia and Mengrelia, are as it were a bridge over thoſe ſubterraneous waters.

When the Caſpian ſea has been, on occaſion of winds, too much emptied into the Euxine, it is repleniſhed from the Perſian Gulph, which is a kind of reſervoir for it. And the ſubterraneous communication between the Red Sea and the Mediterranean is now out of all diſpute.

And how many inſtances of this have we in rivers? So late Geographers aſſure us, that the river Niger in Africa is derived from the river Nile, under the mighty chain of the mountains of

Nubia:

Nubia: on the weſtern ſide of which mountains, it takes the name of Niger, and continues its courſe into the Atlantic ocean. So the vaſt and deep cave in mount Taurus, receives the Tigris, and gives it a paſſage to the other ſide. The ſame river afterward hides itſelf under ground, for near twelve miles, and then breaking out again, diſembogues into the Euphrates, near Babylon.

To come nearer home; the Guadiana, that runs between Spain and Portugal, runs thirty-two miles under ground. Yea, in our own country, the Mole in Surry, falls into the ground near Boxhill, and riſes again at a conſiderable diſtance.

Hence we may ſafely collect that the earth is filled with ſubterraneous aqueducts and caverns, full of air and vapour and copious exhalations from all ſorts of minerals, as well as water.

Beſides theſe cavities, there are mountains whoſe bowels are in a continual flame. And their belching out aſhes, ſmoke, broken rocks and minerals, argue vaſt vacuities, and huge magazines of combuſtible matter, which are lodged therein. In the chain of mountains called the Andes in America, there are no leſs than fifteen volcanos, by whoſe burnings, caverns as big as whole kingdoms are made, and receive the cataracts of mighty rivers. And not only here, but over all the earth, there are ſo many channels, clefts, and caverns, that we do not know, when or where we ſtand upon good ground. Indeed it might amaze men of a ſtout heart, could they ſee into the world beneath their feet, view the dark receſſes of nature, and obſerve the ſtrongeſt buildings ſtand upon an immenſe vault, at the bottom of which runs an unfathomable ſea, and whoſe upper hollows, are filled with ſtagnating air and the

the expirations of ſulphureous and bituminous matter.

Therefore as there are no large tracts of land, without volcanos and ſulphureous caverns, from which branching into ſmaller pipes, the ſubterraneous heat is conveyed throughout the earth: ſo no country can promiſe itſelf an entire immunity from earthquakes: even were there no other cauſe of theſe dreadful events, but ſubterraneous fires. Eſpecially, when it is conſidered, that the earth is in one part impregnated with ſulphur, in others with nitre, allum, vitriol, mercury, bitumen, oker and chalks. For if an artificial powder, made only of nitre, ſulphur and charcoal has ſo wonderful effects, what force muſt that combuſtible matter have, which ariſes from ſulphur, nitre, ſal-almoniac, bitumen, gold, copper, iron, arſenic, mercury, and other metallic and mineral ſpirits, with which the womb of the earth abounds, when the ſubterraneous fires break through into the hollow vaults, where theſe are repoſited by the God of nature? Then, according to the copiouſneſs of theſe combuſtibles, and the more or leſs firmneſs of the ſuper-incumbent earth, theſe fires cauſe tremblings and concuſſions, or violent eruptions: and perhaps open wide and deep gulphs, wherein whole cities, yea mountains are ſwallowed up.

Many ſuch inſtances occur in hiſtory. Pliny tells us, that in his own time, the Mountain Cymbotus, with the town of Eurites, which ſtood on its ſide, were totally ſwallowed up. He records the like of the city of Tantelis in Magneſia, and after it of the mountain Sopelus, both abſorbed by a violent opening of the earth, ſo that no trace of either remained.

remained. Galanis and Garnatus, towns once famous in Phœnicia, are recorded to have met the fame fate. Yea, the vaſt promontory called Phlegium in Ethiopia, after a violent earthquake in the night, was not to be ſeen in the morning, the earth having ſwallowed it up and cloſed over it.

Like inſtances we have of later date. The mountain Picus, in one of the Molucca's, was ſo high, that it appeared at a vaſt diſtance, and ſerved as a land mark to ſailors. But during an earthquake in the iſle, the mountain in an inſtant ſunk into the bowels of the earth: and no token of it remained, but a vaſt lake of water. The like happened in the mountainous parts of China, in 1556: when a whole province, with all its towns, cities, and inhabitants was abſorbed in a moment; an immenſe lake of water, remaining in its place, even to this day.

In the year 1646, during the terrible earthquake in the kingdom of Chili, ſeveral whole mountains of the Andes one after another, were wholly abſorbed in the earth. Probably many lakes of whoſe beginning we have no account, were occaſioned by the like abſorptions.

The greateſt earthquake we find in antiquity is that mentioned by Pliny, in which twelve cities in Aſia Minor were ſwallowed up in one night. But one of thoſe moſt particularly deſcribed in hiſtory is that of the year 1693. It extended to a circumference of two thouſand ſix hundred leagues, chiefly affecting the ſea coaſts and great rivers. Its motions were ſo rapid, that thoſe who lay at their length were toſſed from ſide to ſide:

as

as upon a rolling billow. The walls were dafhed from their foundations, and no lefs than fifty four cities, with an incredible number of villages, were either deftroyed, or greatly damaged. The city of Catanea, in particular, was utterly overthrown. A traveller who was on his way thither, at the diftance of fome miles perceived a black cloud hanging near the place. The fea all of a fudden began to roar: Mount Ætna to fend forth great fpires of flame; and foon after a fhock enfued, with a noife, as if all the artillery in the world had been at once difcharged. Our traveller being obliged to alight inftantly, felt himfelf raifed a foot from the ground, and turning his eyes to the city, faw nothing but a thick cloud of duft in the air. Although the fhock did not continue above three minutes, yet near nineteen thoufand of the inhabitants of Sicily perifhed in the ruins.

The following account of a dreadful earthquake at Calabria in 1638, is related by the celebrated Father Kircher, as it happened while he was on his journey to Mount Ætna.

"Having hired a boat in company with four more, we launched on the 24th of March from the harbour of Meffina, and arrived the fame day at the promontory of Pelorus. Our deftination was for the city of Euphæmia in Calabria. But though we often put to fea, we were as often driven back, At length however, we ventured forward. Proceeding onward, and turning my eyes to Ætna, I faw it caft forth large volumes of fmoke, which entirely covered the whole ifland. This together with the dreadful noife, filled me with apprehenfion. The fea itfelf began to wear

a very

a very unuſual appearance, covered all over with bubbles. My ſurprize was increaſed by the calmneſs of the weather. I therefore warned my companions, that an earthquake was approaching, and making for the ſhore with all poſſible ſpeed we landed at Tropæa. But we had ſcarce arrived at the Jeſuit's College in that city, when our ears were ſtunned with a horrid ſound reſembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. Soon after, the whole tract upon which we ſtood, ſeemed to vibrate, as if we were in the ſcale of a balance that continued wavering. This ſoon grew more violent, and being no longer able to keep my legs, I was thrown proſtrate upon the ground. In the mean time, the univerſal ruin round me, redoubled my amazement. The craſh of falling houſes, the tottering of towers, and the groans of the dying, all contributed to raiſe my terror. On every ſide of me, I ſaw nothing but a ſcene of ruin, danger threatening wherever I could fly. I recommended myſelf to God as my laſt refuge. At that hour, O how vain was every ſublunary happineſs! Wealth, honour, empire, wiſdom, all mere uſeleſs ſounds, and as empty as the bubbles on the deep. Juſt ſtanding on the threſhold of eternity. Nothing but God was my pleaſure, and the nearer I approached, I only loved him the more. After ſome time, however, I reſolved to venture for ſafety, and running as faſt as I could, reached the ſhore. I did not ſearch long, till I found the boat in which I had landed and my companions alſo. Our meeting was all ſilence, and a gloomy dread of impending terrors.

"Leaving this ſeat of deſolation, we proſecuted our

our voyage, and the next day landed at Rochetta, although the earth ſtill continued in violent agitations. But we were ſcarce arrived at our inn, when we were obliged to return to the boat, and in about half an hour, we ſaw the greateſt part of the town, and the inn at which we had ſet up, daſhed to the ground, and burying all its inhabitants beneath its ruins. Proceeding onward in our little veſſel, finding no ſafety at land, and yet having but a very dangerous continuance at ſea, we at length landed at Lapizium, a caſtle midway between Trapæa and Euphæmia. Here wherever I turned my eyes, nothing but ſcenes of ruin and horror appeared; towns and caſtles levelled to the ground: Strombalo, though at ſixty miles diſtance, belching forth flames in an unuſual manner. But my attention was quickly turned to nearer danger. The rumbling ſound of an earthquake alarmed us. It every moment ſeemed to grow louder, and to approach more near. The place on which we ſtood, now began to ſhake moſt dreadfully, ſo that being unable to ſtand, my companions and I caught hold of the ſhrubs near us, and ſupported ourſelves in that manner.

" After ſome time this ſhock ceaſing, we ſtood up in order to go to Euphæmia, that lay within ſight. In the mean time, I turned my eyes towards the city, but could ſee only a dark cloud reſting upon the place. This the more ſurprized us, as the weather was ſo ſerene. We waited till the cloud was part away, then looking for the city, it was totally ſunk. Nothing but a putrid lake was ſeen where it ſtood. We looked about for ſome one that could tell us the ſad cataſtrophe, but could ſee none. All was become a melancholy ſolitude, a ſcene of hideous deſolation.

Such

Such was the fate of the city of Euphæmia. And as we continued our melancholy courſe along the ſhore, the whole coaſt for the ſpace of two hundred miles preſented nothing but the remains of cities. Proceeding thus along, we at length ended our diſtreſsful voyage, by arriving at Naples."

15. Of the great Earthquake at Port-royal in Jamaica, an eye-witneſs writes thus. It happened on July 7, 1692, juſt before noon, and in the ſpace of two minutes, ſhook down and drowned nine tenths of the town. The houſes ſunk outright thirty or forty fathom. The earth opened and ſwallowed up the people, in one ſtreet, and threw them up in another: ſome roſe in the middle of the harbour. While the houſes on one ſide of a ſtreet were ſwallowed up, thoſe on the other ſide were thrown on heaps. The ſand in the ſtreet, riſing like waves in the ſea, lifted up every one that ſtood upon it. Then ſuddenly ſinking into pits, the water broke out, and rolled them over and over. Sloops and ſhips in the harbour were overſet, and loſt: the Swan Frigate was driven over the tops of many houſes. All this was attended with a hollow rumbling noiſe. In leſs than a minute, three quarters of the houſes, with their inhabitants, were all ſunk under water: and the little part which remained was no better than an heap of rubbiſh. The ſhock threw people down on their knees, or their faces, as they ran about to look for ſhelter. Several houſes which were left ſtanding, were removed ſome yards out of their places. One whole ſtreet was made twice as broad as before. In many places the earth cracked, opened and ſhut, with a motion quick and faſt. And two or three hundred of theſe openings might

might be ſeen at a time. In ſome of theſe people were ſwallowed up, in others caught by the middle and preſſed to death. In others the heads of men only appeared, in which condition dogs came and ate them. Out of ſome of theſe openings, whole rivers of water ſpouted up a prodigious height: and out of all the wells the water flew, with a ſurprizing violence. The whole was attended with a noiſome ſtench, and the noiſe of falling mountains at a diſtance, while the ſky in a minute's time turned dull and reddiſh, like a glowing oven. And yet more houſes were left ſtanding at Port-royal, than in all the iſland beſide. Scarce a planter's houſe, or ſugar work was left throughout all Jamaica. A great part of them was ſwallowed up, frequently houſes, people and trees at one gap, in the room of which there afterwards appeared a large pool of water. This when dried up, diſcovered nothing but ſand, without any mark that houſe or tree had been there. Two thouſand people loſt their lives: had it been in the night, few would have eſcaped. A thouſand acres of land were ſunk: one plantation was removed half a mile from its place. Yet the ſhocks were moſt violent among the mountains. Not far from Yall-houſe, part of a mountain, after it had made ſeveral leaps, overwhelmed a whole family, and great part of a plantation, though a mile diſtant. A large mountain, near Port Morant, about a day's journey over, was quite ſwallowed up, and in the place where it ſtood, remained a lake, four or five leagues over. Vaſt pieces of mountains with all the trees thereon, falling together in a confuſed manner, ſtopped up moſt of the rivers, till ſwelling abroad, they made themſelves new channels, tearing up every thing that oppoſed their

their paſſage, carrying with them into the ſea, ſuch prodigious quantities of timber that they ſeemed like moving iſlands. In Liquania the ſea, retiring from the land, left the ground dry for two or three hundred yards. But it returned in a minute or two, and overflowed a great part of the ſhore. Thoſe who eſcaped from the town, got on board the ſhips in the harbour, where many continued two months: the ſhocks all the time being ſo violent, that they durſt not come on ſhore. The noiſome vapours occaſioned a general ſickneſs, which ſwept away three thouſand of thoſe that were left.

The following account of this memorable event is given by the Rector of Port-royal.

On Wedneſday, June 7, I had been reading prayers, (which I have read every day ſince I came to Port-Royal, to keep up ſome ſhew of religion among a moſt ungodly people) and was gone to the Preſident of the Council. We had ſcarce dined, when I felt the ground heave and roll under me. I ſaid, "Sir, what is this?" He replied compoſedly, "It is an earthquake. Be not afraid; it will ſoon be over." But it increaſed more and more: and preſently we heard the church and the tower fall. Upon this we ran to ſave ourſelves; I quickly loſt him, and ran toward Morgan's Fort; as that was a wide open place, and ſecure from the falling houſes. As I ran, I ſaw the earth open, and ſwallow up multitudes of people, and the ſea mounting over the fortifications. I then laid aſide all thought of eſcape, and went homeward to meet death in as good a poſture as I could. I was forced to go through two or three narrow ſtreets, the houſes fell on on each side of me, Some bricks came rolling over my shoes, but none hurt me. When I came to my lodging, I found all things in the same order that I left them. I went to the balcony, and saw that no houses in our street were fallen. The people seeing me, cried to me, to come and pray with them. When I came into the street, every one laid hold of my cloaths and embraced me. I desired them to kneel down in a ring, and prayed with them near an hour, till I was almost spent, between the exercise, and the heat of the sun. They then brought me a chair, the earth working all the time, like the rolling of the sea, insomuch that sometimes while I was at prayers, I could hardly keep on my knees. By the time I had been half an hour longer with them, in setting their sins before them, and exhorting them to repentance, some merchants came, and desired me to go on board one of the ships in the harbour. From the top of some houses, which lay level with the water, I got into a boat, and went on board the Siam Merchant. The day when this happened was exceeding clear, and afforded no suspicion of evil. But about half an hour past eleven, in less than three minutes, Port Royal, one of the fairest towns in the English plantations, was shattered in pieces, and left a dreadful monument of the justice of God.

About ten years after the town was rebuilt, a terrible fire laid it in ashes. Yet they rebuilt it once more. But in the year 1722, an hurricane reduced it a third time to an heap of rubbish. Warned by these extraordinary calamities, which seemed to mark it out as a devoted spot, they removed the public offices from thence, and forbad any market to be held there for the future."

16. Lima

16. Lima in Peru contains about 60,000 perſons. In 1747 an earthquake laid three fourths of the city level with the ground.

17. Callao, the Port of Lima, containing 3 or 4000 inhabitants was totally deſtroyed. Only one man eſcaped, and that by a very ſingular providence. He was going to ſtrike the flag on the fort, that overlooked the harbour, when he ſaw the ſea retire to a conſiderable diſtance, and then return, ſwelling mountains high. The inhabitants ran from their houſes, in the utmoſt degree of terror and confuſion. A cry for mercy aroſe from all parts: and immediately all was ſilent, the ſea had quite overwhelmed the city, and buried it for ever in its boſom. But at the ſame time it drove a little boat to the ſide of the fort, into which the man leaped and was ſaved.

18. Perhaps we have not in hiſtory, many more remarkable deliverances than that of this good man. But more remarkable if poſſible, is the following deliverance, from a danger of a very different kind.

In the neighbourhood of Demonte, as one deſcends through the upper valley of Stura towards the middle of the mountain, there were ſome houſes in a place called Bergemolletto, which on the 19th of March, in the morning (there being then a great deal of ſnow) were entirely overwhelmed by two vaſt bodies of ſnow, that tumbled down from the upper Alps. All the inhabitants were then in their houſes, except one Joſeph Rochia, a man of about 50. Two and twenty perſons were buried under this maſs of ſnow, which was ſixty Engliſh feet in height. Many men

men were ordered to give them aſſiſtance; but were not able to do them the leaſt ſervice. After five days, Joſeph Rochia, got upon the ſnow, (with his ſon, and two brothers of his wife) to try if they could find the place under which his houſe and ſtable were buried; but they could not. However, the month of April proving very hot, and the ſnow beginning to melt, this unfortunate man was again encouraged to uſe his beſt endeavours. On the 24th, the ſnow was greatly diminiſhed, and he conceived hopes of finding out his houſe by breaking the ice. He thruſt down a long pole, but the evening coming on, he proceeded no farther. His wife's brother dreamed the ſame night, that his ſiſter was ſtill alive, and begged him to help her. He roſe early in the morning, told his dream to Joſeph and his neighbours, and went with them, to work upon the ſnow, where they made another opening, which led them to the houſe they ſearched for: but finding no dead bodies in its ruins, they ſought for the ſtable, which was about 240 Engliſh feet diſtant, and having found it, they heard a cry of "help, my dear brother." Being greatly ſurprized as well as encouraged by theſe words, they laboured till they had made a large opening, through which the brother went down, where the ſiſter with a feeble voice told him, "I have truſted always in God and you, that you would not forſake me." The other brother, and the huſband then went down, and found ſtill alive the wife about 45, the ſiſter about 35, and a daughter about 13 years of age. Theſe they raiſed on their ſhoulders to men above, who pulled them up, and carried them to a neighbouring houſe; they were unable to walk, and ſo waſted, that they appeared like mere ſhadows.

Some days after the Intendant came to ſee them, and they gave him the account that follows. In the morning of the 19th of March, we were in the ſtable, with a boy ſix years old, and a girl about 13. In the ſame ſtable were ſix goats, one of which had brought forth two dead kids the evening before; there were alſo an aſs and five or ſix fowls. We were ſheltering ourſelves in a corner of the ſtable, till the church-bell ſhould ring, intending to attend the ſervice. The wife wanting to go out of the ſtable to kindle a fire for her huſband, then clearing away ſnow from the top of the houſe, ſhe perceived a maſs of ſnow breaking down towards the eaſt, on which ſhe went back into the ſtable, ſhut the door, and told her ſiſter of it. In leſs than three minutes they heard the roof break over their heads, and alſo part of the ceiling of the ſtable. The ſiſter adviſed her to get into the rack and manger, which ſhe did very carefully. The aſs was tied to the manger, but got looſe by ſtruggling; and though it did not break the manger, it threw down the little veſſel which the ſiſter took up, and uſed afterwards to hold the melted ſnow, which ſerved them for drink. Very happily, the manger was under the main prop of the ſtable, and thereby reſiſted the weight of the ſnow. Their firſt care was to know what they had to eat; the ſiſter had in her pockets fifteen cheſnuts: the children ſaid they had breakfaſted, and ſhould want no more that day. They remembered there were 30 or 40 loaves in a place near the ſtable, and endeavoured to get at them, but were not able, by reaſon of the ſnow. On this they called out for help

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as loudly as they could, but no one heard them The fister came again to the manger, after fhe had tried in vain to come at the loaves, gave two chefnuts to the wife, and eat two herfelf, and they drank fome fnow water. All this while the afs continued kicking, and the goats bleated very much, but foon after, they heard no more of them. Two of the goats however were left alive, and were near the manger, they felt them carefully, and knew by fo doing, that one of them was big, and would kid about the middle of April; the other gave milk, wherewith they preferved their lives.

The women affirmed, that during all the time they were buried, they faw not one ray of light; neverthelefs, for about twenty days, they had fome notion of night and day: for when the fowls crowed, they imagined it was break of day, but at laft the fowls died. The fecond day, being very hungry, they eat all the remaining chefnuts, and drank what milk the goat yielded, which for the firft days was near two pounds a day, but the quantity decreafed gradually. The third day, being very hungry, they again endeavoured to get to the place where the loaves were, but they could not penetrate to it. They then refolved to take all poffible care to feed the goats, as very fortunately over the ceiling of the ftable, and juft above the manger, there was an hay-loft with a hole, through which the hay was put down into the rack. This opening was near the fifter, who pulled down the hay, and gave it to the goats, as long as fhe could reach it, which when fhe could no longer do, the goats climbed upon her fhoulders, and reached it themfelves. On the fixth day the boy ſickened, complaining of violent pains in the ſtomach for ſix days, on the laſt of which he deſired his mother, who all this time had held him in her lap, to lay him at his length in the manger. She did ſo, and taking him by the hand, felt it was very cold: ſhe then put her hand to his mouth, and finding it likewiſe very cold, ſhe gave him a little milk; the boy cried, "O my father in the ſnow! Oh! father! father! and expired."

The mother told the ſiſter, the boy was dead, and then laid him in the manger where the ſiſter was. In the mean while the milk given by the goat diminiſhed daily. The fowls being dead, they could no longer diſtinguiſh night and day; but according to their calculation the time was near, when the other goat ſhould kid, which as they computed would happen about the middle of April. At length they found the goat was kidding by its cries, the ſiſter helped it; they killed the kid to ſave the milk for their own ſubſiſtence. And now they knew it was the middle of April. Whenever they called this goat, it would come and lick their face and hands, and gave them every day two pounds of milk, for which they ſtill bear a great affection to it.

During all this time, hunger gave them but very little uneaſineſs, except on the firſt five or ſix days. Their greateſt pain was from the extreme coldneſs of the melted ſnow-water, which fell on them; from the ſtench of the dead aſs, dead goat, and fowls; but more than all from the uneaſy poſture they were obliged to continue in. For though the place in which they were buried was twelve Engliſh feet long, eight wide, and five high, the manger in which they ſat ſquatting againſt

againſt the wall, was no more than three feet four inches broad.

19. May we not impute to earthquakes, thoſe huge cavities in the earth, which are found in ſeveral parts of England? Such is Pooles-Hole about half a mile from Buxton, in Derbyſhire, ſaid to have been the refuge of one Poole, a noted robber. It is at the foot of a mountain: its entrance is low and narrow; but it preſently opens into a broad and lofty concavity, of above a mile in length. The water dropping from the roof, congeals into a kind of chryſtal, and forms a thouſand ſurpriſing figures. Here is alſo a large, clear ſtone, reſembling alabaſter, which the Queen of Scots, when here, called her pillar, and it ſtill goes by that name. Along the middle a ſtream of water falls among the rocks, which loudly echoes through the vault. The moſt ſurpriſing thing is, the height of the arch, and the ſpangled roof reſembling fret-work. And indeed the drops of water which petrifying, as they fall, form iſicles, reſembling chryſtal above, and pyramids hardened into ſtone below, have a ſurprizing effect from the light of the candles: the hanging drops dazzling the eyes, as if this mighty arch was covered with diamonds.

Elden-hole is a frightful chaſm in the middle of a field, fifty or ſixty feet long, and about twenty broad. But how deep it is, could never be diſcovered, notwithſtanding all the attempts that have been made. Mr. Cotton endeavoured to fathom it with a line of ſixteen hundred yards; but in vain. Some ſuppoſe theſe to have been paſſages, whereby the waters of the deluge, returned from the ſurface of the earth to the great abyſs.

There is another effect of subterraneous fires, which has been generally imputed to quite different causes. The Giant's Causeway in Ireland, and all other strong concretions of the same kind, where pillars are formed by pentagon, hexagon, or mutangular stones, placed one upon another, they are commonly supposed to be formed by a deposition of stony matter from an aqueous fluid. On the contrary it is evident from various considerations, respecting their structure and other phænomena, that they are concretions of a peculiar kind, generated by an igneous fluid. They are peculiar to vulcanic countries, and differ in every respect from the chrystals produced by the slow and successive precipitation of the stony particles contained in water. Their formation is owing to an intrinsic principle of organization, operating on an ignified fluid: on the concretion of which that principle may be supposed to have operated simultaneously in a large mass, and to have produced these bodies in the same manner as a linget of metal concretes at once in the mold.

In Persia there is a subterraneous fire of a very harmless nature. It rises out of the ground, about twenty miles from Baku, and three from the Caspian sea. The ground is rocky, but has a shallow covering of earth. If this be any where scraped off, and fire applied to the place, it catches fire immediately, and burns without diminution, nor ever goes out, unless you throw cold earth over it, by which it is easily extinguished. A piece of ground, about two English miles in extent, has this wonderful property. In many parts of it there is a continual flame: the chief is in an hole about four feet deep and fourteen in diameter. This

This is said to have burned many thousand years. They burn stones into lime, by filling a hole in the ground with them, and then putting a lighted candle into the hole. The fire immediately kindles, and in about three days burns the stones sufficiently.

It is remarkable, that this flame, how great so ever it be, gives neither smoke nor smell. There is much naphtha all about the place, though not just where the fire is.

Doubtless an inflammable vapour issues in abundance out of the ground in this place. Something of the same kind is found between Bologna and Florence, on the side of one of the Appenines. On a spot of ground three or four miles diameter, there is a constant eruption of fire. The flame rises very high; yet without noise, smoke, or smell. In great rains it sometimes intermits, but afterwards burns with the greater vigour. There are three other such fires on the same mountains. Probably they rise from the veins of bitumen.

20. A late ingenious writer ascribes all earthquakes to the same cause, Electricity. The impressions, says he, they make on land and water, to the greatest distance, is instantaneous. This can only be effected by Electricity. In the late earthquake the concussion was felt through the space of an hundred miles in length, and forty in breadth, at the same instant. Now what could throw a tract of land, of four thousand square miles in surface, into such an agitation in a moment? No natural power is equal to this, but that of Electricity, which alone acknowledges no bounds, neither any sensible transition of time.

The little damage done by most earthquakes, is another argument, for their being occasioned, by a simple vibration of the earth, through an electric shock. This vibration on the water, meeting with the solid bottoms of ships, occasions that thump which is felt by them. That this shakes millions of ordinary houses, and yet not one of them falls, is a farther proof, that it is not a convulsion in the bowels of the earth, but an uniform vibration, like what we occasion in a glass, by rubbing our finger on the edge: which yet may be brought to such a pitch, as to break the glass in pieces, by an electric repulsion of its parts.

There can be little doubt, but some earthquakes are owing to electricity; but many more are owing to other causes: those of Callao, Lima, Port Royal, for instance, were unquestionably owing to water: those in the neighbourhood of Ætna and Vesuvius, with those in the East-Indies, to lakes of fire. The grand fault is therefore the ascribing them either to electricity, or any one cause, exclusive of the rest: whereas some are owing to each of these causes: some to several of them acting conjointly.

21. We have inflammable vapours in England, in three or four different places.

One who accurately observed it, gives the following particular account of a burning well.

" In the latter end of February, I went to see a spring in the road, which leads from Wigan to Warrington. When we came to it, and applied a lighted candle to the surface of the water, there was suddenly a large and vigorous flame produced. But having filled a cup with water at the flaming place, and held a lighted candle to it, it went

went out. Yet the water at that place boiled like water over a fire: though when I put my hand into it, it did not feel so much as warm. This boiling seems to proceed from some sulphureous fumes, the spring being not above forty yards from a coal-pit, and all the country for many miles round being underlaid with coal.

When the water was drained away, I applied the candle to the surface of the earth where the water burned before. The fumes took fire and burnt very bright and vigorous, the flame ascending a foot and an half from the ground: and the basis of it was as broad as a man's hat at the brims. It was not discoloured like that of sulphur, nor had any scent. I ordered a bucket of water to be poured on the fire, and it was immediately quenched."

22. There was a spring of the same kind at Brosely, near Wenlock, in the county of Salop. It was discovered in June 1711, by a terrible noise in the night, which awaked several people in their beds, who desiring to know what it was, rose up, and coming to a boggy place under a little hill about two hundred yards from the Severn, perceived a mighty rumbling and shaking of the earth, and a little water boiling up through the grass. When they dug up some of the earth, the water flew up to a great height, and a candle that was in their hand, set the vapour on fire. There is now (viz. in 1711) an iron cistern round the spring, with a cover, having a hole in the middle of it. If you put a lighted candle to the hole, the water takes fire, and burns like spirits of wine. It burns as long as you keep the air from it; but if you take up the cover, it goes out. The heat of this fire exceeds that of common fire. Some

people, after they have set the water on fire, have put a kettle of water over the cistern, with a joint of meat in it. It was boiled much sooner than it could be, by any artificial fire. If you put wood or even green boughs upon it, it presently consumes them to ashes. The water of itself feels as cold as any common water. Nay, if you put your hand into it as soon as the fire is out, it feels as cold as if there had been no fire near it. But it still continues boiling up, with a considerable noise.

But this well was lost for many years. The poor man in whose land it was, missing the profit he used to have by shewing it, used all his endeavours to find it again: and in May 1744, hearing a rumbling noise under ground, a little nearer the river than the former well was, he lighted upon it again. For five or six feet deep, it is above six feet wide. Within this is a smaller hole, of like depth, dug in the clay, in the bottom of which is a cilinderic earthen vessel, four or five inches diameter, having the bottom taken off, and the sides fixed in the clay. Within the pot is brown water, thick as puddle, continually forced up with a violent motion and a hollow noise, rising and falling by turns, five or six inches. Upon putting a candle at the end of a stick, within a quarter of a yard, it took fire, darting and flashing in a violent manner, about half a yard high, much like spirits in a lamp, but with a greater agitation. The man said it had made a tea-kettle boil in nine minutes, and that it would burn forty-eight hours without any sensible diminution. It was extinguished by putting a wet mop upon it. And still the water felt very cold.

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The well lies about thirty yards from the Severn, which in that place, and for ſome miles above and below, runs in a vale full an hundred yards perpendicular below the level of the country on either ſide. But the well is now loſt again, the water being drawn off by a coal-pit.

23. There is a fire of the ſame kind at Pietra Mala, a village on the Appenines. The flame is extremely bright, covers a ſurface of three yards by two, and uſually riſes about four feet. After great rains or ſnows, the whole bare patch, about nine yards diameter, flames. The gravel out of which it riſes, at a very little depth, is quite cold. There are four of theſe fires in the neighbourhood: the middle of the ground whence one of them riſes, is a little hollowed, and has in it a puddle of water, through which there are ſtrong ebullations of air. This air will not take fire; but that which riſes through the wet and cold gravel, flames briſkly.

In Dauphiny and ſome other parts of France, the ſurface of ſeveral ſprings take fire in the ſame manner on the approach of a candle. Sulphureous vapours undoubtedly exhale from the waters: as is the caſe in the famous Grotto del Cani.

This lies on the ſide of a little hill, between Naples and Pozzoli. The ſides of it are cut perpendicular in the earth. It is about three feet wide; near twelve feet long; five or ſix feet high at the entrance, and leſs than three at the farther end.

The ground ſlopes a little from this end to the mouth, and more from thence to the road. If you ſtand a few ſteps without, and ſtoop ſo as to have your eye nearly on a level with the ground of the grotto, you may ſee a vapour within, like that which appears over a chaſing-diſh of red-hot coals, only that it is more ſluggiſh, and does not riſe above five or ſix inches high. Its ſurface more diſtinctly terminated than that of other vapours, balances viſibly under the air, as if unwilling to mix with it.

The ground of the grotto is always moiſt; and ſo are the ſides to the height of ten inches. Yet this never increaſes ſo as to form any drops. While you ſtand upright, you remark nothing more, than a ſlight earthy ſmell, common in all ſubterraneous places which are kept ſhut. But if you put down your hand, within ten inches of the ground, it feels as if you put it into the ſteam of boiling water. Yet your hand contracts neither ſmell nor taſte. A vapour ſimilar to that in the grotto, riſes alſo from the ground without. But it is weaker, and does not riſe ſo high. This partly ſpreads itſelf from the cavern, partly exhales from the earth.

A lighted flambeau thruſt into the vapour, preſently goes out; yet without any noiſe or hiſſing. The thick ſmoke which appears immediately after its extinction, remains floating on the vapour, and being lighter than it, but heavier than the air above it, ſpreads between both. Indeed common ſmoke is lighter than air: but that impregnated with the vapour is heavier.

If a young vigorous dog be held down within the vapour, he at firſt ſtruggles, pants, ſnorts, and rattles in the throat. But in three minutes he lies as dead. Carry him into the open air, and he draws in long draughts, as one recovering from a fit, and in two minutes gets upon his

legs,

legs, and ſeems to ail nothing. A cock having his head plunged into the vapour, was ſuffocated all at once beyond recovery. Frogs are ſtupified by it in three or four minutes: yet though they have laid in it a quarter of an hour, ſoon recover when placed in the open air. Large flies, beetles and butterflies, were longer without giving ſigns of their ſuffering, and longer in recovering. A toad reſiſted the vapour near half an hour, a lizard above an hour and a quarter. And a large graſs-hopper ſtirred in the vapour, after being more than two hours in it.

An Engliſh gentleman kneeled down in the grotto, and leaning on his hands, bowed his face to within two or three inches of the ground, holding his breath, keeping his eyes open, and his tongue a little out of his mouth. He remained thus three or four ſeconds, without any painful impreſſion, or any ſort of taſte on his tongue. And hence it manifeſtly appeared, that this is not a poiſonous vapour.

He afterward advanced his face to the ſurface of the vapour, and took in breath gently. He was ſenſible of ſomething ſuffocating, juſt like the air of a hot and moiſt ſtove. Likewiſe he felt a ſlight acrimony in the throat and noſe, which made him cough and ſneeze: but no head-ach, no ſickneſs at ſtomach, nor any other inconvenience.

It is clear then upon the whole, that animals die in this vapour, not as poiſoned, but rather as drowned, in a fluid not capable of ſupplying the place of the air, which is neceſſary for reſpiration, and equally neceſſary to ſuſtain fire, as the flame of a lighted flambeau.

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24. A fire of a ſtill ſtranger nature appeared in Wales, about Chriſtmas, 1693. A fiery vapour came from the ſea, and moved up and down for many weeks. It ſet on fire ſixteen ricks of hay, at Harlech, in Merionethſhire, and two barns, and annoyed the country, as well by poiſoning the graſs, as firing the hay. It was a blue, weak flame, and did no harm to the men who tried to ſave the hay, though they ventured even to touch it. An intelligent perſon who lived near Harlech, informed his friend ſome time after, "The fire ſtill continues there. It comes over a part of the ſea, from a marſhy place in Carnarvonſhire, eight or nine miles off. The graſs over which it moves kills all manner of cattle that feed upon it, ſheep, goats, ſwine, cows and horſes. But what is very remarkable is, that any great noiſe, as beating a drum or ſounding an horn, effectually repells it from any houſe, or barn, or ſtack of hay."

25. A much ſtranger flame than that which iſſues out of the earth, is that which iſſues out of the ſtomach of animals. The anatomical lecturer at Piſa in the year 1597, happening to hold a lighted candle near the ſubject he was diſſecting, on a ſudden ſet on fire the vapours that came out of the ſtomach he had juſt opened. In the ſame year, as Dr. Ruiſch, then anatomy profeſſor at Piſa, was diſſecting a woman, a ſtudent lighting him with a candle, he had no ſooner opened the ſtomach, than there iſſued out a yellow greeniſh flame. A like thing happened ſome years after at Lyons, in diſſecting a woman. Her ſtomach was no ſooner opened, than a conſiderable flame burſt out and filled the place. But this is not ſo much to be wondered at, ſince the experiments made by Dr. Vulpari, anatomical profeſſor at Bo-

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logna. He affirms, any one may ſee, iſſuing from the ſtomach of an animal, a matter that burns like ſpirits of wine, if the upper and lower orifices are bound faſt with a very ſtrong thread. The ſtomach thus tied muſt be cut, above and under the ligature, and afterwards preſſed with both hands, ſo as to make all that it contains, paſs to one ſide. This will produce a ſwelling in that part, which muſt be held with the left hand to hinder its eſcaping. A candle then being held about half an inch from the ſtomach, let it be ſuddenly opened by the right hand, and a bluiſh flame will immediately guſh out, which will ſometimes laſt a minute. The ſame way flame may be brought forth from the inteſtines alſo.

Nor is it from carcaſes only that flames have iſſued. This has been the caſe with live perſons likewiſe. Bartholine relates, that a Poliſh Cavalier, having drank a quantity of brandy died in a little ſpace, after an eruption of a flame through his mouth. He relates alſo the caſe of three others, who after drinking much brandy experienced the ſame ſymptom. Two preſently died; the third eſcaped by immediately drinking cold water. Still more aſtoniſhing is the caſe of a woman at Paris, who uſed to drink brandy to exceſs. She was one night reduced to aſhes by a fire from within, all but her head and the ends of her fingers. In like manner Cornelia Bandi, an aged lady of unblemiſhed life, near Ceſena in Romagna, in 1731, retired in the evening into her chamber; and in the morning was found in the middle of the room, reduced to aſhes, all except her face, ſkull, three fingers and her legs, which remained entire, with her ſhoes and ſtockings. The aſhes were light: the floor was ſmeared with a groſs, ſtinking moiſture, and the walls

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and furniture covered with a moiſt ſoot, which had ſtained all the linen in the cheſt.

Perhaps a larger account of ſo remarkable an incident will not be unacceptable to the curious reader.

The counteſs Cornelia Bandi, in the ſixty-ſecond year of her age, was all day, as well as uſual. When ſhe was in bed, ſhe paſſed two or three hours in talking with her maid; then ſhe fell aſleep. The maid going into her chamber in the morning, ſaw two feet diſtant from the bed, an heap of aſhes, and two legs with the ſtockings on. Between them was part of the head; but the brains, half the ſkull, and the whole chin were burnt to aſhes. The aſhes, when taken up, left in the hand a greaſy and ſtinking moiſture. The bed received no damage; the cloaths were raiſed on one ſide, as by a perſon riſing from it.

Doubtleſs the fire was kindled within her by the juices and fermentations in the ſtomach, acting on the many combuſtible matters, which abound in living bodies, for the uſes of life. Theſe in ſleep, by a full reſpiration, are put into a ſtronger motion, and conſequently are more apt to take fire.

Borelli obſerves, That ſuch accidents often happened, to great drinkers of wine and brandy. Such flames would frequently riſe in us, if the natural moiſture did not prevent.

Undoubtedly ſhe was burnt ſtanding; hence her ſkull was fallen between her legs, and the back part of her head was damaged more than the fore part, partly becauſe of her hair, partly becauſe in the face, there were many places, out of which the flames might paſs.

An inſtance of the ſame kind occurred at Chriſt Church in Hampſhire, on June 26, 1613. One John Hitchell, a carpenter of that pariſh, having ended his day's work, came home and went to reſt with his wife. Her mother being frightened in her ſleep, called to them for help. None anſwering, ſhe ſtarted up and waked her daughter, who found her huſband dead by her ſide. She dragged him out of the bed into the ſtreet; but the heat then forced her to let him go. He lay burning there for three days. Not that there was any appearance of fire outwardly, but only a ſmoke aſcending from his carcaſe, till it was burnt to aſhes: except only a ſmall part of his bones, which were caſt into a pit.

Grace Pett, was a fiſherman's wife, of the pariſh of St. Clement's, in Ipſwich, about ſixty. She had a cuſtom for ſeveral years of going down ſtairs every night, after ſhe was undreſt, to ſmoke a pipe. Her daughter, who lay with her, did not miſs her till the morning, April 10, 1744, when going down ſtairs ſhe found her mother's body extended over the hearth, with her legs on the deal floor, and appeared like a block of wood, burning with a glowing fire without flame. The neighbours coming in at her cries, found the trunk of the body in a manner burnt to aſhes. It then appeared like an heap of charcoal, covered with white aſhes, the head, arms, legs, and thighs were alſo much burnt. A child's cloaths, on one ſide of her, and a paper-ſkreen on the other, were untouched. The deal floor alſo on which her legs lay, was neither ſinged nor diſcoloured.

26. Almoſt as ſtrange, though not attended with any ill conſequence, was the following incident. In November, Mrs. Suſanna Sewall, wife to major Sewall,

Sewall, in New England, obſerved a ſtrange flaſhing of ſparks in all the apparel ſhe put off, which continued till Candlemas. In the company of many perſons, ſhe ſent for ſeveral parts of her wearing apparel, and when they were ſhaken, ſparks flew out, making a noiſe, much like bay-leaves thrown into the fire. One ſpark lit on major Sewall's thumb-nail, without any heat, and continued at leaſt a minute before it went out. They cauſed Mrs. Sewall one day to put on her ſiſter Digge's petticoat; and when ſhe put it off at night, it ſparkled as her own uſed to do.

27. There is no body but may be by fire converted into glaſs; not excepting gold itſelf. And this is the laſt effect of fire: no art can carry the change of a natural body any farther.

As to the nature and properties of it. 1. Common glaſs is an artificial compound of ſalt with ſand or ſtones. 2. It is fuſible by a ſtrong fire, and when fuſed is tenacious and coherent. 3. It does not waſte in the fire. 4. When melted it cleaves to iron. 5. When red hot it is faſhionable into any ſhape, and capable of being blown into a hollowneſs, which no mineral is. 6. It is frangible when thin, fryable when cold, and tranſparent whether hot or cold. 7. It is flexible, elaſtic, and diſſoluble by cold. It can be cut only by emery or a diamond. 9. It is not diſſoluble by Aquafortis, Aqua Regia or Mercury. 10. Neither acids nor any thing elſe extract colour, taſte, or any ſenſible quality from it. 11. It loſes nothing either of its ſubſtance or of its weight, by the longeſt and moſt frequent uſe. 12. It is not capable of being calcined, neither of contracting ruſt.

But there is no property of glaſs more remarkable than its ductility. Glaſs-ſpinners draw threads of of their brittle matter, melting over a lamp, with far more eafe and expedition, than common fpinners do thofe of flax or filk. Thefe may be drawn fine as a hair, yea, as the thread of a fpider's web, fo as to wave with every wind. And the finer they are, the more flexible. If the ends of two fuch threads be knotted together, they may be drawn and bent till the fpace in the middle of the knot does not exceed the forty-eighth part of an inch in diameter.

Near the bay of Acra, in Paleftine, runs a little river, now called Kardanah, fuppofed to be the ancient Belus, famous for its fand, much ufed in making glafs, and faid to have given rife to the invention of it. The Sidonians are reported to have made this difcovery, from the following accident. Some travellers having reared an hearth on the fand of this river with large pieces of nitre, and fet fome fern on fire under a kettle, in order to boil their victuals, perceived the fand and the nitre to melt and incorporate with the fern-afhes, and prefently after to run in a tranfparent ftream, which hardened as it cooled. From hence the hint of making glafs was taken, which was gradually improved to its perfect ufe and beauty.

28. There are few phænomena relative to glafs more hard to be accounted for, than that of the Bologna bottle, fo called, becaufe it was firft difcovered at Bologna. If you let thefe bottles fall from fome height on a brick-floor, they will not be broken; but drop into them fome hard body, and they will burft in pieces. I took one of thefe, fays Dr. I. which held near a pint, and let it fall five feet and a half on a brick floor, and it was not broken. I dropt into it a bit of flint,

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weighing eleven grains, and immediately it burst in pieces.

I dropt into another bottle a ball of lead, weighing one hundred and forty grains, into a third a piece of brass weighing three hundred grains, and neither of them was broken.

These glasses only differ from common phials in this, they have not cooled gradually in what is called, the nealing furnace, but are exposed to the open air as soon as formed. They resist hard blows from without. I have given to some, violent strokes with a mallet, and they have not broke. They likewise do not break, though several heavy bodies be dropt into them. I have dropped into them from the height of three feet, musket-balls, and pieces of iron, brass, gold, without any effect; but when I dropt into it from the height of three inches, a shiver of flint no bigger than a small pea, in about two seconds the glass flew. Having tried the experiment on several others with the same piece of flint, most of them broke in the moment of the stroke, the rest one or two seconds after it.

I let fall into several glasses a flint of half the size, and they flew in like manner. I let fall into one, a flint no larger than a grain of sand, shook the glass, and set it down. I did the same with four others. In about half an hour one of them flew, and the other four soon after.

I let fall into one a sapphire set in a ring: and though the bottom of the glass was near an inch thick, the sapphire passed through it as through a spider's web. The glass flew all ways, and the ring remained on the table, just where it fell.

A bit of china, half a line thick and two lines broad, broke several glasses, so did a bit of glass of the same size; so did diamonds also. And a very

very ſmall piece of tempered ſteel, broke all the glaſſes into which I dropped it.

Some large hollow cups made at Worceſter of common green glaſs, much larger than the others, and ſome of them above three inches thick at the bottom, though they were not affected by a muſket-ball, dropt from the height of near three feet, were inſtantly broken with a ſhiver of flint, weighing but two grains.

There is ſomething aſtoniſhing in the power of Teleſcopes, to bring far diſtant objects near; and of Microſcopes, to render thoſe clear and diſtinct, which are quite inviſible to the naked eye. And no leſs amazing in another kind, is the force of burning glaſſes. 1. A piece of wood laid before a large burning-glaſs, took fire in an inſtant. 2. Water contained in an earthen veſſel boiled immediately, and in a ſhort time quite evaporated. 3. A maſs of lead, three inches thick, began to melt in a moment, and ſoon after ran in a continued thread. 4. A ſteel-plate grew red-hot almoſt in an inſtant, and ſmall holes were made through it. 5. Slate becomes black glaſs, tiles, yellow glaſs, earthen pots, a darkiſh yellow glaſs. 6. A pumice ſtone became white glaſs, earth black glaſs, bones an opake one.

But in the extremely hot weather at Paris in 1705, the rays of the ſun, collected by a large glaſs, had ſcarce any force, though the ſeparate rays quite inflamed the air. The reaſon of ſo ſurpriſing a thing ſeems to be, that the heat raiſed from the earth's great ſulphureous exhalations, which embarraſſed, ſtopped, and in ſome degree abſorbed the rays of the ſun.

29. Equally ſtrange are the phænomena of the Glaſs-drop. The make of this drop is as ſimple, as its

its explanation is difficult. They take up a ſmall quantity of melted glaſs on the top of an iron rod, and let it drop into a pail of water. When it does not break in the operation, it forms the Glaſs-drop. This is of ſuch firmneſs, that is bears ſmart blows of a hammer, without breaking. But if you break only the tip of the ſmall end, the whole ſhatters into powder. This ſhattering is attended with a loud report, and the powder ſcatters all around. If the experiment be made in the air-pump, the drop burſts more impetuouſly, and the duſt is finer than when it burſts in the open air. This is a plain matter of fact. I do not undertake to account for it.

Gunpowder is commonly ſuppoſed to have been invented by Barthold Schwartz, about the year 1380. But Roger Bacon knew of it, an hundred and fifty years before Schwartz was born. For in his treatiſe de Nullitate Magica, publiſhed at Oxford in 1216, are theſe words. "You may raiſe thunder and lightning at pleaſure, by only taking ſulphur, nitre, and charcoal, which ſingle have no effect, but mixed together and confined in a cloſe place, cauſe a noiſe and exploſion greater than that of a clap of thunder."

The effect of gunpowder is owing to the ſpring of the air, incloſed in the grains and in the ſpaces between them. All theſe ſprings are dilated by the fire, and ſet a playing at once. The powder itſelf only ſerves to light the fire, which puts the air in action.

Aurum fulminans, a preparation of gold, is far ſtronger than gunpowder. A ſcruple of this acts more forcibly than half a pound of that. A ſingle grain laid on a knife, and lighted at a candle, goes off with a greater noiſe than a muſket.

30. Air

30. Air is that clear, tranſparent, compreſſible fluid which is extended about a degree round the terraqueous globe, being with us about 46,656,000,000 times more denſe and ſluggiſh than æther, betwixt which and the air there is a very great affinity or attractive force, which is as their denſity; i. e. the air contiguous to the æther takes in and concentrates the æther proportionally to its greater denſity, by which it is rendered more ſpringy and active, with this difference, that the air by contact and coheſion in the parts of bodies, becomes ſolid and unelaſtic (but æther never); from whence again, by heat, fire, or diſſolution of parts being ſeparated, its elaſticity returns. This element has a near affinity or relation to water, becauſe it eagerly takes up rarified water into itſelf, as water again drinks up a portion of air within its contact; ſo that air and water actuated by æther, make the levers and wedges by which nature performs all her changes in bodies. And it ſerves as the common medium of communication between us and all bodies.

The preſſure of a column of air upon a ſquare inch only, is equal to fifteen pounds weight. That upon the ſurface of an human body, generally amounts to at leaſt thirteen ton weight: ſeeing all fluids preſs with an equal force every way, upwards, downwards, ſideways, and in all directions. If then every ſquare inch on a man's body, ſuſtains a preſſure of 15 pounds, the preſſure on the whole ſurface of a middle-ſized man, will amount at leaſt to 13,320 pounds.

"But how is it then that our bodies are not cruſhed in pieces?" Our bodies, as well as all others, are filled with air throughout: and the ſpring of the internal air is equal to the preſſure of of that without. And when two equal forces act in contrary directions, they entirely destroy each other's effects: hence however, if the ambient air press upon us, it is all one as if did not press at all.

The elasticity of the air is a counterbalance to its gravitation. And how necessary is it, that these should balance each other? Were the power of gravity to be suspended for a moment, and that of elasticity to remain, the atmosphere would instantly be dissipated, through the infinite regions of space. But while the weight of the air and its elastic force are equal, they produce an equilibrium among the particles of air, in every part of the atmosphere.

As the higher it is, the air is more and more expanded, gravitation being less and less, so the parts of the air in the upper regions will be expanded only not to infinity.

The air is generally invisible. And it is necessary it should be so. For as it is the medium through which we see objects, if the parts of it were perceptible, it would render the view of those objects far less perfect and distinct. Hence a greatly magnifying telescope, as it shews the body of air, makes the view of other objects more confused.

Yet in some cases you may seem to see the air. In a very hot summer's day, in an open part of the country, place yourself on an eminence, nearly facing the sun. Then, if there be a gentle wind, there will be a reflexion of light from the body of the air in the vale below. And you will see the undulations or waves of air almost as perfectly as you may those of water, agitated by a gentle wind. And yet in truth, it is not the air which you see, but the vapours that float therein.

One

One property of air is its Weight or Gravity. This you will immediately feel, if you lay your hand on the mouth of a veſſel, which is emptied of air. If you lay a ſquare piece of glaſs on the orifice of an Air-pump, when the air is drawn out, it will be broke to ſhivers with a great noiſe. Or extract the air from between two ſmoothly poliſhed marbles, and cloſe the edges with wax, they will then be ſo ſtrongly preſt together, as not eaſily to be ſeparated. But we need no other proof of it than the Barometer: a glaſs tube, cloſe at one end, and filled with mercury. Immerge the other end in a baſon of the ſame fluid, and when it is erected, the mercury in the tube will riſe thirty inches, above the ſurface of that in the baſon.

The changes then in the Barometer are wholly owing to the changes in the weight of the atmoſphere. But to what are theſe owing? It ſeems, chiefly to the winds, For 1. Theſe muſt alter the weight of the air in any particular place, either by bringing together and accumulating the air, which is the caſe when two winds blow at the ſame time from oppoſite points; or by ſweeping away part of the air, as when two winds blow oppoſite ways from the ſame point; or laſtly, by cutting off the preſſure of the atmoſphere, which happens when any wind blows briſkly any way: 2. Cold, nitrous particles load the atmoſphere, and increaſe its weight: 3. So do heavy, dry exhalations from the earth, 4. The air being rendered heavier is more able to ſupport the vapours, which being intermixed with it, make the weather fair and ſerene. When it is rendered lighter by the contrary cauſes, it becomes unable to ſupport the vapours, which then ſink, gather into drops, and fall in rain.

With us the mercury is higheſt when the wind is north or north-eaſt, and ſo brings the cold, condenſed air of the northern climates. In all northern countries the mercury varies more than in the ſouthern, the winds being more frequent, ſtrong, various and oppoſite to each other. Between the tropics it ſcarce varies at all, the winds being ſmall, and generally blowing the ſame way.

The preſſure of the air, is, cæteris paribus, as its height. Carry the Barometer to an higher place, where the incumbent column of air is ſhorter, and a ſhorter column of air is ſuſtained: it being found to deſcend at the rate of a quarter of an inch for every hundred feet of aſcent.

Now air, as all other fluids, muſt preſs equally every way. Hence it is, that ſoft bodies ſuſtain their preſſure, without any change of figure, and brittle bodies without breaking, though that preſſure be equal to that of a column of mercury, thirty inches high, or a column of water of thirty feet. Nothing can keep theſe bodies unchanged, but the equable preſſure on all ſides, which reſiſts as much as it is reſiſted. And hence on removing or leſſening that preſſure on one ſide, the effect of it is ſoon perceived on the other.

It is by means of its gravity, 1. That the air cloſely inveſts the earth with all the bodies on it, and bends them down: that it prevents the arterial veſſels of plants and animals from being too much diſtended, by the impetus of the circulating juices: and that it hinders the blood from oozing out, through the pores of their containing veſſels. Hence they who travel up high mountains, the higher they aſcend, are relaxed the more, till they fall into ſpitting of blood.

2. The

2. The mixture of contiguous fluids is chiefly owing to this. Hence many fluids which readily mix in the air, when that is removed, remain separate. 3. It determines the action of one body upon another. Thus it presses the particles of fire against the fuel. Whereas upon removing the air, the fire immediately goes out. So Aqua Regia ceases to dissolve gold, if the air be taken away: hence also on the tops of high mountains, as on the Pike of Teneriffe, the most acrid bodies, such as pepper, ginger, salt, have no sensible taste; for want of a sufficient gravity in the air to press their particles into the pores of the tongue.

Another property of air is Elasticity. It yields to an impression, by contracting its dimensions, and returns to them, on removing the impressive cause. This endeavour to expand itself, every particle of air continually exerts, against an equal endeavour of the ambient particles. Hence it is, that a bladder full of air, will burst in an exhausted receiver: while one that before seemed empty, swells and appears to be full of air.

This power does not seem to have any bounds. Nor is it easy to be destroyed. Let air be expanded ever so much, it still retains its spring. Nor is this sensibly diminished by any experiment which has yet been made.

There is no fixing any bounds to its condensation, any more than to its dilatation. It will dilate into a thousand times its former space, yea into 13,679 times. And all this by its own expansive force, without any force of fire. The air we breathe near the surface of the earth is comprest by its own weight, into at least the

13679th part of the ſpace it would poſſeſs in vacuo. And if the ſame air be farther condenſed by art, the ſpace it will take up when moſt dilated, will be (according to Mr. Boyle) to that it poſſeſſed when moſt condenſed, as 550,000 to one.

If while we increaſe the elaſticity of air, on one ſide by compreſſion, we increaſe it on the other ſide by heat, the force of both ſoon becomes irreſiſtable; and a French philoſopher ſuppoſed, that air thus confined and expanding was ſufficient for the exploſion of a world. In order to determine the Elaſticity of air, the wind-gun has been invented, which is an inſtrument that compreſſes a large quantity of air into a tube in which there is an ivory ball, and then gives the compreſſed elaſtic air free power to act and drive the ball as directed. The ball thus driven will pierce a thick board, and will be as fatal at ſmall diſtances, as if driven with gun-powder. I do not know whether ever the force of this inſtrument has been aſſiſted by heat; certain I am, that this, which could be very eaſily contrived by means of phoſphorus, or any other hot ſubſtance applied to the barrel, would give ſuch a force as I doubt whether gun-powder itſelf could produce.

Every thing we ſee gives of its parts to the air, and has a little floating atmoſphere of its own round it. The roſe is encompaſſed with a ſphere of its own odorous particles; while the nightſhade infects the air with ſcents of a more ungrateful nature. The perfume of muſk flies off in ſuch abundance, that the quantity remaining becomes ſenſibly lighter. A thouſand ſubſtances that eſcape all our ſenſes, we know to be there; the

the powerful emanations of the loadſtone, the effluvia of electricity, the rays of light, and the inſinuations of fire. Such are the various ſubſtances through which we move, and which we are conſtantly taking in at every pore, and returning again with an imperceptible diſcharge.

The great mixture of all earthly bodies is continually operating upon itſelf; which perhaps, may be the cauſe of its unceaſing motion; but it operates ſtill more viſibly upon groſſer ſubſtances, as are expoſed to its influence; for ſcarce any ſubſtance is found capable of reſiſting the coroding qualities of the air. The air, ſay the chymiſts, is a chaos furniſhed with all kinds of ſalts and menſtruums; and therefore it is capable of diſſolving all kinds of bodies. It is well known that copper and iron are quickly eaten with ruſt; and that in the climates near the equator no art can keep them clean. In thoſe countries, inſtruments, knives, and keys, though kept in the pocket, nevertheleſs are quickly incruſted; and the great guns, with every precaution, after ſome years, become uſeleſs. Stones may be ſuppoſed to be more eaſily ſoluble. The marble of which the noble monuments of *Italian* antiquity are compoſed, although in one of the fineſt climates in the world, nevertheleſs ſhew the impreſſions which have been made upon them by the air. In many places they ſeem worm-eaten by time; and in others they appear crumbling into duſt. Gold alone ſeems to be exempted from this general diſſolution. It is never found to contract ruſt, tho' expoſed never ſo long: the reaſon is, that ſea-ſalt, which is the only menſtruum of gold, is but very little mixed with the air, being a very fixed body, and not apt to volatilize. In the elaboratories however, where the air is impregnated with it, gold is found to ruſt, as well as other metals.

By its elaſticity air inſinuates into the pores of bodies, carrying with it this faculty of expanſion; whence it muſt neceſſarily put all the particles it is mixed with, into perpetual oſcillations. And as its elaſticity is never the ſame for two moments together, there muſt be an inceſſant dilatation and contraction in all bodies. To this is owing all putrifaction and fermentation, neither of which will proceed in vacuo. And indeed all natural corruption and alteration ſeem to depend hereon: ſo that metals, particularly gold, are ſo durable, only by being impervious to air. And yet it may be doubted, whether air itſelf be the true, original, univerſal diſſolvent; or rather the ethereal fire, which is intimately united with every particle of it: and without which air is effete and uſeleſs, neither able to feed flame, nor to ſuſtain animal life.

That there is ſome matter in the air much finer than the air itſelf, appears from many conſiderations. In an exhauſted receiver ſomething remains, which conveys the heat, near as readily as air. Now this muſt be a body, and a body ſubtle enough to penetrate the pores of glaſs. Doubtleſs then it penetrates the pores of all other bodies, and conſequently is diffuſed thro the uni verſe. And this ſeems to be not only more ſubtle than the air, but far more weighty and elaſtic. To the weight of this may be owing the weight of the air, and of all other bodies: to its elaſticity, the elaſticity of the air, and of all other elaſtic bodies. This alſo may cauſe the reflection and other phænomena of light: as alſo ſenſation, and muſcular motion. Indeed it ſeems to be the firſt ſpring of all the action in the univerſe.

Air is ſometimes deprived of its elaſticity, and wrought

wrought into the ſubſtance of other bodies, from which nevertheleſs it may be extracted, and reſume its elaſtic ſtate. As to *animal ſubſtances*, a very conſiderable quantity of air is extracted from them by diſtillation, not only from the blood and fat, but alſo from the moſt ſolid parts of animals. Half a cubic inch of a fallow deer's horn, produced 117 cubic inches of air: half a cubic inch of Oyſter ſhells, no leſs than 162 cubic inches.

As to *vegetable ſubſtances*, half a cubic inch of Heart of Oak generated 108 cubic inches; a cubic inch of Peas 396 cubic inches, or 113 grains, which was above a third of its weight. This air will flaſh, if touched with a candle.

Camphire generates no air: Brandy next to none: well water, or Rain-water, a little: Pyrmont-water, twice as much: which air contributes to the briſkneſs of this and other mineral waters.

From Minerals much air may be extracted. Half an inch of Newcaſtle Coal yielded 180 inches of air, which weighed near one third of the coal.

Yet a good part of the air extracted from theſe bodies, in ſome days gradually loſt its elaſticity: becauſe the acid, ſulphureous fumes, raiſed with that air, reſorbed and fixed the elaſtic particles. But when a means was found, to prevent this, it loſt only a ſeventeenth or eighteenth part: and that chiefly in the firſt twenty four hours; the reſt was permanently elaſtic.

There is another way of producing air, which ſeems to be more natural, namely by fermentation. A cubic inch of * Oil of Vitriol with half an

* Mr. Geoffry ſhews, that the mixture of any vitriolic ſalts with inflammable ſubſtances, will yield common Brimſtone: particularly of oil of Vitriol with oil of Turpentine. Brimſtone therefore is nothing but vitrolic ſalt, united with ſome combuſtible ſubſtance.

an inch of Sal Ammoniac generated fix cubic inches of air: fix inches of powdered Oyfter-fhells, and an equal quantity of White-wine vinegar, generated twenty-nine inches.

That much air is incorporated into the fubftance of *vegetables*, appears from the following experiments.

Forty-two inches of Ale from the tun generated in three months, 636 cubic inches of air: twelve inches of Malaga-raifins, in fix weeks generated 411 inches: twenty fix inches of Apples, in thirteen days generated 968 inches of air. They then in three or four days reforbed about twelve inches, and afterwards neither generated nor reforbed.

That the air arifing from diftilled or fermenting bodies, is true air, appears from hence, that it continues in the fame expanded ftate for weeks, or months, which expanded vapours will not do. And that it is elaftic appears, by its dilating and contracting with heat and cold, as common Air does.

Air then makes a very confiderable part of the fubftance of vegetables as well as animals. And befide thefe particles of air, which ftrongly adhere to, and are wrought into their fubftance, there is in them a large quantity which is upon the wing, and in a very active ftate.

To fhew how much air is contained in white paper, take as many flips of it as weigh an hundred grains. Burn thefe warily by the flame of a candle, and then weigh the afhes. You will find the hundred grains reduced to fix. So ninety four grains out of one-hundred, are undeniably *transformed* into Air. They could not be annihilated. And they could not rife and fly away without a repelling force to carry them off. Thus the

the candle itself is by degrees transformed from heavy, palpable wax, into a light, impalpable body of air. But observe: all bodies which thus become Air, pass through the intermediate state of Flame. So that, properly speaking, the same body was one moment *paper*, the second moment *fire*, and the third, *Air*. How different states for the same sort of matter to subsist in, in so short a time.

The Air-pump shews how much Air is, even in water. Place a tall glass of water in the receiver. Turn the winch, and you see bubbles of Air through the body of the water. First, they are thick, but small; then they grow large, and rise to the top of the water. And as long as the pump works, so long the Air rises, but more slowly, and in larger bubbles. In wine the Air-bubbles rush violently to the top and burst. Nay, and the liquor perfectly boils, like water on the fire. Yea, and hot water may be made to boil by the Air-pump, as well as by fire. Hence it appears, that boiling is nothing but the motion produced from the expansion of the Air, whether by fire, or by the warmth and pump conjointly.

By another experiment it appears, that any piece of wood is pervious to the Air, and that its Air-vessels run through the whole length or substance of the tree. Nay, quicksilver may be made to pass through a piece of wood, and descend in the form of a shower of rain.

By the Air-pump we likewise measure the weight, and find that a pint of it weighs 8 grains. Consequently a gallon weighs a little more than a drachm: therefore a bushel weighs an ounce and half a drachm.

Another experiment proves what one would not suspect. Bodies moving in a fluid, meet so much the more refiftance, as their bulk is larger in equal weight. So a cork of equal weight with a guinea, meets with fo much the more refiftance from the Air. But in an exhaufted receiver, the largeft bulk of cork, which was before the moft refifted, now proves the heavier body, and accordingly falls *more fwiftly* than the gold.

Again. Strike a flint againft the fteel *in vacuo*, and it will occafion no fparks. So neceffary is Air to the very appearance of fire.

Air is generated likewife from minerals by fermentation. By other fermenting mixtures it is abforbed again, and by others generated and abforbed alternately.

A quarter of an inch of *filings of iron*, and an inch of compound *aquafortis*, in four days abforbed 27 inches of Air. When hot water was poured upon it, it generated three or four inches, which after fome days it abforbed again. A quarter of an inch of Iron filings, with an inch of powdered Brimftone, abforbed nineteen inches in two days. Powdered Brimftone mixed with Newcaftle Coal, neither generated nor abforbed.

An inch of Chalk, and as much Oil of Vitriol in three days generated 31 inches of Air. Part of this it afterwards reforbed. Two inches of Lime and as much Sal Ammoniac abforbed 115 inches. The fumes of this are therefore very fuffocating. All burning and flaming bodies, abforb much air. And whereas the air which fome fubftances abforb, is afterwards remitted, that which is abforbed by burning brimftone, by the flame of a candle, or by human refpiration, does not recover its elafticity.

The elafticity of the Air in the veficles of the lungs is continually decreafing, through the vapour it is there loaded with; fo that there needs

fresh

fresh air continually; otherwise those vesicles will soon fall flat, whereby the motion of the blood through the lungs being stopt, instant dea h ensues. And this seems to be exactly the case of most of those, who are killed by lightning, which so totally destroys the elastic Air in the lungs, that they instantly fall flat.

31. Many have imagined that the animal fluids are furnished with Air by the lungs only. But undoubtedly they are also supplied therewith, by way of the chyliferous canals: and that in no small quantity. For the Air, like all other animal fluids, requires to be perpetually renewed; accordingly old particles fly off every moment, and new ones succeed in their place.

It may be demonstrated, that urine contains much air. Doubtless so does the perspirable matter: which being the lightest of all aninal fluids, is the chief vehicle of the effete and useless Air.

And that candles soon go out, if they are confined in a small quantity of Air, seems not to be so much owing, to their having rendered the Air effete, by consuming its vivifying spirit, as to its destroying the elasticity thereof, by its acid, fuliginous vapours.

But nothing destroys the elasticity of air like brimstone, whether burning or in fermenting mixtures. And as the attractive power of bodies, is found to be more or less, as they have more or fewer sulphureous particles, so we may reasonably ascribe the fixing the elastic particles of Air, to the strong attraction of the sulphureous particles, with which Sir Isaac Newton supposes all bodies to abound, more or less.

The various mixtures in the stomach, sometimes generate, ſometimes abſorb Air. In a good digeſtion the generating power exceeds the abſorbing power but a little. When it exceeds it much, we are troubled more or leſs, with diſtending flatus's.

We have ſeen how much Air may be extracted from animal and vegetable bodies, into whoſe ſubſtances it was before intimately and firmly incorporated. And conſequently great quantities of Air muſt be continually expended in their production. Part of this, we ſee, may reſume its elaſtic ſtate, when their texture is diſſolved: but part probably never regains its elaſticity, at leaſt, not in many centuries. However, we may ſee, what immenſe treaſures of this important element, the wiſe Author of nature has abundantly provided, the conſtant waſte of it being abundantly ſupplied, by heat or fermentation from innumerable denſe bodies.

If all the parts of nature were endued with a ſtrongly attracting power only, whole nature would immediately become one unactive, cohering lump. It was therefore abſolutely neceſſary there ſhould be every where intermixed, a due proportion of ſtrongly elaſtic particles. And ſince abundance of theſe are continually reduced from an elaſtic to a fixed ſtate, it was alſo neceſſary that theſe particles ſhould be endued with a property of reſuming their elaſticity, whenever they were diſengaged from that maſs, in which they were fixed. And hereby this beautiful frame of things, is maintained in a continual round, of the production and diſſolution of animal and vegetable bodies.

The Air is very inſtrumental in the production and growth of animals and vegetables: in its elaſtic ſtate, by invigorating their juices; and in its

its fixed ſtate, by greatly contributing to the union and firm connection of their conſtituent parts. It is alſo a very powerful agent in the diſſolution of the ſame bodies.

32. That fixed air is a cementing principle, appears (to omit others) from that well known experiment. Quick lime diſſolves fleſh, by extracting and imbibing the fixed air, which it contained. But while the fleſh falls in pieces from the loſs of the principle, the lime grows ſolid by having it reſtored.

That it contributes alſo to the *diſſolution* of bodies appears hence. During the progreſs of Putrifaction, a volatile matter flies continually from the putrifying ſubſtance. And this is no other than air, which is now extricated and thrown off from a fixed and unelaſtic ſtate, but immediately returns to it again, on meeting with a proper recipient.

The preſerving bodies from Putrifaction, depends almoſt in every inſtance, on reſtraining the flight of the fixed air. For as this cements their conſtituent parts, ſo Putrefaction, which is the diſunion of them, cannot take place while this remains.

And this Air both corrects, and prevents putrid acrimony in the animal fluid. Hence any food which does not contain a due proportion of it, is found to promote putrifaction: as do all damaged vegetables, which being incapable of fermentation, are incapable of producing the due quantity of air.

But pure air is no where to be found. That which ſurrounds us is the moſt heterogeneous body

body in nature. It is no other than an univerſal chaos, a colluvies of all kinds of bodies. No bodies can withſtand the force of fire. And whatever fire can volatilize is found in the air. Hence for inſtance, the whole foſſil kingdom muſt be found therein: for all that tribe is convertable into fume. Gold, the moſt fixed of all adheres to ſulphur in mines, and is raiſed along with it. All the parts of the Animal kingdom muſt likewiſe be in the air. For beſides the copious effluvia they emit by perſpiration (whereby an animal in the courſe of its duration, impregnates the air with many times the quantity of its own body) any dead animal, when expoſed to the air, is in a certain time carried wholly off. And we know that all vegetables by putriſaction become volatile, and ſo evaporate into air.

Air, 2. volatilizes fixed bodies. Thus ſea-ſalt being calcined and fuſed, then expoſed to the air to liquify; when liquified, ſet to dry again; then fuſed again, and the operation thus repeated; will by degrees be almoſt wholly evaporated, nothing remaining but a little earth.

Air, 3. fixes volatile bodies. Thus though aqua fortis or ſpirit of nitre, readily evaporates by the fire; yet if the air near be impregnated with ſpirit of urine, the volatile ſpirit is fixed, and falls o wn in a liquid form.

But the air's being open or incloſed is of conſequence in chymical operations. So, to make ſulphur inflammable, a free air is required: in a cloſe veſſel it will not kindle. And thus all animals and vegetables can only be calcined in open air. In cloſe veſſels they never become any other than black coals.

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By the Air-pump the air is in a great meaſure drawn out of a veſſel called the Receiver. And hence we learn how much all vital, nutritive and alterative powers depend upon the air. A candle in the exhauſted receiver uſually goes out in a minute. A kindled charcoal is totally extinguiſhed in about five minutes. Red hot iron is not affected thereby: only it will not light ſulphur or gun-powder, but melt it. Load-ſtones act, as well as in the open air. Smoke ſinks in a darkiſh body to the bottom, leaving the upper-part, clear and tranſparent. The ſyphon does not run therein: but attrition produces heat, as in the open air. If ſome grains of an heap of gun-powder be kindled by a burning-glaſs, they will not fire the contiguous grains. Glow-worms loſe their light as the air is exhauſted; but recover it not on its readmiſſion. Vipers and frogs ſeem dead in leſs than two hours, but recover in the open air. Snails live ten hours: efts two or three days; leeches five or ſix.

The atmoſphere is a body of air and vapours, which ſurrounds the globe to the height of about ſixty miles, gravitates towards its center, and is carried along with it in all its motions. This continually preſſes on our bodies, with a weight equal to a pillar of air, whoſe baſe is equal to the ſurface of our bodies. Now a pillar of air of the height of the atmoſphere, is equal to a pillar of water thirty-two feet high. Every foot ſquare therefore of the ſurface of our bodies is preſſed on by a weight of air, equal to 35 cubic feet of water: and a cubic foot of water weighing 76 pound (Troy weight) conſequently every foot ſquare of the ſurface of our bodies ſuſtain a pillar of air, equal to 2,260 pounds. If then the ſurface of a man's body contains fifteen ſquare feet, he ſuſtains

ſuſtains a weight equal to 39900 pounds. This is the caſe, when the air is heavieſt. But the difference between the greateſt and the leaſt preſſure of air upon our bodies is equal to 3982 pounds.

Hence it is ſo far from being a wonder, we ſhould ſometimes ſuffer in our health, by a change of weather, that it is the greateſt wonder we ſhould not always ſuffer. For when we conſider our bodies are at ſome times preſt upon by near two ton weight more than at others, it is ſurpriſing that every change does not break our whole frame to pieces.

In truth the veſſels of our bodies being ſo much ſtraitened by an increaſed preſſure, would ſtagnate the blood to the very heart, had not the author of nature wiſely contrived, that when the reſiſtance to its circulation is greateſt, the force by which the heart contracts ſhould be ſo too. For upon an increaſe of the weight of the air, the lungs are more ſtrongly expanded, and the blood by being more intimately broken, made fitter for finer ſecretions, the nervous in particular, by which the heart is more ſtrongly contracted. On the other hand, when the weight of the ambient air is ever ſo little abated, the air contained within the blood, unfolds its ſprings, and forces the blood to take up a larger ſpace than it did before.

The reaſon we are not ſenſible of this preſſure, is well explained by Borelli: ſand perfectly rammed into an hard veſſel, cannot be penetrated, even by a wedge. And water in a bladder compreſſed on all ſides, cannot give way in any part. In like manner, within the ſkin of an animal, are contained various parts: ſome hard, as bones; ſome ſoft, as muſcles; and ſome fluid, as blood. Now it is not poſſible that bones ſhould be broke

or

or displaced in the body, unless the pressure lay heavier on one part than another. If the pressure be so divided, that it be equal all round, upward, downward, sideways, and no part of the skin to be exempt therefrom, it is plain, no fracture or luxation can follow.

The same may be observed of the muscles and nerves, which though soft, yet being composed of solid fibres, do mutually sustain each other, and resist the common weight. The same holds of the blood and other humours. As water is not capable of condensation, so these liquids, while contained in their vessels, cannot be forced out of them by an universal compression. Add to this, that the air itself which is contained in every part of the body, is such a balance to the external air, that no hurt can ensue from its pressure.

33. Oil of vitriol, when exposed to the Air, continually increases in weight. Let a phial of this stand unstopped, and it will be constantly running over. Perhaps the cause of this odd phænomenon is, the moisture contained in the air, which this liquor, a potential fire, imbibes as greedily, as actual fire does nitre.

34. At the height of forty-one miles, the air is so rarified, as to take up three thousand times the space it does here. At fifty-three miles high, it would be expanded thirty thousand times as much as it is here. But it is probable, the utmost power of its spring, cannot produce so great an expansion: and that no part of the atmosphere extends above forty-five miles from the surface of the earth.

At that distance, (as was observed) it is expand-

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ed into three thouſand times the ſpace it occupies here. And we have ſeen it condenſed into the ſixteenth part of the ſame ſpace. It ſeems then, that the Air is capable of being condenſed into the hundred and eighty thouſandth part of the ſpace it would take up when free from preſſure. But what texture muſt it be of, to make it capable of this immenſe expanſion and contraction? How imperfectly is this accounted for, by comparing it to wool, cotton, and the like elaſtic bodies.

35. But there is an amazing difference between the fixed, and the common Air, with regard to their effects upon animal bodies. The fixed Air, even when ſet free, and in a ſtate of perfect elaſticity, whether it be during the firſt ſtage of fermentation by fire, by efferveſcence, or by putrifaction; if it be received into the lungs of any animal, cauſes inſtant death. But the ſame air, when received into the ſtomach, whether thrown off by efferveſcent mixtures in medicine, or extricated from the food by natural fermentation; in the firſt inſtance often operates like a charm, in reſtraining vomitings; and in the ſecond is abſolutely needful, for the ſupport of life and health.

With regard to the common Air, on the contrary no animal can live long without taking large quantities of it into the lungs. Yet if a ſmall portion of it be forced into the blood-veſſels of any animal, death preſently enſues.

So that theſe two ſpecies of air have quite different provinces, with reſpect to animal life. The firſt, common Air muſt mix wholly with the blood. The ſecond only communicates ſome ſubtle matter to it: probably electric fire, which we know is connected with every particle of common air.

CHAP.

CHAP. III.

Of *METEORS*.

1. WHATSOEVER is carried aloft into the air, and suspended there, is termed a Meteor. These are either Watry, Fiery, or Airy. The Watry, are Mists, Clouds, Rain, Snow, Hail. Watry particles which are rarefied so as to float in the air, are then termed Vapours. If these are visible and hang near the earth, we call them Mists; if they are higher in the air, Clouds. Some of these are so thin, as to transmit the rays of the sun, others so dense as to intercept them.

The manner wherein the vapours that constitute clouds and rain are raised, seems to be this. Fire being the lightest of all bodies, easily breaks loose from them; and in its passage carries along with it particles or little cases of water. These being lighter than the air, are buoyed up and swim therein: till striking against one another, or thickened

thickened by cold, they are reduced into clouds and drops.

To illuſtrate this, we may obſerve in water over the fire, 1. That the evaporations are proportioned to the heat. As ſmall heat throws off few vapours, ſcarce viſible: a greater heat carries off larger and more numerous veſicles of water, which we call a Steam. Violent heats lifts up great quantities of water, which the air cannot buoy up: and this we call Boiling. 2. If theſe vapours be intercepted in their aſcent, by any denſe body, eſpecially if it be cold; they are thereby reduced into drops, like thoſe of rain. 3. In froſty weather the vapours riſe but a little above the water, and there hang or glide on. If the weather be cold; after a little aſcent, they fall again into the water. But in a warm ſtill air, they aſcend ſwiftly and largely, and mount up, till they are out of ſight.

To explain this a little farther, it may be obſerved, that the parts of water being ſo ſmall and moveable, are eaſily ſeparated from one another. And when they are ſo divided into ſmall parcels, as to become about eight hundred times lighter than common water, they are as light as the air, and will by every ſucceſſive degree of ſeparation, riſe in the air in proportion to their lightneſs, the heavier air forcing the rarified fluid to aſcend into the atmoſphere, till it finds a place in equilibrium among bodies of equal lightneſs to itſelf. This ſeparation or comminution (if I may ſo call it) of water into ſmall parcels, may be performed either by colliſion againſt harder and more compact bodies, or by heat. The firſt we often ſee performed at the bottom of caſcades, where the water that falls but a few fathoms, ſhall riſe in a miſt from the bottom where it is broke; and there are

are inſtances of clouds riſing from the fall of waters, which may be ſeen five miles off. Colliſion will therefore excite vapours; but what is more conſtantly producing this effect in every part of the univerſe, is heat; whether from the ſun, which is always buſy this way, or from artificial ignition, or that generally inviſible elemental fire, which is diſtributed through all matter. It is not neceſſary for us to conſider in this caſe, any other than the diviſibility of water, and the inſinuating and diſperſive qualities of fire. Fire we ſee ſeparates more or leſs the parts of all bodies, whether fluid or ſolid, and makes them riſe in the air; and it does no more to water: it ſeparates it into ſuch ſmall portions, that the air is more ponderous than the ſteam, and of conſequence remains nearer the earth by its ſuperior gravitation.

2. The Dew which uſually falls in England in a year amounts to ſomething more than three inches and a quarter depth. The evaporation of a winter's day is nearly the ſame as that of a ſummer's day. For the earth being moiſter in winter, that exceſs of moiſture anſwers to the exceſs of heat in ſummer.

Within the tropics they have no rain for many months together. But the Dews are far greater than with us. Yet the moiſture evaporated in a ſummer's day, far exceeds that which falls in the night. Hence the dews there, cannot be of any benefit to the roots of the trees, becauſe they are remanded back from the earth by the following day's heat, before they can ſoak to any conſiderable depth. The great benefit therefore of Dew in hot weather muſt be, by being imbibed into vegetables, to refreſh them for the preſent, and ſupply them with moiſture towards the expence of the ſucceeding day.

Mean

Mean time the ſun draws freſh ſupplies of moiſture from the ſtrata of the earth, which by means of its penetrating warmth inſinuates itſelf into the roots. By the ſame genial heat it is carried up through their bodies and branches, and thence paſſing into the leaves, it is vigourouſly acted upon in thoſe thin plates, till perſpiring through their ſurface, it mounts with rapidity in the free air.

But the ſtrangeſt circumſtance relating to Dew, is this. In the ſame night place ſeveral ſubſtances in the open air, whilſt a large Dew falls; and ſome of them will receive much of it, ſome little, and others none at all. The drops make a ſort of choice, what bodies they ſhall fix themſelves to. Glaſs and chryſtals they fix themſelves to readily, and in the largeſt quantities. Metals do not receive them at all, nor do the drops ever fix on them. If a glaſs veſſel be ſet out in the evening, on ſilver plate, the glaſs will be found quite covered with Dew, and the ſilver perfectly dry. China-ware is a ſort of glaſs. Six pounds of mercury being expoſed to the air in a china plate, the Dew ran in ſtreams on the edge of the plate, but not a drop was on the mercury.

Is there not ſome alliance between the phænomena obſerved in Dew, and thoſe which appear in electric bodies? All hard bodies may by rubbing become electric, excepting only metals. And metals are the only bodies which wholly refuſe to admit the Dew.

But this is not all. A pewter plate placed all night in the open air, receives no Dew on its upper-ſide, but the under-ſide is covered with it. On the contrary, place a china plate near it, and the upper-ſide of it is quite wet, but the under-ſide is quite dry. So one receives the Dew only

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on the upper, the other only on the under surface! Who can account for this?

Mr. Kershaw has observed, that Dew newly gathered and strained, is not very clear, but of a yellowish colour:

That when he endeavoured to putrify it by various degrees of heat, he quite failed of his intention: for heat rather clarified and preserved it sweet, than caused any putrifaction:

That after it had been exposed to the sun, corked up, for a whole summer, there was no other change than that much green stuff (such as we see in standing water) floated on the top:

That after it had been exposed to the sun many weeks in an open glass, it was full of little insects, like tadpoles, which in a while dropt their skins, and became gnats:

That vapouring away great quantities of this dew, he procured two pounds of greyish earth, which lay in leaves, one above another, like brown paper, but very friable:

Lastly, that by often calcining and filtring this earth, he extracted two ounces of a fine, small, white Salt, which much resembled Rock Salt, it was when viewed through a microscope.

If clouds are condensed, so as to fall in drops, this we stile Rain. It may rise from various causes. Sometimes cold alone condenses a warm cloud. But it is generally wind which presses the cloud so close together, that the particles of water unite in large drops, which being specifically heavier than the air, can no longer be suspended by it.

But

But by what powier are the Drops of Rain ſo equally diſperſed? This may be ſhewn by an eaſy experiment. Put a quantity of braſs-duſt into an electric phial. When this is charged, invert it, and throw ſome of the duſt out. This will be ſpread over a flat ſurface, with exact uniformity, and will fall juſt like Rain or Snow. It is highly probable, this is the caſe with the clouds. Being highly electrified, they of courſe ſpread their contents equally over the ſurface of the earth.

Again. How comes it to paſs, that we have not conſtantly either too much or too little rain in any one place? It is not chance, which can never ſteer clear of extremes. It is the hand of Providence. There is no other rational way of accounting for ſuch an œconomy in the clouds. Such a juſt and neceſſary diſtillation and diſtribution of water from the grand alembic of the atmoſphere, could never proceed, but from the ſuperintendance and direction of that Omnipotent Chymiſt, in whoſe hands are all the ſecondary powers of nature, to vary their operations, as he ſees moſt conducive to the general good of mankind.

Bloody Rains, as they have been ſometimes called, ſeem to be only the excrements of inſects. Accordingly Gaſſendus gives us an account of a bloody rain in France which much terrified the people. But upon enquiry, it was found only to be red drops, coming from a ſort of butterflies which flew about in great numbers.

During a ſcarcity in Sileſia, a rumour was ſpread, of its raining Millet-Seed. But it was ſoon

ſoon found to be only the ſeeds of the ſmall Hen-bit, growing thereabouts in great plenty. So in the Archipelago it was thought Aſhes were rained, with which ſhips were covered for many leagues. But in truth, they came from an eruption of Véſuvius happening at that time. More lately, it was reported at Warminſter in Wiltſhire, that it rained Wheat. But the ſuppoſed Wheat was really Ivy-berries, blown thither in a conſiderable quantity by a hurricane. Nay, in 1696 a field near Cranſtead in Kent, was overſpread with young whitings, ſuppoſed to fall from the clouds, but doubtleſs brought thither from the ſea, by a violent ſtorm.

Nor is it ſtrange that any of theſe things ſhould be thus tranſported by tempeſtuous winds, conſidering to what diſtance, and in what quantities the ſea-water was carried by the ſtorm, Nov. 26, 1703. A phyſician travelling ſoon after, twenty miles from the ſea, chewing ſome tops of hedges, found them ſalt. The graſs of the down about Lewes was ſo ſalt, that for ſome time the ſheep could not eat it. And the Miller, three miles from the ſea, attempting with his man to ſecure his mill, were ſo waſhed with flaſhes of ſea-water, that they were almoſt ſtrangled.

A few years ago, during a violent ſtorm of wind, much rain fell in the weſtern part of Cornwall, which was mere ſea-water, as ſalt as that which was juſt taken out of the ſea. It ſeemed to have been drawn out of the ſea, and thrown upon the land in the ſame hour: ſo that there was no time for that wonderful operation of nature, whereby the water that aſcends in clouds, is freed from its salt and bituminous particles, before it falls to the earth.

3. When the particles of water in a clould are frozen, it occasions Snow, which floats in the air till it is driven together, so as to be heavy enough to sink. When the drops of rain in falling toward the earth, meet with a stream of cold air, they are often froze into ice, and so fall to the ground in the form of Hail. Hence the reason appears, why Snow, which is only frozen mist, is lighter than either Rain or Hail.

But why is Snow, though it seems to be soft, truly hard? Because it is true ice. It seems soft, because at the first touch of the finger on its sharp edges or points, they melt. Otherwise they would pierce the finger, just as so many lancets.

But why, though it be true ice, which is an hard and dense body, is it so very light? Because of the extreme thinness of each icicle, in comparison of its breadth. So gold, the most ponderous of all bodies, when beaten into leaves, rides upon the air.

Why is it white? Because its parts, though singly transparent, yet must appear white when mixed together: as do the parts of froth, of powdered glass, and other transparent bodies, whether soft or hard.

You will see Snow of a peculiar kind, if you try the following experiment. Set a tall phial of aqua fortis by the fire, till it is warm. Then put in filings of pure silver, a few at a time, and after a brisk ebullition, the silver slowly dissolves.

Place

Place this in a cold window. As it cools, the ſilver particles ſhoot into chryſtals, ſeveral of which running together, form a flake of ſnow, and deſcends to the bottom of the phial. While they are deſcending, they perfectly repreſent a ſhower of ſilver Snow. And the flakes lie upon one another at the bottom, like real ſnow upon the ground.

Many particles of Snow are of a regular figure, like rowels, or ſtars of ſix points. On each of theſe points are other collateral ſtars, but many of the points are broken. Others have been thawed, and are froze again into irregular cluſters. All theſe are perfect ice, ſo that the whole of Snow is an infinite number of icicles. A cloud of vapours condenſing, forthwith deſcends, till meeting with a freezing air, each drop immediately becomes an iſicle, ſhooting itſelf into ſeveral points. Theſe deſcending ſtill, and either ſtriking on each other, or meeting with gales of warmer air, are a little blunted or thawed, and froze again into cluſters, and ſo intangled as to fall in flakes.

Even in our temperate climate, we have ſometimes had very extraordinary ſhowers of Hail. On April 29, 1697, a thick black cloud, coming from Carnarvonſhire, poured ſuch an Hail on Cheſhire, Lancaſhire, and ſome other counties, that in a line two miles broad and ſixty miles long, it did inconceivable damage. It not only killed all ſmall animals, but ſplit trees, and beat down horſes and men. The Hail-ſtones, many of which weighed five ounces, ſome ſeven or eight, were of various figures: ſome round, others half round, ſome ſmooth, others emboſſed, or variouſly granulated.

The icy ſubſtance of them was tranſparent and hard; but there was a ſnowy kernel in the middle of each.

May 4, in the ſame year, there was a ſhower of Hail, in Hertfordſhire, which exceeded this. Fields of rye were cut down as with a ſcythe; ſeveral men killed, and vaſt oaks ſplit. The ſtones were from ten to fourteen inches round, ſome oval, ſome picked, and others flat.

Mezeray relates that in Italy, in 1510, there was, after an horrible darkneſs, a ſhower of Hail which deſtroyed all the fiſh, birds and beaſts of that country. It was attended with a ſtrong ſmell of ſulphur. Some of the ſtones weighed an hundred pounds.

4. The Rainbow is always ſeen in the region oppoſite to the ſun, and never but when it rains on that ſide. Its colours are conſtantly in this order; the outermoſt red, the next yellow, the third green, the innermoſt violet colour: but theſe are not always equally vivid. When two Rainbows appear, the upper exhibits the ſame colours, but fainter, and in an inverted order. The ſeat of the Rainbow is the drops of Rain, on which the rays of the ſun fall, and after various refractions and reflections, ſtrike on the eye of the beholder. This is rendered indiſputable from hence, that the very ſame colours, and in the ſame order, are exhibited in the drops of water, ſpouted from a fountain.

The Moon alſo ſometimes exhibits a Rainbow; but only when ſhe is full: her light being at other times too faint to affect the ſight, after two refrac-
tions

tions and a reflection. It has all the colours of the folar Rainbow, very diftinct and pleafant, only confiderably fainter.

A Rainbow is likewife fometimes exhibited by the Sea, when a ftrong wind carries the tops of the waves aloft, and the fun's rays falling upon them are refracted and reflected, as in a fhower. But the colours of this are lefs lively, lefs diftinct, and lefs durable than thofe of the common Bow. Scarce above two colours are diftinguifhable, a dark yellow on the fide next the fun, and a pale green on the oppofite fide. But fometimes 20 or 30 of them are feen at once. They appear at noon-day, in a pofition oppofite to that of the common Rainbow, the concave fide being turned upwards.

5. Halo's are circles of various colours, which are fometimes feen round the fun or moon. The fpace contained within them (efpecially near thofe parts which are tinctured with the moft lively colours,) is more dufky than the fky without. (They never appear in rainy weather.) Perhaps the air is at that time full of very fmall icy particles, on which the rays of the fun or moon falling, after refraction, exhibit that appearance.

6. As to Mock Suns, we fometimes fee a large, white circle, parallel to the horizon, in feveral parts whereof more or fewer funs appear, though not always of the fame fize or colour. As an Halo frequently appears at the fame time, it is probable they fpring from much the fame caufe, namely, from icy particles floating in the air, be-

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tween the ſun and the eye of the ſpectator. The rays of the Sun reflected from theſe, may form that bright circle, in certain parts whereof, by a double refraction and reflection of them, thoſe fictitious ſuns appear. In the ſame manner, the appearances termed Mock Moons may be accounted for.

7. Among Fiery Meteors are reckoned, Thunder, Lightning, Ignes Fatui, Lambent Flames, and what are called, Falling Stars. Unleſs we account for theſe (as indeed it is eaſy to do) upon the principles of electricity, we muſt ſuppoſe they are owing to ſulphureous or bituminous particles, floating in the air, which when collected in ſufficient quantities, take fire by various means. If a large quantity of inflammable vapour takes fire at once, the flame tears the cloud with incredible force, as well as immenſe noiſe. But the light moving ſwifter than the ſound, is ſeen before that is heard. Sometimes an exhalation of a milder kind takes fire, and produces lightning without thunder. When it thunders and lightens, it commonly rains too, the ſame ſhock driving together and condenſing the clouds. And the wiſdom of God appoints it ſo, for the preſervation of his creatures. For if lightning falls on one who is throughly wet, it does him no harm at all. Not that the water quenches or reſiſts the fire; but it conveys it into the ground.

High places are moſt frequently ſtruck with lightning, if they have ſharp points, as ſpires of churches, or tops of trees, which, as it were, attract the fire. It ſometimes burns the clothes without hurting the body; ſometimes breaks the bones without ſcorching the ſkin. It melts the

ſword

ſword in the ſcabbard, or money in the pocket, while the ſcabbard or pocket remains as it was. In general, it paſſes innocently through thoſe things that make little or no reſiſtance; but tears thoſe in pieces with impetuous force, which reſiſt its paſſage.

One very peculiar effect of lightning, is what the vulgar call, Fairy Circles. Theſe are of two kinds. One kind, is a round, bare path, about a foot broad, with green graſs in the middle, and is frequently ſeven or eight yards in diameter. The other is a circle of the ſame breadth, of very green graſs, much freſher than that in the middle. Theſe are generally obſerved after ſtorms of thunder and lightning. And it is no wonder, that lightning, like other fires, moves circularly, and burns more at the extremity than in the middle. The ſecond kind of circles without all doubt ſpring originally from the firſt: the graſs, which was burnt up by the lightning, growing afterward more freſh and green.

But of what kind was that Meteor which appeared March 21, 1676? Two hours after ſun-ſet, it came over the Adriatic ſea, from E. N. E. to W. S. W. and croſſed over all Italy, being nearly vertical to Rimini on the one ſide, and Leghorn on the other. It was at leaſt thirty-eight miles high. In all places near its courſe, it made a hiſſing noiſe like a ſky-rocket. Having paſſed Leghorn, it gave a ſound like that of a large cannon, and quickly after like a cart, running over ſtones. It was computed to move 160 miles in a minute, which is above ten times as ſwift as the diurnal motion of the earth. Its ſmaller diameter was judged to be above half a mile. No wonder then, that so large a body, moving with such incredible swiftness through the air, though so much rarified, should cause that hissing noise. It is much harder to conceive, how such an impetus could be impressed upon it: how this impetus should be determined, in a direction so nearly parallel to the horizon? And what sort of substance it must be, that could be so impelled and ignited at the same time? Whatever it was, it sunk, and was extinguished in the Tyrrhene Sea, to the W. S. W. of Leghorn. The great noise was heard, on its immersion into the water, the rattling sound upon its quenching.

On Thursday, March 19, 1719, there appeared at London, about eight at night, a sudden great light, moving after the manner, but more slowly than a falling star, in a direct line, a little beyond, and withal below Orion's Belt, then in the south-west. In its way, it turned tapering upward, and at last spherical, near as big as the full moon. It was whitish, with an eye of blue, as bright as the sun in a clear day. It seemed in half a minute to move twenty degrees, and to go out, as much above the horizon. There remained after it for more than a minute, a track of a reddish colour, such as that of red hot iron; and sparks seemed to issue from it, such as come from red hot iron, beaten upon an anvil.

Within doors the candles gave no light; and without, not only the stars disappeared, but the moon, nine days old, though the sky was clear, and she was then near the meridian: so that for some seconds, we had perfect day. Its height was seventy three miles and an half. Hence it might

might be feen in all places, which were not diftant from it more than two hundred and twenty leagues. Accordingly, it was feen at the fame inftant, over Spain, France, Great-Britain, Ireland, Holland, and the hither parts of Germany.

Another appearance, which refembles lightning is the Aurora Borealis, commonly called Northern Lights. This is ufually of a reddifh colour, inclining to yellow, and fends out corufcations of bright light, which feem to rife from the horizon in a pyramidical form, and fhoot with great velocity up to the zenith. It appears frequently in the form of an arch, rifes far above the region of the clouds, yet never appears near the equator, but always nearer the poles.

8. Vapours of the fame kind, that give rife to lightnings in the air, occafion Damps in the earth. The Damps ufual in mines are of four forts. The approach of the firft and moft common is known by the flame of the candle leffening till it goes out: as alfo by the men's difficulty of breathing. Thofe who efcape fwooning are not much hurt by this: but thofe who fwoon away, are commonly on their recovery feized with ftrong convulfions. The fecond is the Peafbloom Damp, fo called becaufe of its fmell. This comes only in fummer, and is common in the Peak of Derbyfhire. They who have feen the third fort of Damp, defcribe it thus. In the higheft part of the roof of thofe paffages in a mine, which branch out from the main groove, a round thing hangs about as big as a foot-ball, covered with a thin fkin. If this be broken, the Damp immediately fpreads, and fuffocates all that are near. But

ſometimes they contrive to break it at a diſtance; after which they purify the place with fire. The fourth is the Fire-damp: a vapour, which if touched by the flame of a candle, takes fire, and goes off like gunpowder. And yet ſome who have had all their cloaths burnt off by one of theſe, and their fleſh torn off their bones, at the very time felt no heat at all, but as it were a cool air.

Sir James Lowther, having collected ſome of this air in bladders, brought it up to London. Being let out at the orifice through a tobacco-pipe, it would take fire at the flame of a candle. And even this is imitable by art. Moſt metals emit ſulphureous vapours, while they are diſſolving in their ſeveral menſtruums. Iron for inſtance, while it diſſolves in oil of vitriol, emits much ſulphureous vapour. If this be received into a bladder, and afterwards let out in a ſmall ſtream, it takes fire, juſt in the ſame manner as the natural vapour.

This experiment explains one cauſe of earthquakes and volcanos; ſince it appears hence, that nothing more is neceſſary to form them, than iron mixing with vitriolic acid and water. Now iron is generally found, accompanied with ſulphur; and ſulphur conſiſts of an inflammable oil, and an acid like oil of vitriol.

This acid in the bowels of the earth, being diluted with a little water, becomes a menſtruum to iron, with a violent effervefcence and an intenſe heat. The air coming from this mixture is extremely rarefied, and the more it is compreſſed by the incumbent earth, ſo much the more its impetus will be increaſed to an unlimited degree. Nor does there need fire to ſet theſe vapours to work.

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The air in the bladder, if it be much heated, will of itſelf take fire, as ſoon as it is brought into contact with the external air.

Other Damps are ſometimes as mortal as thoſe in mines. In the year 1701, a maſon being at work in the city of Rennes, near the brink of a well, let his hammer fall into it. A labourer who was ſent down for it, was ſuffocated, before he reached the water. A ſecond, ſent to draw him up, met with the ſame fate. So did a third. At laſt a fourth, half drunk, was let down with a charge to call out immediately, if he felt any inconvenience. He did call, as ſoon as he came near the water, and was drawn up inſtantly. Yet he died in three days, crying out, he felt a heat, which ſcorched his entrails. Yet the three carcaſes being drawn up with hooks, and opened, there appeared no cauſe of their death.

The ſame hiſtorians relate, that a baker of Chartres, having carried ſeven or eight buſhels of brands out of his oven into a cellar 36 ſtairs deep, his ſon, a ſtrong young fellow, going with more, his candle went out on the middle of the ſtairs. Having lighted it afreſh, he no ſooner got into the cellar, than he cried for help, and they heard no more of him. His brother, an able youth, ran down, cried, "I am dead," and was heard no more. He was followed by his wife, and ſhe by a maid, and ſtill it was the ſame. Yet an hardy fellow reſolved to go and help them; he cried too, and was ſeen no more. A ſixth man deſired an hook to draw ſome of them out. He drew up the maid, who fetched a ſigh and died. Next day one undertook to draw up the reſt, and was let down on a wooden horſe with ropes, to be drawn up whenever he ſhould call. He ſoon called, but the rope breaking, he fell back again, and was a while after drawn up dead. Upon opening him the membranes of the brain were found extremely ſtretched, his lungs ſpotted with blood, his inteſtines ſwelled as big as one's arm, and red as blood, and all the muſcles of his arms, thighs and legs, torne and ſeparated from their bones,

Whence this ſtrange difference ſhould ariſe, that the vapours of ſome mines catch fire with a ſpark, and others only with a flame, is a queſtion that we muſt be content to leave in obſcurity, till we know more of the nature both of mineral vapour and fire. This only we may obſerve, that gunpowder will fire with a ſpark, but not with the flame of a candle: on the other hand, ſpirits of wine will flame with a candle, but not with a ſpark. But even here the cauſe of this difference remains a ſecret.

A like inſtance of the fatal nature of foul air, happened at Boſton in New England. Mr. Adams and his ſervant being employed to repair a pump, uncovered the well, and Mr. Adams went down by a rope; but he had not gone ſix feet, before he dropt ſuddenly without ſpeaking a word, to the upper part of the joint of the pump, where being ſupported about a minute, and breathing very ſhort, he then fell to the bottom, without any ſigns of life. His ſervant haſtily went down, to help his maſter; but at the ſame diſtance from the top, was ſtruck, and without diſcovering any ſigns of diſtreſs, fell to the bottom. The workmen prepared a third, with a tackle about his waſte.

On

On his descent, he was quickly speechless and senseless. Though he made no sign, they drew him up. He was the very picture of death, but by the use of proper means recovered. He remembered nothing of what had passed. The other bodies when taken up, had all the marks of a violent death.

The vapour of fermenting liquors is equally extraordinary in its effects. This vapour appears over the fermenting liquor as a fog in a meadow, but more fleecy. It is heavier than air, and falls quick to the ground, and disappears. Van Helmont calls it, Gas Sylvestre. Boerhaave says, " There is nothing more surprizing in fermentation, than that Spiritus Sylvestris, nor is there any poison that I am acquainted with, so subtle, swift, and fatal. For if a very large vessel, full of must, in the very act of fermentation, should discharge this spirit through a small vent-hole in the top of the vessel, and the stoutest man should apply his nose to the hole, and at once draw in this vapour, he would drop down dead in an instant, without any apparent cause of it. It extinguishes flame instantaneously. If a lighted candle be let slowly into it, the flame is borne up from the wick, and the candle may be raised up again so as to receive the flame." One put a mouse into it, which was killed in about a second of time, it kicked once or twice, and then was quite dead.

May we ascribe to a kind of Damp, a sort of murrain, which appeared in Italy, and made great havock among the cattle? It spread itself in the form of a blue mist, over those pastures where they grazed: so that whole herds came home

home ſick, and moſt of them died in twenty-four hours. Many who went among them, were infected, and died in the ſame manner. Some imputed this contagion to noxious vapours, thrown out of the earth, by earthquakes preceding. It paſſed through Germany to Poland, going without intermiſſion, eleven or twelve miles in twenty-four hours, and ſuffering no cattle in its way to eſcape, whether within doors or without. Hence others imagined it was owing to ſome volatile inſect, which was able to make but ſhort flights.

9. Ignis Fatuus, vulgarly called Will with the Wiſp, is chiefly ſeen in dark nights, irregularly moving over meadows, marſhes, and other moiſt places. It ſeems to be a viſcous exhalation, which being kindled in the air, reflects a kind of thin flame in the dark, though without any ſenſible heat. It is often found to fly along rivers or hedges, probably becauſe it there meets with a ſtream of air to direct it. In Italy there are luminous appearances, nearly reſembling theſe, which on a cloſe inſpection have been found to be no other than ſwarms of ſhining flies.

In all the territories of Bologna, theſe *fiery appearances* are common. There are ſome places where one may be almoſt ſure of them, every dark night, as near the bridge Della Salcarata, and in the fields of Bagnara, theſe are large: ſometimes equal to the light of a faggot, rarely leſs than that of a link. That at Bagnara not long ſince kept a gentleman company for a mile, moving juſt before him, and caſting a ſtronger light on the road than the link he had with him.

All

All of them refemble a flame, and are continually in motion, but the motion is various and uncertain. In winter, when the ground is covered with fnow, they are moft frequent of all. Nor does rain hinder them: nay, in wet weather they give the ftrongeft light: wind alfo does not difturb them. As they are not hindred by wet, and fet nothing on fire, though ever fo combuftible, may it not reafonably be fuppofed, that they have fome refemblance to that kind of Phofphorus, which fhines indeed in the dark, yet does not burn like common fire?

The following experiments fhew a little more of the nature of this ftrange fubftance.

Salt of Phofphorus, kept in a vitrifying heat, at laft runs into perfect glafs. What a wonderful fubject is this? And how furprifing it is, that fo inflammable a body fhould become glafs! Here then is a perfect tranfmutation of bodies: the Phofphorous being tranfmuted into a tranfparent glafs of a bluifh green, coming nearer the hardnefs of a diamond, than any other glafs whatever. And the glafs is in the very fame quantity with the Phofphorus, which produces it ounce for an ounce.

Another odd circumftance relating to Phofphorus is, cut it fmall, or fcrape it with a knife, and lay it on a glafs difh in moift air. In a week it refolves into a liquid, near eighty times its original weight. This liquid is the fame in all refpects, with that which comes from the fublimed flowers by deflagation. And this may be turned into the fame glafs with the original Phofphorus.

One

One of the moſt ſingular kinds of *lambent Fires*, is that diſcovered at certain times on ſea water. Where the ſhip goes ſwiftly in the night, in many ſeas the whole breaking of the water will appear behind it, as if on fire, ſparkling and ſhining all the way that it moves from the ſhip.

It is in this part as bright and glittering as if the moon ſhone upon it, and chiefly when there is neither moon nor ſtars, nor any light in the lanterns. But it is not always the ſame; ſometimes it is ſcarce perceivable, ſometimes very vivid and bright. Sometimes it is only juſt behind the ſhip, ſometimes it ſpreads a great way on each ſide. It commonly reaches thirty or forty feet from the ſtern of the ſhip, but is fainter as it is farther off. At the ſtern it is often ſo bright, that a perſon on deck may ſee to read by it. The luminous water that follows the ſhip is ſometimes diſtinct from the reſt of the ſurface. Sometimes it is ſo blended with the adjacent water, that the appearance is confuſed. The luminous matter ſeems compoſed of ſmall ſparkles, which are ſometimes in the figure of a ſtar, ſometimes it forms globules, without any radiations from them. Theſe are, ſome of the ſize of a large pin's head; ſome larger, even to a foot in diameter. Sometimes the luminous matter is in oblong ſquares, of three or four inches. When the ſhip goes ſwiftly, theſe figures all combine and form a ſort of luminous whirlpool. Nor does a ſhip only, but whatever moves ſwift through the ſea, cauſe the ſame appearance. Large fiſh when they ſwim near the ſurface, leave a luminous road behind them. So do a number of fiſh moving together. And ſometimes the throwing out a rope, or any thing that breaks the ſurface of the water, will render it luminous. If

ſea-

ſea-water be taken up, and placed in a veſſel, as ſoon as it is ſtirred, it will ſparkle: and if a linen rag be dipped in ſea-water, and hung up, when it is thoroughly dried, it will appear luminous on being rubbed in the dark; and when half dry, it need only be ſhook, to ſhew a great number of ſparkles. When theſe ſparkles are once formed, and fall on any ſolid body, they will laſt a conſiderable time. If they remain on the water, they will ſoon go out.

The waves beating againſt the rocks or ſhore, yea, or againſt one another, will occaſion the ſame appearance, and often yield a long courſe of light the whole night. In the Braſils the ſhores often ſeem all on fire, by the waves daſhing againſt them. In general, the thicker and fouler the ſeas are, the more of this light they afford. In many places the ſea is covered with a yellowiſh matter like ſaw-duſt, which ſeems to be the excrement of ſome ſea-animal. The water where this is found, gives more light, upon moving, than any other.

Some parts of the northern ſeas are covered with this, for ſeveral leagues together, and this is often luminous all over in the night, though not ſtirred by any thing moving through it.

In the gulph of Venice the water is luminous, only from the beginuing of ſummer till the end of harveſt. This light is moſt copious in places abounding with ſea-graſs, eſpecially when any thing moves the water. One filled a flaſk with this water; but it emitted no light till it was ſtirred in the dark. When this was ſtrained through a fine cloth, the cloth ſhone in the dark, but not the

the water. This light confifted of innumerable lucid particles. When fome of this fea-grafs was taken up, there were above thirty of thefe particles on one leaf, one of which when it was fhaken, fell off. It was as fine as an eye-lafh and about as long. Viewed with a microfcope it appeared to be a worm or maggot, confifting of eleven rings, with as many mamillæ on the fides inftead of feet. Their whole bodies were lucid, though leaft fo, when at reft. In fpring they confine themfelves to the fea-grafs: but in fummer they are difperfed all over the fea, and moftly on the furface. When this fea fparkles more than ufual, it is the fure fign of a ftorm: and this proceeds from the greater agitation of the worms, already fenfible of the approaching change. Hence it is clear, that the glittering of this fea, in a fhip's courfe, is occafioned by thefe worms: which probably is the cafe in fome other feas alfo. And they are certainly the caufe of the light in the Pinna-Marina, a large mufcle frequently caught by the Algerine fifhermen.

Many Sea-fifh indeed have a vifcous matter about their gills, efpecially when they have been fome time dead. Thefe, when kept in fea-water, fhine as bright as a flaming coal. A ftick rubbed on their gills, becomes luminous wherever it has touched them, and continues fo, while it continues moift; but as it dries, the light fades.

There is a fmall fhell-fifh, called a Dactylus, which is luminous all over. When it is taken out of the fhell, in the dark, every part of its furface fhines with a bright light. Nor is it the furface only; but the whole body. For if it be wounded

wounded either lengthways or acroſs, the out parts were as luminous as the ſurface. It is therefore a true, natural phoſphorus, and makes every thing luminous that touches it, which remains ſo as long as it is wet. When it is freſh caught it abounds with water, and the very drops which fall from it are luminous.

Some boiled Mackrel having been left in the water for pickle, the cook, a day or two after, ſtirring the water, found it very luminous. Where-ever the drops of it fell on the ground they ſhined. The next day we repeated the trial. The water 'till ſtirred, gave no light; but when gently ſtirred by the hand, it ſhone bright; and by a briſker motion it ſeemed to flame. The fiſh ſhone, as well from the inſide as the out: yet they were not either fetid or inſipid. When fetid, they did not ſhine at all.

The chief circumſtances which Mr. B. noted concerning *luminous fleſh* were, 1. It was a neck of veal, bought ſome days before: 2. In this about twenty places ſhone, though not alike: 3. Moſt of theſe were as big as the nail of a man's finger, and irregularly ſhaped: 4. The parts which ſhone moſt were the griſly, or the bruiſed parts of the bones; 5. Some of theſe were ſo bright, that holding a printed paper to them, I could read ſeveral letters: 6. One could not diſcern in any of them the leaſt degree of heat, neither of putrifaction: 7, One of theſe being put in a cup of cold water, the light continued the ſame.

Not only water, fiſh and fleſh, but ſome ſort of *wood* will ſhine as bright as a burning *coal.* And herein they agree, 1. Both have light *in themſelves*: 2. Both need the air, to make them continue ſhining: 3. Both having loſt their light, by

being

being deprived of air, recover it, when fresh air is let in: 4. Both are easily quenched by water, and 5. Neither of them is affected by the coldness of the air.

But herein they differ: 1. The light of a coal is put out by compression: that of wood is not: 2. The coal is quite extinguished by withdrawing the air: that of the wood is only eclipsed: let the air in again within half an hour, and it immediately recovers: 3. A coal put into a small, close glass, will not burn many minutes: a piece of wood will shine many days: 4. A burning coal emits much smoke, shining wood none at all.

A diamond, by an easy friction in the dark, by the finger or a woollen cloth, appears in its whole body to be luminous: and if it has been rubbed a good while, it will keep its light for a little time. If when the sun is set, one hold up a piece of flannel stretched tight between both hands at a little distance, and another rubs the diamond swiftly and strongly on the other side of it, the light to the eye of him that holds the cloth, seems much more pleasant and perfect. What is more surprising, is, that a diamond exposed to the open air, in view of the sky, (even without being in the sunshine) gives nearly the same light of itself without rubbing, as when rubbed in a dark room. But if you hold your hand or any thing else over it, to hinder its communication with the sky, let it lie ever so long in the open air, yet it will give no light.

A well-polished piece of Amber, will yield light, if rubbed in the dark. And if it be drawn swiftly

ſwiftly through a woollen cloth, very many little cracklings are heard, and each produces a little flaſh of light. If drawn gently it produces a light, but no crackling.

The following is the moſt ſatisfactory account I have ever ſeen of this phænomenon.

The ſplendor of the ſea-water during the night, hath long been a ſubject of admiration, and upon the coaſts of Chioggia it is particularly remarkable: at firſt ſight one would imagine that the brilliant images of the fixed ſtars were reflected by the ſea, when agitated by the winds. This brightneſs becomes much more vivid and copious, in places abounding with the Alga Marina, or Sea Weed.

One ſummer-night I took a veſſel full of the ſea water home with me. I placed it in a dark room, and obſerved as often as I diſturbed the water, a very bright light iſſued from it. I then paſſed the water through a very cloſe linen cloth, to try if it would ſtill retain its ſplendor after ſuch percolation. But notwithſtanding I agitated it in the moſt violent manner, I could not excite the leaſt luminouſneſs in it. The linen cloth however afforded the moſt charming ſpectacle imaginable: it was covered with an infinity of lucid particles. To the naked eye they appear ſmaller than the fineſt hairs: their colour of a deep yellow, and their ſubſtance delicate beyond imagination: but having a mind to examine them more curiouſly, I furniſhed myſelf with a good microſcope, and was ſoon convinced that theſe luminous atoms are really living animals of a very ſingular ſtructure, and from the brightneſs of their luſtre, I thought myſelf authoriſed to name them *Marine Glow-Worms.*

Theſe

Theſe little animals, ſimilar to caterpillars, and other inſects of that ſpecies, are compoſed of eleven articulations, or annuli, a number which, according to the celebrated Malpighi, is peculiar to the whole vermicular race. Upon theſe annuli, and near the belly of the animal, are a ſort of ſmall fins or wings, which ſeems to be the inſtruments of its motion. It has two ſmall horns iſſuing from the fore part of its head, and its tail is cleft in two. Their whole body is luminous, and when cut to pieces, every piece emits a vivid light for ſome time; probably ſo long as the convulſive motion of the dying parts continues.

Many philoſophers of the firſt rank have imagined that the luminouſneſs of the ſea-water in the night ſeaſon is occaſioned by ſome electric matter. " The ſurface of the ſea, ſay they, having been expoſed all the ſummer to the impulſe of the ſolar rays, when it begins to be agitated by the autumnal winds, throws out luminous ſparks perfectly ſimilar to thoſe which iſſue from electrified bodies."

But ocular demonſtration now convinces us, that this brightneſs is to be aſcribed to theſe little animals.

The light of a Glow-worm is ſo ſtrong, that it will ſhew itſelf through ſeveral ſubſtances. The creature ſeems dead in the day-time, and its light is not then viſible even in a dark room, unleſs it be put in motion, and then it is very faint. After ſun-ſet the light begins to return, and with it the life and motion of the animal. Indeed, the motion and light ſeem to depend on each other: it never ſhines, but when it moves: and when it ſhines moſt, the body is one third longer than in the

the day-time. While it ſhines brighteſt, it ſometimes turns about, and the light is no larger than a pin's head. But on being touched, it immediately extends itſelf, and the light is as large and bright as ever.

The luminous parts are two ſmall ſpecks under the tail. The uſe of this light is, to direct the animal in its courſe, and in taking of its prey. It is admirably placed for this purpoſe. The tail is eaſily bent under its belly, and throws its light full upon any object, about or under the head of the animal, and the eyes are placed not on the upper part, but on the under ſide of the head, ſo that they have all the advantages of it, while the light in this part is not offenſive to the eyes, as it naturally would have been, if carried about the head. The creature can upon occaſion cover this light, ſo as not to be known, or purſued by its enemies. It is an inſect of the beetle-kind, of a brown and duſky colour. It has ſhell wings as the other beetles have. Its head is covered with a ſort of broad-brimmed hat, under which are the eyes which are black and large.

Falling Stars, ſo called, ſeem to be vapours of an unctuous kind, kindled in the lower regions of the air: unleſs this alſo (as many other phænomena of the ſort) be owing to what is vulgarly termed Electricity.

10. From a thouſand experiments it appears, that there is a fluid far more ſubtle than air, which is every where diffuſed through all ſpace, which ſurrounds the earth, and pervades every part of it. And ſuch is the extreme fineneſs, velocity, and expanſiveneſs of this active principle, that all other matter ſeems to be only the body, and this the ſoul of the univerſe.

It

It is highly probable this is the general instrument of all the motion in the universe: from this *pure fire*, (which is properly so called) the vulgar *culinary fire* is kindled. For in truth, there is but one kind of fire in nature, which exists in all places, and in all bodies. And this is subtle and active enough, not only to be under the great Cause, the secondary cause of motion, but to produce and sustain life throughout all nature, as well in animals as in vegetables.

This great machine of the world, requires some such constant, active, and powerful principle, constituted by its Creator, to keep the heavenly bodies in their several courses, and at the same time give support, life, and increase to the various inhabitants of the earth. Now as the heart of every animal is the engine which circulates the blood through the whole body, so the Sun, as the heart of the world, circulates this fire through the whole universe. And this element is not capable of any essential alteration, increase, or diminution. It is a species by itself; and is of a nature totally distinct from that of all other bodies.

That this is absolutely necessary both to feed common fire, and to sustain the life of animals, may be learned from an easy experiment. Place a cat, together with a lighted candle, in a cold oven: then lute the door close, having fixed a glass in the middle of it; and if you look through this, you may observe at one and the same instant, the candle goes out, and the animal dies. A plain proof, that the same fire is needful to sustain both culinary fire and animal life: and a large quantity of it. Some doubtless pervades the oven-door; but not enough to sustain either flame or life. Indeed, every animal is a kind of fire-engine

gine. As ſoon as the lungs inſpire the air, the fire mingled with it is inſtantly diſperſed through the pulmonary veſſels into the blood: thence it is diffuſed through every part of the body, even the moſt minute arteries, veins and nerves. In the mean time the lungs inſpire more air and fire, and ſo provide a conſtant ſupply.

The air ſeems to be univerſally impregnated with this fire, but ſo diluted, as not to hurt the animal in reſpiration. So a ſmall quantity of a liquor dropt in water may be friendly to an human body, though a few drops of the ſame liquor given by themſelves, would have occaſioned certain death. And yet, you cannot conceive one particle of the water, without a particle of the medicine. It is not impoſſible, this may be one great uſe of air, by adhering ſo cloſely to the elementary fire, to temper and render ſalutary to the body, what would otherwiſe be fatal to it.

To put it beyond diſpute, that this Fire is largely mixed with the air, you may make the following experiment. Take a round lump of iron, and heat it to a degree called a *welding* heat: take it out of the fire, and with a pair of bellows, blow cold air upon it. The iron will then as effectually melt, as if it were in the hotteſt fire. Now when taken out of the forge, it had not fire enough in it to conquer the coheſion of its parts: but when this fire is joined with that which was mixed with the air, it is ſufficient to do it. On the ſame principle we account for the increaſe of a coal or wood fire, by blowing it.

And let none wonder, that Fire ſhould be ſo connected with air, as hardly to be ſeparated. As ſubtle as Fire is, we may even by art attach it to other bodies; yea, and keep it priſoner for many years: and that, either in a ſolid or fluid form. An inſtance of the firſt we have in ſteel; which is made ſuch, only by impacting a large quantity of fire into bars of iron. In like manner, we impact a great quantity of fire into ſtone to make lime. An inſtance of the ſecond kind we have in ſpirits, wherein fire is impriſoned in a fluid form. Hence common ſpirits will burn all away. And if you throw into the air, ſpirits rectified to the higheſt degree, not one drop will come down again, but the univerſal Fire will take hold of and abſorb it all.

That this fire ſubſiſts both in air, earth, and water: that it is diffuſed through all and every part of the univerſe, was *ſuſpected* by many of the ancient naturaliſts, and *believed* by the great Sir Iſaac Newton. But of late years it has been fully demonſtrated: particularly, by Mr. Stephen Gray, a Penſioner at the Charter-houſe: who ſome years ſince preſented to the Royal Society, an account of many experiments he had made, whereby this ſubtle fluid became clearly perceptible both to the ſight and feeling. Becauſe the glaſs tube, by means of which thoſe experiments were made, was obſerved when rubbed to attract ſtraws and other light bodies (a known property of amber, called in latin *Electrum*) theſe experiments were termed *Electrical:* a word which was ſoon affixed to that ſubtle fluid itſelf, and every thing pertaining to it. But improperly enough: ſeeing the attracting (or ſeeming to attract) ſtraws and feathers, is one of the moſt inconſiderable of all the effects, wrought by this powerful and univerſal Cauſe.

It

It was afterwards found, that a glaſs globe was preferable to a glaſs tube. A greater quantity of ethereal fire is *collected* by this means, than by the other. I ſay, *collected*; for that fire is no more *created* by rubbing, than water is by pumping. The grand reſervoir thereof is the earth, from which it is diffuſed every way. Accordingly in theſe experiments, the globe rubbing againſt the cuſhion, collects Fire from it. The cuſhion receives it from the frame of the machine; the frame of the machine from the floor. But if you cut off the communication with the floor, far leſs Fire can be *produced*, becauſe leſs is *collected*.

Many new diſcoveries have been made by means of a large, but thin glaſs phial. This phial is hung on any metallic body, which communicates by a wire, with the globe. This metallic body has been termed, *the prime conductor*, as it conducts or conveys the Fire, collected by the globe, either into the phial, or into any other body communicating therewith.

But all bodies are not capable of receiving it. There is in this reſpect an amazing difference between them. The excrements of nature, as wax, ſilk, hair, will not receive the ethereal Fire, neither convey it to other bodies: ſo that, whenever in circulating it comes to any of theſe, it is at a full ſtop. Air itſelf is a body of this kind; with great difficulty either receiving or conveying this Fire to other bodies: ſo are pitch and roſin (excrements, as it were, of trees.) To theſe we may add glaſs, amber, brimſtone, dry earth, and a few other bodies. Theſe have been frequently ſtiled

Electrics per se; as if they alone contained the *Electric Fire:* an eminently improper title, founded on a palpable mistake. From the same mistake, all other bodies, which easily receive and readily convey it, were termed *Non-Electrics*; on a supposition, that they contained no *Electric Fire:* the contrary of which is now allowed by all.

That this Fire is inconceivably subtle, appears from its permeating even the densest metals, and that with such ease, as to receive no perceptible resistance. If any one doubt, whether it pass through the substance, or only along the surface of bodies, a strong shock taken through his own body, will prevent his doubting any longer. It differs from all other matter in this, that the particles of it repel, not attract each other. And hence is the manifest divergency in a stream of Electrical Effluiva. But though the particles of it repel each other, yet are they attracted by all other matter. And from these three, the extreme subtlety of this Fire, the mutual repulsion of its parts, and the strong attraction of them by other matter, arises this effect, that if any quantity of Electric Fire be applied to a mass of common matter of any bigness or length, (which has not already got its quantity) it is immediately diffused through the whole.

It seems this globe of earth and water, with its plants, animals, buildings, have diffused through their whole substance, just as much of this Fire as they will contain. And this we may term their *natural quantity*. This is not the same in all kinds of matter: neither in the same kind of matter,

matter, in all circumſtances. A ſolid foot of one kind of matter (as glaſs) contains more of it than a ſolid foot of another kind. And a pound weight of the ſame kind of matter, when rarefied, contains more than it did before.

We know that this Fire is *in* common matter, becauſe we can pump it *out* by the globe: we know that common matter has near as much of it as it can contain, becauſe if we add a little more to any portion of it, the additional quantity does not enter, but forms a kind of atmoſphere round it. On the other hand we know, that common matter has not more of it than it can contain. Otherwiſe all looſe portions of it would repel each other; as they conſtantly do, when they have ſuch atmoſpheres. Had the earth, for inſtance, as much Electric Fire in proportion, as we can give to a globe of iron or wood, the particles of duſt and other light matter, would not only repel each other, but be continually repelled from the earth. Hence the air, being conſtantly loaded therewith would be unfit for reſpiration. Here we ſee another occaſion to adore that wiſdom, which has made all things by weight and meaſure.

The form of every electric atmoſphere, is that of the body which it ſurrounds: becauſe it is attracted by every part of the ſurface, though it cannot enter the ſubſtance already replete. Without this attraction, it would not remain round the body, but diſſipate into the air.

The atmoſphere of an electrified ſphere, is not more eaſily drawn off, from any one part of it than from another, becauſe it is equally attracted by every part. But it is not ſo with bodies of other figures. From a cube it is more eaſily drawn off at the corners than at the ſides: and ſo from the corners of bodies of any other form, and moſt eaſily from the ſharpeſt corners. For the force with which an electrified body retains its atmoſphere, is proportioned to the ſurface on which that atmoſphere reſts. So a ſurface four inches ſquare retains its atmoſphere, with ſixteen times the force that one of an inch ſquare does. And as in pulling the hairs from a horſe's tail, a force inſufficient to pull off an handful at once, could eaſily pull it off hair by hair: ſo though a blunt body cannot draw off all the atmoſphere at once, a pointed one can eaſily draw it off, particle by particle.

While the Electric Fire, which is in all bodies, is left to itſelf, undiſturbed by any external violence, it is more or leſs denſe, according to the nature of the body which it is in. In denſe bodies it is more rare: in rare bodies it is more denſe. Accordingly every body contains ſuch a quantity of it, rare or denſe, as is ſuitable to its nature. And there is ſome reſiſtance to every endeavour of altering its denſity, in the whole of any body, or in any part of it. For all bodies reſiſt either the increaſe or diminution of their natural quantity. And on the other hand, when it has been either increaſed or diminiſhed, there is a reſiſtance to its return to its natural ſtate.

With regard to the different reſiſtance made by different bodies, in either of theſe caſes, it is an invariable rule, that glaſs, wax, roſin, brimſtone, ſilk, hair, and ſuch like bodies, reſiſt the moſt; and next to theſe, the air, provided it be

dry,

dry, and in a ſufficient quantity. That this reſiſtance is leaſt in metals, minerals, water, animals, and vegetables: which we may rank together, becauſe the difference in their reſiſtance is very inconſiderable: and that in theſe bodies the reſiſtance is greater, when their ſurfaces are poliſhed, and extended in length, than when their ſurfaces are rough and ſhort, or end in ſharp points.

When a body has more Electric Fire forced into it, than it has naturally, it is ſaid to be electrified *poſitively*. When part of the natural quantity is taken away, it is ſaid to be electrified *negatively*. Now when an iron bar is *negatively* electrified, the fire drawn out, does not go in again as ſoon as the experiment is over, but forms an atmoſphere round it, becauſe of the reſiſtance it finds in its endeavour to dilate itſelf, either into the air, or into the bar. And when it is electrified *poſitively*, the ſame kind of atmoſphere is formed, by the fire accumulated upon it. Whether therefore bodies are electrified *negatively* or *poſitively*, and remain ſo when the experiment is over, there are ſimilar atmoſpheres ſurrounding them, which will produce ſimilar effects.

But we can electrify no body beyond a certain degree; becauſe when any is electrified to that point, it has an atmoſphere round it, ſufficiently ſtrong to balance any power that endeavours to electrify it farther.

And in the ordinary courſe of nature, this ſubtle, active fluid, which not only ſurrounds every groſs body, but every component particle of each, where it is not in abſolute contact with its neighbouring particle, can never be idle, but is ever in action, though that action be imperceptible to our ſenſes. It is ever varying its condition, though imperceptibly, in all parts of all bodies whatever; and electrifying them more or leſs, though not ſo forcibly as to give ſenſible ſigns of it. All bodies then, and all their component particles, when in their natural ſituation, have round their ſurfaces, where they are not in abſolute contact with other ſurfaces, an imperceptible atmoſphere, ſufficient to balance the ſmaller force with which they are attacked: every way ſimilar to the perceptible atmoſphere of bodies forcibly electrified. In theſe imperceptible atmoſpheres is placed the power which reſiſts their being electrified to an higher degree than they are naturally. And this power lies in the elaſticity of the ſubtle fluid, every where diſperſed both round all bodies and in them.

Glaſs is very difficultly electrified, which ſeems to prove it has a very denſe electric atmoſphere. Metals are eaſily electrified. Conſequently they have rare, and therefore weakly reſiſting atmoſpheres. But as heat rarefies all bodies, ſo if glaſs be heated to a certain degree, even below melting it will give as free a paſſage to the Electric Fire, as braſs or iron does: the atmoſphere round it being then rendered as rare as that of metals. Nay, when melted, it makes no more reſiſtance than water. But its reſiſtance increaſes, as it cools. And when it is quite cold, it reſiſts as forcibly as ever. Smoothly-poliſhed wax, reſiſts as much as glaſs. But even the ſmall heat raiſed by rubbing, will render its atmoſphere as rare as that of metals, and ſo intirely deſtroy its reſiſtance. The ſame is true of roſin and brimſtone. Even the heat ariſing from friction, deſtroys the reſiſt-

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ance which they naturally make to being electrified: a ſtrong proof, that the reſiſtance of all bodies thereto, is exerted at their ſurfaces, and cauſed by an electric atmoſphere of different denſities, according to the different circumſtances.

Moſt experiments will ſucceed as well with a globe of brimſtone, as with one of glaſs. Yet there is a conſiderable difference in their nature. What glaſs repels, brimſtone (as alſo roſin) attracts. Rubbed glaſs emits the electric fire: rubbed brimſtone, roſin and wax receive it. Hence if a glaſs globe be turned at one end of a prime conductor, and a brimſtone one at the other, not a ſpark of Fire can be obtained; one receiving it in, as faſt as it is given out by the other. Hence alſo if a phial be ſuſpended on the prime conductor, with a chain from its coating to the table, and only one globe turned, it will be electrified (or *charged* as they term it) by twenty turns of the wheel: after which it may be *diſcharged*, that is, unelectrified, by twenty turns of the other wheel.

The difference between *Non Electrics* (vulgarly ſpeaking) and *Electrics per ſe*, is chiefly this. 1. A *Non Electric* eaſily ſuffers a change, in the quantity of Fire it contains. Its whole quantity may be leſſened, by drawing out a part, which it will afterwards reſume. But you can only leſſen the quantity contained in one of the ſurfaces of an *Electric*: and not that, but by adding at the ſame time an equal quantity to the other ſurface. So that the whole glaſs will always have the ſame quantity in its two ſurfaces. And even this can be only done in glaſs that is thin: beyond a certain thickneſs, we know no power that can make this change. 2. The Ethereal Fire freely moves from place to place, in and through the ſubſtance of a non-electric, but through the ſubſtance of an Electric it will by no means paſs. It freely enters an iron rod, and moves from one end to another, where the overplus is diſcharged. But it will not enter, or move through a glaſs rod. Neither will the thinneſt glaſs which can be made, ſuffer any particle of it entering one of its ſurfaces, to paſs through to the other.

Indeed it is only metals and liquids, that perfectly *conduct* (or tranſmit) this Fire. Other bodies ſeem to conduct it, only ſo far as they contain a mixture of theſe; accordingly, moiſt air will conduct it in proportion to its moiſtneſs. But dry air will not conduct it at all: on the contrary, it is the main inſtrument, in confining any electric atmoſphere to the body which it ſurrounds. Dry air prevents it diſſipating (which it does preſently when *in vacuo*) or paſſing from body to body. A clear bottle full of air, inſtead of water, cannot be electrified. But exhauſted of air, it is electrified as effectually as if it was full of water. Yet an Electrical atmoſphere and air, do not exclude one another. For we breathe in it freely, and dry air will blow through it, without altering it at all.

When a glaſs phial is electrified, whatever quantity of Fire is accumulated on the inner ſurface, an equal quantity is taken from the outer. Suppoſe, before the operation begins, the quantity of fire contained in each ſurface, is equal to twenty grains: ſuppoſe at every turn of the globe, one grain is thrown in: then after the firſt ſtroke there are twenty one within, nineteen only without: after the ſecond, the inner ſurface will have twenty

twenty-two, the outer but eighteen: and ſo on, till after twenty ſtrokes, the inner will have forty, the outer none. And the operation ends: for no power or art of man can throw any more on the inner ſurface, when no more can be taken from the outer. If you attempt to throw more in, it is thrown back through the wire, or flies out in cracks, through the ſides of the phial. The equilibrium cannot be reſtored in this phial, but by a communication formed between the inner and outer ſurface, by ſomething external, touching both the outer, and the wire, which communicates with the inner ſurface. If you touch theſe by turns, it is reſtored by degrees: if both at once, it is reſtored inſtantly. But then there is a ſhock occaſioned by the ſudden paſſing of the fire through the body, in its way from the inner to the outer ſurface. For it moves from the wire to the finger, (not from the finger to the wire, as is commonly ſuppoſed.) Thence it paſſes through the body to the other hand, and ſo to the outer ſurface.

The force with which this ſhock may be given, is far greater than one would conceive. It will kill rats, hens, or even turkeys in a moment: others that are not quite killed, it ſtrikes blind. It will give polarity to a fine needle, making it point north and ſouth, as if touched by a loadſtone. It will invert the polarity of a compaſs, and make the north point turn to the ſouth. At the ſame time the ends of the needles are finely blued, like the ſpring of a watch. It will melt off the heads and points of pins and needles, and ſometimes the whole ſurface of the needle is rnn, and appears, as it were, bliftered, when examined by a magnifying glafs. It will melt thin gold or filver, when held tight between two panes of glafs, together with the furface of the glafs itfelf, and incorporate them in a fine enamel. Yea, a ftrong fpark from an electrified phial makes a fair hole through a quire of paper doubled: which is thought good armour againft the pufh of a fword, or even a piftol bullet. And it is amazing to obferve in how fmall a portion of glafs, a great electrical force may be, A thin glafs bubble, about an inch diameter, being half filled with water, partly gilt on the outfide, when electrified gives as ftrong a fhock, as a man can well bear: allowing then that it contains no more fire after charging then before, how much Fire muft there be in the fmall glafs? It feems to be a part of its very fubftance. Perhaps if that Fire could be feparated from it, it would be no longer glafs. It might in lofing this, lofe its moft effential property, its tranfparency, brittlenefs, and elafticity.

Some have not improbably fuppofed, that all *Electric* bodies, fo called, are by their original conftitution, throughly faturated with Electric Fire: that it remains fixed in them, (unlefs while the texture of thofe bodies is quite altered by liquefaction) that Fire fixed in a body conftitutes an *Electric*, and all bodies where it is not fixed are *Non Electrics*. Agreeably to which they fuppofe, that in all *Non Electrics*, the original Fire loofely inhering, is eafily driven on by the new collected Fire, which then poffeffes its place: but that in *Electrics*, the original Fire being impacted into their fubftance, and therefore more firmly inhering, will not give way to, or be driven on

by,

by, the new collected fire. Such is air in particular; with the particles of which the original Fire is closely incorporated. Dry air seems to be so fully saturated with it, that it is scarce capable of receiving any more: whereas all new-collected Fire is continually endeavouring to return into the earth. Let wires be electrified ever so strongly, yet the moment any part of them is touched by a person standing on the floor, they are electrified no longer; all the fire escaping through him into the earth.

Upon the principles of Electricity, we may give a more rational account of many appearances in nature, than has yet been done: of thunder and lightning in particular. In order to which we may observe, all electrified bodies retain the Fire thrown into them, till some non-electric approaches: to which it is then communicated with a snap, and becomes equally divided. Electric Fire is strongly attracted by water, and readily mixes with it. And water being electrified, the vapours arising from it, are equally electrified. As these float in the air, they retain the additional Fire, till they meet with clouds, not so much electrified. Then they communicate it with a shock.

The ocean is compounded of water and salt; one an electric, the other not. When there is a friction among the parts near its surface, the Fire is collected from the parts below. It is then plainly visible in the night, at the stern of every sailing vessel. It appears from every dash of an oar: in storms the whole sea seems on Fire. The particles of water then repelled from the electrified

surface,

ſurface, continually carry off the Fire as it is collected. They riſe and form clouds which are highly electrified, and retain the Fire, till they have an opportunity of diſcharging it.

Particles of water riſing in vapours, attach themſelves to particles of air. One particle of air may be ſurrounded by twelve particles of water as large as itſelf, all touching it, and by more added to them. Particles of air thus loaded would be drawn nearer together by the mutual attraction of the particles of water, did not the fire, common or electric, included therein, aſſiſt their mutual repulſion. Hence they continue ſuſpended. But if air thus loaded, be compreſſed by adverſe winds, or by being driven againſt mountains, or if it be condenſed by the loſs of its fire, it will continue ſuſpended no longer, but will deſcend in dew. And if the water ſurrounding one particle of air comes into contact with that ſurrounding another, they naturally coaleſce into a drop, and ſo deſcend in rain.

The Sun ſupplies Common Fire to all Vapours riſing either from ſea or land. Vapours having both this and Electric Fire, are better ſupported than thoſe which have this only. For when Vapours riſe into the coldeſt region, the common fire may fail. But the cold will not diminiſh the electric: this is always the ſame. Hence clouds raiſed from freſh waters, from moiſt earth, or growing vegetables, more eaſily deſcend and depoſit their waters, as having but little electric fire, to keep the particles ſeparate from each other. So that the greateſt part of the water raiſed from the land, falls on the land again. But clouds raiſed

raiſed from the ſea, having both fires, and much of the electric, ſupport their water far more ſtrongly, and being aſſiſted by winds, may bring it from the middle of the wideſt ocean to the middle of the broadeſt continent. And yet a way is provided whereby theſe alſo are readily brought to depoſit their water. For whenever they are driven againſt mountains by the winds, thoſe mountains take away their electric fire: and being cold, the common alſo: hence the particles immediately cloſe. If the air was not much loaded, the water falls in a dew on the top and the ſides of the mountain. If it was, the Electric Fire being taken at once from the whole cloud, it flaſhes brightly, and cracks loudly. And the particles inſtantly coaleſcing for want of that fire, fall in an heavy ſhower.

When a ridge of mountains ſtops the clouds, and draws the Electric Fire from the cloud firſt approaching it; the next, when it comes near the firſt, now deprived of its fire, flaſhes into it, and depoſits its own water. The third cloud approaching, and all that ſucceed, act in the ſame manner, as far back as they extend, which may be for ſeveral hundred miles. Hence the continual ſtorms of thunder, lightning, and rain, on the eaſt ſide of thoſe vaſt mountains, the Andes, which, running north and ſouth, intercept all the clouds brought againſt them from the Atlantic Ocean. In a plain country, there are other means to make them drop their water. For if an electrified cloud, coming from the ſea, meets in the air a cloud coming from the land, and therefore not electrified, the firſt will give its flaſh into the latter, and thereby both will be made to depoſit

poſit their water. The concuſſion of the air contributes alſo to ſhake down the water, not only from thoſe two clouds, but from others near them. When the ſea and land clouds would paſs at too great a diſtance from each other, they are mutually attracted, till within the diſtance. For the ſphere of Electrical Attraction is far beyond the flaſhing diſtance. And yet where a cloud contains much fire, it may ſtrike at a conſiderable diſtance. When a conductor has but little fire in it, you muſt approach very near before you can draw a ſpark. Throw into it a greater quantity of fire, and it will give a ſpark at a greater diſtance. But if a gun barrel, when electrified, will ſtrike and make a noiſe at the diſtance of an inch, at what a diſtance, and with how great a noiſe, may ten thouſand acres of electrified cloud ſtrike? No wonder that this ſhould melt metals, (which our artificial flaſh does in ſome degree,) though perhaps not ſo properly by its heat, as by inſinuating into the pores, and creating a violent repulſion between the particles of the metal it paſſes through. This overcomes the attraction whereby they cohere, and ſo melts the metallic body. And this accounts for its melting a ſword in the ſcabbard, or gold in the pocket, without burning either.

But thunder-clouds do not always contain more than their natural quantity of Electric Fire. Very frequently they contain leſs. And when this is the caſe, when they are negatively electrified, although the effects and appearances are nearly the ſame, yet the manner of operation is different. For in this caſe, it is really the fire from the mountains, or other parts of the earth, which ſtrikes into the cloud; and not, as we imagine,

fire

fire from the cloud which ſtrikes into the earth. And we may eaſily conceive, how a cloud may be negatively electrified. When a portion of water is rarefied into a thin vapour, the fire it contains is rarefied too. Conſequently it has then leſs than its natural quantity of fire. Such a cloud therefore coming within a due diſtance of the earth, will receive from it a flaſh of Electric Fire; which flaſh, to ſupply a great extent of cloud, muſt often contain a great quantity of fire. Such a cloud alſo paſſing over woods of tall trees, may ſilently receive ſome ſupply, either from the points of the boughs, or from the ſharpeſt ends and edges of the leaves. The cloud thus ſupplied, flaſhes into other clouds that have not been ſo ſupplied; and thoſe into others, till an equilibrium is produced, among all that are within a ſtriking diſtance of each other. And hence are repeated ſtrokes and flaſhes, till they deſcend in ſhowers to the earth, their original. Rain, eſpecially when in large drops, generally brings down the Electric Fire: falling ſnow, often: ſummer hail, always, though ſilently. Conſequently any of theſe may prevent thunder and lightning; or, at leaſt, abate its violence. Rain is helpful in another reſpect likewiſe. By wetting men or beaſts, it ſaves many lives. For if your cloaths are throughly wet, and a flaſh of lightning ſtrikes the top of your head, it will run in the water over the ſurface of your body into the ground: whereas if your cloaths were not wet, it would go through your body. Hence a wet chicken cannot be killed by a ſtroke from the phial; whereas a dry one is killed in an inſtant. See here alſo the wiſdom and goodneſs of Him, *who ſendeth forth lightning with the rain!* It ſhould

likewiſe

likewiſe be obſerved, that wherever electrified clouds paſs, ſpires, towers, chimneys, and high trees, as ſo many points, draw the Electric Fire, and the whole cloud frequently diſcharges there. Therefore it is highly dangerous in ſuch a ſtorm, to take ſhelter under a tree.

Common Fire is more or leſs in all bodies, as well as Electrical. If there be a ſufficient quantity of either in any body, it is inflamed. But when the quantity of Common Fire therein is ſmall, there needs more Electric Fire to inflame it. Where the quantity of Common Fire is greater, leſs of the Electric will ſuffice. So if ſpirits are heated, a ſmall ſpark inflames them. If they are not, the ſpark muſt be greater. Sulphureous vapours, whether riſing from the earth, or from ſtacks of moiſt hay or corn, or any other heated and reeking vegetable, contain abundance of Common Fire. A ſmall addition of Electric then will inflame them. Therefore they are eaſily kindled by lightning.

Any who would be clearly convinced of the nature of Lightning, may make the following experiment. Make a ſmall croſs of two thin ſtrips of wood, the arms being juſt ſo long as to reach the four corners of a large, thin ſilk handkerchief when extended. Tie the corners of this to the extremities of the croſs; and ſo you have the body of a kite: add to this a proper tail, loop, and ſtring, and it will riſe in the air like one made with paper: but this is fitter to bear the wind and wet in a ſtorm without tearing. To the top of the croſs fix a ſharp-pointed wire, riſing a foot above it. Tie a ſilk ribbon to the end of the

the twine next the hand; and where the ſilk and twine join, faſten a key. Raiſe this kite when a Thunder-ſtorm is coming on. But he that holds the ſtring, muſt ſtand in a porch, or under ſome other covering, that the ribbon may not be wet. He muſt likewiſe take particular care, that the twine do not touch the top or ſide of the porch. As ſoon as the Thunder-cloud comes over the kite, the pointed wire draws the Electric Fire from it. The kite and all the twine are then electrified, as plainly appears by this, that the looſe filaments of the twine ſtand out every way, and are attracted by an approaching finger. And when the kite and twine being wet, conduct the Fire freely, it will ſtream from the key, on the approach of the knuckle. By this key the phial may be charged, and all other experiments made, as by the globe. And this is a demonſtration, that the Electric Fire thereby obtained, is the very ſame with that of Lightning.

Another proof of this we have, in the remarkable caſe of the Rev. Mr. Winder, Rector of Halſted, in Eſſex; who at the age of fifty-four was a ſtranger to diſeaſe; nay, almoſt unacquainted with pain of any kind. But on June 3, 1761, he began to falter in his ſpeech. He did not regard it, till on July 1, he ſuddenly fell from his chair, by a ſtroke of the palſy. When a little recovered, he was almoſt wholly deprived of ſpeech, and in great meaſure of his ſenſes. But by proper medicines he was in a few weeks ſo far reſtored, as to walk a little by the help of a cane. In other reſpects he was as before, till in June 1762 he was removed to Tunbridge. After drinking the waters ſix weeks, he was much relieved: but

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an univerſal weakneſs ſtill remained. He had alſo violent palpitations of the heart, tremblings of the limbs, ſubſultuſteordinum; with frequent vertigos. Worſe than all was, a conſtant pain fixed deep in his breaſt, with an extreme dejection of ſpirit. Thus he continued till the 24th of Auguſt: when about ten at night, while he was aſleep in bed, it began to thunder and lighten violently. The noiſe ſuddenly awakened him. At the inſtant he felt a quick, ſtrong ſhock, affecting him all over, juſt like an electric ſhock. At the ſame time the chamber was filled with lightning, which left behind it a ſtrong phoſphorous ſmell. Immediately he felt as if ſome obſtruction in his cheſt was ſuddenly removed; and his breaſt recovered its full liberty and expanſion, the oppreſſion being entirely gone. When he aroſe in the morning, he was in perfect health: his head was quite ſerene; his breaſt eaſy, and he could move all his limbs with as much ſteadineſs and agility as ever. Every paralytic ſymptom was gone. He could have walked ten or twelve miles with eaſe. And from that very hour he has continued in a ſtate of perfect health.

What a clear proof this, that the Fire of Lightning has the ſame nature and force with the Electric?

The Gymnotus, of South-America, appears to poſſeſs Electrical Powers greatly ſuperior to thoſe of the European Torpedo. Some of them have been ſeen in the Surinam river upwards of twenty feet long, whoſe ſtroke was inſtantly fatal. That on which the following experiment was made, was three feet ſeven inches long, and was brought from Guiana to Philadelphia.

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On putting a ſmall fiſh into the veſſel in which it ſwam, it was ſuddenly ſtunned and killed by it. The effect was evidently produced by a concuſſion, which was felt by one whoſe fingers were dipped in the water, at the very moment the fiſh was ſhocked by it. Eight or ten perſons, forming a circle, were all ſhocked by it, when the firſt in the ſeries touched the eel, and the laſt put his hand into the water. The commotion given by it, was conveyed through the ſame metallic or other conductors, as convey the Electric Fluid; and was intercepted by the common non-conductors of that fluid. Whatever therefore be thought of the Torpedo, it is plain this Eel is an Electric Machine, and has the power of ſuſpending or giving the Electric Shock, juſt at its own pleaſure.

Electricity has ſomething in it common, both with Light and with Magnetiſm. In common with Magnetiſm it counteracts, and in light ſubſtances overcomes the force of gravity. Like that, it exerts its force *in vacuo*, as powerfully as in the open air. And this force extends to a conſiderable diſtance, through various ſubſtances of different textures and denſities.

In common with Light, Electricity pervades glaſs; but it ſuffers no refraction. Its direction is ſtill in right lines, and that through glaſſes of different forms, included one within the other, and large ſpaces left between them.

Indeed the electric attraction through glaſs, is much more powerful, when the glaſs is made warm: becauſe warm glaſs does not condenſe the water from the air, which makes the glaſs a conductor of Electricity: and alſo becauſe as heat enlarges the

the dimensions of all known bodies, and consequently makes their constituent parts recede from each other, the electric effluvia finds a more easy passage through the pores.

And Electricity in common with Light, when its forces are collected, produces fire and flame.

That the electric matter is far more subtle than air, appears, from its passing through those bodies which air cannot penetrate; glass in particular. And that it is elastic, appears from its increasing the motion of fluids, and from its extending itself to a considerable distance round excited bodies.

Do not all these experiments shew, that the electric matter is pure elementary fire, an original distinct principle, formed by the Creator himself? And not as some have apprehended, mechanically producible from other bodies?

And may it not be doubted whether this be not the only *elastic* body in the universe? Whether it be not the original spring, which communicates Elasticity to all other elastic bodies? To the air in particular: which is elastic no longer, when detached from electric fire, but commences *fixed* and unelastic; and seems to recover its Elasticity, only by recovering that ethereal fire which had been violently separated from it?

Scarce any phænomenon in nature has been esteemed more difficult to be accounted for, than those luminous appearances in the sky, termed Aurora Borealis, or Northern Lights. But these also may be rationally explained upon the principles of Electricity. We often see clouds at different heights, passing different ways, north and south at the same time. This manifestly proves different currents of air, one of them under the other.

Now

Now as the air between the tropics is rarefied by the ſun, it riſes: the denſer air is preſſed into its place. The air ſo raiſed moves north and ſouth, and if it has no opportunity before, muſt deſcend in the polar regions. When this air with its vapours deſcends into contact with the vapours ariſing there, the electric fire which it brought begins to be communicated, and is ſeen in clear nights; being firſt viſible where it is firſt in motion, namely in the moſt northern parts. But from thence the ſtreams of light ſeem to ſhoot ſoutherly, even to the zenith of northern countries.

To the ſame principle we may refer what ſome term St. Helmo's Fire, and the antient's Caſtor and Pollux, a thin, ſhining light, which is ſometimes ſeen dancing on the decks or rigging of ſhips. A very remarkable account of this, is given by a late author. "In the night it became exceeding dark, and thundered and lightened dreadfully. We ſaw mean time on different parts of the ſhip, above thirty St. Helmo's Fires. One which was on the top of the vane of the main-maſt, was more than a foot and a half in length. I ordered one of the ſailors to take down the vane: the noiſe of the fire reſembled that of fired wet gunpowder. Scarce had he lowered the vane, but the fire left it, and fixed on the top of the main-maſt. After remaining there a conſiderable time, it went out by little and little.

"How immenſe a quantity of electric matter muſt have been at that time in the atmoſphere ſurrounding the ſhip, to furniſh more than thirty St. Helmo's Fires, (the ſame we ſee at the end of our conductors in electrifying) one of which was above a foot and a half long? The maſts, yards, and

and every part of the ſhip were then real conductors of the electric fire between the atmoſphere and the ſea, and by that means preſerved the ſhip."

A perſon electrified acquires a flammific power, ſtrong enough to light with one of his fingers, or with his cane, warm brandy. When the finger draws near, a crackling ſpark iſſues out, and ſets it on fire.

The electric ſparks of iron are of a ſilver white, thoſe of braſs, green, and thoſe drawn from an egg, yellowiſh. This ſeems to prove, that the electric matter iſſuing from a body, is ſaturated with ſome parts peculiar to it.

Electricity quickens almoſt all ſorts of motion, that of water in particular, which then glitters in the dark, the fire appearing intermingled with the water. It accelerates the motion of the human blood, quickening the pulſe of fifteen or ſixteen ſtrokes in a minute. The blood that flows from the vein of one electrified, gliſters, ſeparates into ſmall drops, and ſpouts out conſiderably farther than otherwiſe it would do.

It exceedingly haſtens the vegetation of plants. Myrtle trees, which were electrified, budded much ſooner than others of the ſame kind and bigneſs, in the ſame green-houſe. And ſeeds electrified daily have ſhot up and grown more in three or four days, than others of the ſame kind, and alike in all other circumſtances, have done in eleven or twelve.

It cures abundance of diſeaſes, even the moſt ſtubborn; particularly thoſe of the nervous kind; many of them in a moment, by a ſingle touch; moſt

moſt, in a few days. So that this is not only one of the greateſt curioſities in the world, but one of the nobleſt medicines that God ever gave to man.

Another phænomenon, which could never before be accounted for, is undoubtedly owing to this cauſe, the Sparkling obſerved on new Flannel, when it is rubbed in the dark. Very probably the acid ſteams of ſulphur, which is burnt under the flannel when it is bleached, unite with the oil wherewith hair always abounds, and ſo form an animal ſulphur, which upon any ſtrong agitation of theſe hairs, will become luminous. This Sparkling is moſt obſervable in froſty weather, as Electricity is always ſtrongeſt at that time. Flannel loſes this property when it is waſhed, the lixivial ſalts of the ſoap, deſtroying the ſulphureous acid, and likewiſe diſcharging its native acid. The wearing flannel, even without its being waſhed, will have the ſame effect: as the effluvia which go off in preſpiration, diſſolve the ſulphur, and weaken the ſpring of the air.

A gentleman has lately made ſome curious experiments on the Electricity of hair. A lady had told him, that on combing her hair in froſty weather, in the dark, ſhe had ſometimes obſerved ſparks of fire to iſſue from it. This made him think of attempting to collect the electrical fire from hair alone, without the aſſiſtance of any other electrical apparatus. To this end he deſired a young lady to ſtand on a caſe of bees-wax, and to comb her ſiſter's hair, who was ſitting on a chair before her. Soon after ſhe began to comb, the young lady on the wax was greatly aſtoniſhed to find her whole body electrified, darting out ſparks of fire againſt every object that approached her. The hair was extremely electrified and affected an electremeter at a very great diſtance. He charged a metal conductor from it with great eaſe; and in the ſpace of a few minutes collected as much fire from her hair as to kindle common ſpirits; and by means of a ſmall phial, gave many ſmart ſhocks to all the company.

Electricity will probably ſoon be conſidered as the great vivifying principle of nature, by which ſhe carries on moſt of her operations. It is a fifth element, diſtinct from, and of a ſuperior nature to the other four, which only compoſe the corporeal parts of matter: but this ſubtle and active fluid is a kind of ſoul that pervades and quickens every particle of it. When an equal quantity of this is diffuſed through the air, and over the face of the earth, every thing continues calm and quiet; but if by any accident one part of matter has acquired a greater quantity than another, the moſt dreadful conſequences often enſue before the equilibrium can be reſtored. Nature ſeems to fall into convulſions, and many of her works are deſtroyed: all the great phænomena are produced; thundering, lightening, earthquake, and whirlwinds; for there is now little doubt, that all theſe frequently depend on this ſole cauſe. And again, if we look down from the ſublime of nature to its minutiæ, we ſhall ſtill find the ſame power acting, though perhaps in leſs legible characters; for as the knowledge of its operations, is ſtill in its infancy, they are generally miſunderſtood, or aſcribed to ſome other cauſe. But doubtleſs in proceſs of time theſe will be properly inveſtigated;

investigated; when men will wonder, how much they have been in the dark. It will then possibly be found, that what we call sensibility of nerves, and many of those diseases known only by name, are owing to the body's being possessed of too large or too small a quantity of this subtle and active fluid; that very fluid perhaps, that is the vehicle of all our feelings; and which has been so long searched for in vain in the nerves.

We all know that in damp and hazy weather, when it seems to be blunted, and absorbed by the humidity; when its activity is lost, and little or none of it can be collected, our spirits are more languid, and our sensibility less acute. And in the sierce wind at Naples, when the air seems totally deprived of it, the whole system is unstrung, and the nerves seems to lose both their tension and elasticity, till the north or west wind awakens the activity of this animating power; that soon restores the tone, and enlivens all nature, which seemed to droop and languish during its absence.

It is likewise well known, that there have been instances of the human body becoming electric without the mediation of any electric substance, and even emitting sparks of fire with a disagreeable sensation, and an extreme degree of nervous sensibility.

About eight or nine years ago, a lady of Switzerland was affected in this manner. She was uncommonly sensible of every change of weather, and had her electrical feeling strongest in a clear day, or during the passage of thunder clouds, when the air is known to be replete with that fluid. Her case was decided to be a nervous one.

Two gentlemen of Geneva had a ſhort experience of the ſame complaint, though in a much ſuperior degree. Profeſſor Sauſſure and young Mr. Jalabert, when travelling over one of the high Alps, were caught amongſt thunder clouds: and to their utter aſtoniſhment, found their bodies ſo full of electrical fire, that ſpontaneous flaſhes darted from their fingers with a crackling noiſe, and the ſame kind of ſenſation as when ſtrongly electrified by art.

It ſeems pretty evident, that theſe feelings were owing to the bodies being poſſeſſed of two great a ſhare of electric fire. This is an uncommon caſe; but it is not at all improbable, that many of our invalids, particularly the hypochondraiac, owe their diſagreeable feelings to the oppoſite cauſe, or the bodies being poſſeſſed of too ſmall a quantity of this fire; for we find that a diminution of it in the air ſeldom fails to increaſe their uneaſy ſenſations, and *vice verſa*.

Perhaps it might be of ſervice to theſe people to wear ſome electric ſubſtance next their ſkin, to defend the nerves and fibres from the damp, or new electric air. I would propoſe a waiſtcoat of the fineſt flannel, which ſhould be kept perfectly clean and dry; for the effluvia of the body in caſe of any violent perſpiration, will ſoon deſtroy its electric quality: this ſhould be covered by another of the ſame ſize of ſilk. The animal heat, and the friction that exerciſe muſt occaſion betwixt theſe two ſubſtances, produce a powerful electricity; and would form a kind of electric atmoſphere around the body, that might poſſibly be one of the beſt preſervatives, againſt the effect of damps.

As

As for our Swifs lady I have little doubt that her complaints were owing in great part to her drefs: and that a very fmall alteration almoft in any part of it, would effectually have cured her.

A lady who has her head furrounded with wires, and her hair ftuck full of metal pins, and who at the fame time ftands upon dry filk, is to all intents and purpofes an electrical conductor, infulated, and prepared for collecting the fire from the atmofphere; and it is not at all furprizing that duriug thunder ftorms, or when the air is extremely replete with electrical matter, fhe fhould emit fparks, and exhibit other appearances of electricity. I imagine a very trifling change of drefs, which from the conftant verfatility of their modes, may fome day take place, would render this lady's difeafe altogether epidemical among the fex. Only let the foles of their fhoes be made of an electric fubftance, and let the wires of their caps and pins of their hair, be fomewhat lengthened and pointed outwards; and I think there is little doubt, that they will often find themfelves in an electrified ftate: but indeed, if they only wear filk, or even worfted ftockings, it may fometimes prove fufficient; for electrometers have been often infolated as perfectly by placing them on a piece of dry filk or flannel, as on glafs.

How little do our ladies imagine, when they furround their heads with wire, the moft powerful of all conductors; and at the fame time, wear ftockings, fhoes, and gowns of filk, one of the moft powerful repellants, that they prepare their bodies in the fame manner, and according to the fame principles as electricians prepare their conductors for attracting the fire of lightning! If they cannot be brought to relinquifh their wire caps, and their pins, might they not fall upon ſome ſuch preſervatives as thoſe which of late years have been applied to objects of leſs conſideration or conſequence?

11. Next in ſubtilty to this ethereal fluid the Ether of Plants appears to be. It ſeems to be deſtitute of all groſs air. For exhauſt this ever ſo accurately, it remains unmoved, and does not emit any air-bubbles, which immediately ariſe in other liquors. A little of it poured on the hand, gives a ſenſe of cold, equal to that cauſed by the contact of ſnow. Blow upon it once or twice, and your hand is dry. It cauſes an hiſſing when poured upon warm water, as if a piece of hot iron were thrown into it. Put a lump of ſugar which has imbibed a little of it, into a veſſel full of hot water, the ſugar ſinks; but the Ether ruſhing forth, excites a ſtrong ebullition. If a ſpoonful of it be poured into a copper-pot full of boiling water; hold a candle near, and inſtantly there iſſues a great flaſh of lightning. Hence it appears, that this Ether, is both a very fluid water, and a moſt ſubtle fire; ſo that if kindled in a thouſand times the quantity of cold water, it burns inextinguiſhably.

It does not manifeſt the leaſt oilineſs to the touch; yet is it the true, natural diſſolvent of all fat oils and gums whatever.

It has a wonderful harmony with gold, even greater than that which is between gold and Aqua Regia. Diſſolve a piece of gold in Aqua Regia: on the ſolution cold pour half an ounce of Ether. Shake the glaſs, and all the gold will paſs into this, and the Aqua Regia robbed of all its gold, will depoſit a white powder, which ſoon turning green,

green, is the copper wherewith the gold was adulterated. Ether then is the moſt noble and efficacious inſtrument in chymiſtry, and pharmacy, inaſmuch as eſſences and eſſential oils are extracted by it immediately, without the mediation of fire, from woods, barks, roots, herbs, flowers, ſeeds, and the various parts of animals.

For inſtance, take mint, ſage, cinnamon, or all together, cut and bottle them; pour on them a ſpoonful or two of Ether, and after it has ſtood an hour in a cool place, fill up the bottle with cold water, and preſently you will ſee the eſſential oil ſwimming upon the water. In like manner, though not ſo immediately, it extracts the pureſt gold from any of the baſer minerals. And the gold thus extracted, is better and ſooner purified by this one operation, than by fuſion with antimony. It is the lighteſt of all liquors. Seven ounces of this fill a phial, which contains twenty even of oil of vitriol. And it is the pureſt flame, leaving neither ſoot nor aſhes after its deflagration.

12. Wind is a current of air. Wherever the air is rarefied or condenſed beyond its natural degree, a wind muſt neceſſarily enſue, till the equilibrium be reſtored: the condenſed air immediately expanding itſelf toward that which was rarefied. The cauſes of this condenſation or rarefaction, are heat, cold, and a thouſand things beſide.

The Heat in the Weſt India iſlands would be intolerable, if the winds riſing as the ſun gathers ſtrength, did not blow from the ſea, ſo as to temper the heat even of the noon-day ſun. On the other hand, as the night advances, a breeze arifes from the land, and blows as from its center towards the fea, to all points of the compafs at once.

At Aleppo the coldeft winds in the winter are thofe which blow from N. W. to E. the nearer the eaft the colder. But from May 1, to the end of September, the winds blowing from the fame points, bring with them a heat which one would imagine came out of an oven, and which, when it blows hard will affect metals within the houfes, as if they had been expofed to the rays of the fun. Yet it is remarkable, that water kept in jars is much cooler at this time, than when a cool wefterly wind blows.

But what degree of heat can an human body bear? A gentleman, defirous to afcertain this, heated feveral rooms by means of flues, from 100 degrees of Fahreneit's Thermometer to 210. He found he could bear the heat of 210 without fuffering much, and could breathe freely, when his pulfe beat 165 beats in a minute. Even then placing the ball of the thermometer under his tongue, the glafs funk to 100, and the flefh of his body felt as cold as a corpfe. Yet his watch chain was fo hot, he could fcarce touch it.

Hence he inferred that a human body has, to a certain degree a power of *deftroying heat*, as well as a power of *generating heat*, as circumftances may require. This refults from the principle of life itfelf, and accordingly is not found in any inanimate body.

A wind of a very peculiar kind, paffed over the city of Rome, on the night of the 11th of June, 1749. There firft appeared a very black long and lofty cloud, which emitted flames on all fides. It moved

moved along with a ſurprizing ſwiftneſs, within three or four feet of the ground. It firſt gathered in the neighbouring ſea, came from Oſtia to Rome, entered the city between the gates of St. Paul and St. Sebeſtian, and croſſing in a ſtrait line, went out at the north angle of a large ſquare, between the Porta Pia and that of St. Lawrence. It ſtripped off the roofs of houſes, blew down the chimneys, broke doors and windows, forced up the floors, and unpaved the rooms. It tore up the vines, and overthrew the trees in its way, and where its action was moſt violent, the very rafters of the houſes were broke, yea, and hurled againſt houſes at a conſiderable diſtance. The loftieſt buildings felt its fury the moſt: thoſe of one ſtory were little damaged. It was traced to ſome diſtance without the city, then it died away.

The motions of all theſe hurricanes is circular, and they carry up into the air, tiles, ſtones, and whatever comes in their way, and throw them violently to a conſiderable diſtance. To this may be owing ſome of thoſe ſurprizing ſhowers which are recorded in hiſtory. A whirlwind, for inſtance, paſſes over a place where wool is ſpread to dry. It takes it up, and ſcatters it in ſmall locks, at a conſiderable diſtance. Here is the appearance of a ſhower of wool. If it ſweeps along a mineral rivulet, of which there are many among the mountains of Italy, it carries innumerable metallic particles away, and ſprinkles them on ſome diſtant town or fields. Here is what they call a ſhower of iron.

Hurricanes are foreſeen at the Antibes by a calm, and then a ſhifting of breezes from all quarters; the ſun-ſets blood red, ſmall clouds fly to and fro with great rapidity. Sea-birds quit the air and ſeek the ſhore. Soon after a north breeze ſprings up, which comes to the north-eaſt. Afterwards it is ſouth and ſouth-eaſt, and the air is darkened by a black cloud.

In the laſt hurricane, the wind ſtood at north-eaſt, and blew with ſuch violence, that the largeſt trees were torn up by the roots, their trunks broken to pieces, and not a leaf left on thoſe other trees, which yielded to the fury of the winds. The houſes were thrown down, and the tops of the ſugar-mills, which could not well be thrown down, were cruſhed in pieces. At the end of an hurricane we ſee lightning, and hear the noiſe of thunder. Then the wind ſoftens gradually, till all becomes quiet.

When there was a violent hurricane at Guadeloupe, there appeared upon the iſland, a thick black cloud, which ſeemed on fire, and gravitating toward the earth. It occupied a ſpace of five or ſix leagues in front. Above it the air was almoſt clear, there appearing only a kind of miſt. The whole force of an hurricane is lodged in the very body of a cloud, containing wind, rain, lightning, and thunder: where the air is compreſſed, and rolling upon itſelf, cauſes the ſtorms, which nothing can reſiſt. Nor does the hurricane end, till the cloud burſts, and the thunder and lightening come on.

One ſpecies of Hurricanes is that which is termed a Water-Spout. Theſe are ſeen to deſcend from a cloud as a pillar, having two motions, one round their own axis, the other pro-

greſſive

greſſive in a ſtrait direction. Such a ſpout is a gyration of clouds, by contrary winds meeting in the centre, and there (where the condenſation and gravitation are greateſt) ſinking down into a great tube, like a ſcrew. In its working and whirling, it ſucks and raiſes the water, in the ſame manner as the ſpiral ſcrew does. One of theſe ſometimes appears on the land. On June 21, ſome years ſince, the clouds near Hatfield in Yorkſhire were obſerved to be much agitated and driven together. They ſoon became very black, and were hurried round: hence proceeded a whirling noiſe like that of a mill. Soon after there iſſued a long tube from the centre of the congregated clouds, having a ſcrew-like motion, by which means the water wherever it came was raiſed up. In Auguſt following, the wind blowing at the ſame time out of ſeveral quarters, created a great whirling among the clouds, the centre of which every now and then ſunk down, like a long, black pipe, wherein was diſtinctly ſeen a motion like that of a ſcrew, continually drawing and ſcrewing up, as it were, whatever it touched. Groves and trees bent under it circularly, like wands. Some of the branches it tore off. It is commonly ſuppoſed, that the water at ſea riſes in a column, before the tube touches it. But this is a miſtake. The tube often touches the ſurface of the ſea, before the water riſes at all.

But Water-Spouts happen ſeveral ways. Sometimes the water is ſeen to boil, and raiſe itſelf for a conſiderable ſpace about a foot from the ſea, before the tube touches it. Above this there appears as it were a thick and black ſmoke, in the midſt of which is a ſort of pipe, reſembling a tunnel, reaching up to the clouds. At other times theſe tunnels come from the clouds, and ſuck up the water with great violence. Sometimes theſe diſcharge themſelves into the ſea, to the unavoidable deſtruction of ſuch ſhips as are in their way: ſometimes on the ſhore, beating down all they meet with, and raiſing the ſand and ſtones to a prodigious height.

A very diſtinct account of this kind was given ſome time ſince by an eye witneſs.

"We were on the coaſt of Barbary, when three Water-Spouts came down: one of them bigger than three maſts, the other two ſcarce half as big: all of them were black, as the cloud from which they fell; all ſmooth, and ſmaller at the lower end. Sometimes one became ſmaller, and then larger again; ſometimes it diſappeared, and quickly fell down again.

"There was always a great boiling and flying up of the water, like the appearance of a ſmoaking chimney in a calm day. Sometimes it ſtood as a pillar ſome yards above the ſea, and then ſpread itſelf and ſcattered like ſmoak. One ſpout came down to the very middle of this pillar, and joined with it. Afterwards it pointed to the pillar at ſome diſtance, firſt in a perpendicular, and then in an oblique line.

"It was hard to ſay, whether this Spout fell firſt from the cloud, or the pillar roſe firſt from the ſea, both appearing oppoſite to each other, as in the twinkling of an eye. But in another place the water roſe up to a great height, without any Spout pointing to it. Only here, the water did not riſe like a pillar, but flew ſcatteringly, and advanced as a moving buſh upon the ſurface of the ſea. This proves, that the riſing

of

of the water may begin, before the Spout from the cloud appears.

"All these Spouts, but especially the great one toward the end, began to appear like a hollow canal, along the middle of which one might distinctly perceive the sea water fly up very swiftly: soon after the spout broke in the middle, and disappeared by little and little; the boiling up, yea, the pillar of sea-water continuing a considerable time after."

There is something very uncommon in the Fetter, a lake which parts East and West Gothland. It is about eighty miles long and eighteen broad. Its water is very clear, and in some places so deep, as not to be sounded by a line of 300 fathom. It is often disturbed by storms, which sometimes begin so suddenly, that the surface of the water is agitated, before the least breath of wind is perceived, And it is not uncommon for boats in one part of the lake to be tossed by a violent storm, while others at a small distance, are in a perfect calm. Immediately before a storm, while the sky is clear, a noise is perceived in the Lake like thunder. Of this the inhabitants of Visingore, an island in the middle of the Lake, are more sensible than any others. For from that part of the island, whence the wind will blow, they hear a noise like the firing of cannon. Whenever this is heard in the east, they expect hail and rain to follow. Undoubtedly all these storms are owing to subterraneous winds. To these likewise we may attribute the sudden cracking of the ice upon the Lake in the spring. This is one minute strong enough to bear horses and sledges, and the next broken in pieces. A strange noise underneath, which

which precedes the breach, warns travellers to make the beſt of their way. But thoſe who happen to be at a great diſtance from land are ſwallowed up, unleſs they can float upon ſhoals of ice, till they meet with relief. The violent *under-currents* obſerved in this lake, are alſo very ſurprizing. Theſe directly oppoſing the winds, give the fiſhermen a great deal of trouble. From theſe, as well as from its unfathomable depths, it is ſuppoſed to have a communication under ground with another lake, called Venner, about forty miles to the weſtward.

13. It remains only to add a few **Reflections**, on ſome of the preceding heads.

How uſeful is the atmoſpere to the life, the health, the comfort, and the buſineſs of the whole globe? It is the air, † by which all animals live: not

† As the air is of abſolute neceſſity to animal life, ſo it is neceſſary it ſhould be of a due conſiſtence, not foul, for that ſuffocates; not too thin; for that ſuffices not.

In the diving-bell, after ſome time of ſtay under water, they are forced to come up and take in freſh air. But Cornelius Drebell contrived not only a veſſel to be rowed under water, but alſo a liquor to be carried therein, that would ſupply the want of freſh air. The veſſel was made for King James the Firſt. It carried twelve rowers beſides the paſſengers. It was tried in the Thames. A perſon who was therein told it one who related it to Mr. Boyle. As to the liquor, Mr. Boyle diſcovered by a phyſician, who married Drebell's daughter, that from time to time, when the air in the ſubmarine boat was ſo clogged by the breath of the company, as to be unfit for reſpiration, by unſtopping a veſſel full of this, he ſpeedily reſtored it, ſo that they breathed again without difficulty.

not only the inhabitants of the earth, but the of waters too. Without it most animals live scarce half a minute, and none of them, many days.

And not only animals, but even trees and plants owe their life and vegetation to this useful element: as is manifest from their glory and verdure in a free air, and their paleness and sickliness, when excluded from it.

Thus necessary is the air to the life of animals. And it is no less so, to the conveyance of many of them. All the winged tribes owe their flight and buoyancy to it. And even the inhabitants of the waters, cannot easily ascend or descend in their own element without it.

It would be endless to specify the uses of the air in the operations of nature. To touch only on one or two instances. How admirable is that property of it, the conserving animated bodies, whether animal or vegetable, while it dissolves all other bodies; by which means many things which would prove nuisances to the world, are put out of the way, and reduced to their first principles. Even chrystal-glasses, especially if not used, it will in time reduce to powder. And thus divers minerals, stones, fossil-shells, trees, which have lain under ground for many ages, and so

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And as too gross, so too thin an air, is unfit for respiration. Hence the difficulty of breathing, (as all travellers relate) upon the top of high mountains. But the cause of this difficulty is not the thinness only, but the too great lightness thereof, which renders it unable to be a counterbalance to the heart, and all the muscles ministring to respiration.

ſo ſecure from corruption, when in the open air, have quickly mouldered away.

Another admirable uſe of our atmoſphere is, its miniſtring to the enlightning the earth, by reflecting to us the light of the ſun, § and refracting his beams to our eye, before he ſurmounts our horizon, by which means the day is protracted throughout the whole globe, and the long and diſmal nights are ſhortened in the frigid zones. Yea, the ſun riſes in appearance, when he is indeed many degrees below the horizon.

Let us a little more attentively conſider the light which whitens the ſky before the ſun riſes. There is ſomething ſurpriſing in this. We ſee the light only by the rays which flow to our eyes. Now the Sun being as yet beneath the earth, cannot project any of his rays directly to us. And the rays which dart on the extremities of the land that terminates our ſight, proceed farther into the heavens, unleſs they meet with any body, which reflects them back to us. Is there any particular body in nature deſigned to do us this ſervice? There is, namely the atmoſphere, which is framed over our heads in ſuch a manner, that notwithſtanding its extenſive maſs, it ſuffers us to ſee the ſtars, at an immenſe diſtance from us; and notwithſtanding its tranſparency, bends and gathers

§ To this is owing that whiteneſs which is in the air in the day-time, cauſed by the rays of light, ſtriking on the particles of the atmoſphere, as well as upon the clouds above, and the other objects beneath on the earth. To the ſame cauſe we owe the twilight, namely to the ſun-beams touching the uppermoſt parts of the atmoſphere, which they do, when the ſun is eighteen degrees below the horizon.

thers for us numberlefs rays, of which we fhould otherwife be quite deprived.

Any ray that falls perpendicularly on the atmofphere, enters it without any obftacle, and defcends through it to the earth in the fame right line. But thofe which fall obliquely upon it, are admitted into, or repelled from it, according to the fituation of the luminous body. If this be more than eighteen degrees below the horizon, all its rays are fcattered abroad. If lefs, the rays enter the atmofphere, and are refracted to our fight. This is the true caufe of the twilight, and indeed of the continuance and principal beauty of the day, even when the fun is in its higheft elevation. The earth which receives his rays, reflects them into the atmofphere, which once more returns the greater part of them. Thus it preferves to us that fplendor which is the beauty of nature, and that heat which is the foul of it. For it collects numberlefs rays, the greater or fmaller union whereof, is the meafure of heat and cold. Thus it becomes to us a mantle of the fineft texture, redoubling the heat, yet not preffing us by its weight.

The Atmofphere at the fame time caufes and maintains round us, that light which lays our whole habitation before our eyes. In order to clear this, fuppofe the atmofphere were deftroyed, 1. The rifing of the fun would not be preceded by any twilight, but the moft intenfe darknefs would furround us, till the moment of his rifing. 2. In that inftant he would break out in his full brightnefs, and fo continue till his fetting: and that moment it would be pitch dark. 3. In the day

day his light would resemble a clear fire, which we see by night in the midst of a spacious field. We should see what was near us, but nothing else: the distant lands would not be perceived, and the night would still continue, notwithstanding the sun. For instead of the white tint of day, which displays all nature by brightening the azure of the heavens, and colouring all the horizon, we should see nothing but an abyss of darkness, there being nothing to reflect the solar rays. The stars indeed would be seen at noon-day: but then those luminous bodies, which now appear to be placed in a delightful azure, would seem fastened on a dismal, mourning carpet.

" But how does that fine azure depend on the atmosphere?" This will plainly appear, if it be considered, what a quantity of rarefied water is suspended from the top of the atmosphere to the bottom. And there is never a greater quantity suspended there, than in the fine days, when no clouds are to be seen. It is these rarefied waters, that intercept and reflect to us, the rays reflected from the earth. And this prodigious mass of waters, being a simple and uniform body, the colour of it is simple, and always the same.

" But are these azure skies, which we confound with the starry heaven, nothing more than a little air and water? And what we took for the heaven, only a cover wrapt close round the earth?" So it is. And this is a new wonder, and a new proof of our Creator's wisdom! A few small bubbles of air and water are indeed in themselves things very insignificant; but that hand which has with so much art and caution placed them

them over our heads, has done it merely, that his ſun and ſtars might not be rendered uſeleſs to us. He embelliſhes whatever he pleaſes; and theſe drops of water and air become in his hands an inexhauſtible ſource of glory. He draws from them thoſe twilights, which ſo uſefully prepare our eyes for the receiving a ſtronger light. He fetches out of them the brightneſs of the dawn. From them he produces the ſplendor of the day. He makes them contribute to the increaſe and preſervation of that heat which nouriſhes every thing breathing. Of them he makes a brilliant arch, which inchants the ſight of man, and becomes the ceiling of his habitation.

I ſhall only add the excellent uſe of the atmoſphere, in reſpect of two of its meteors, the winds, and the clouds and rain.

The winds || are of ſuch abſolute neceſſity to the wholeſomeneſs of the atmoſphere, that all the world would be poiſoned without thoſe agitations. We find how putrid and unfit for reſpiration, a confined, ſtagnating air is. And if the whole maſs of air and vapours were always at reſt, inſtead

|| The moſt univerſal and conſtant alterations of the ballance of the atmoſphere are from heat and cold. This is manifeſt in the general Trade-Winds, blowing all the year between the tropics from eaſt to weſt: the cauſe whereof is undoubtedly by the ſun's daily progreſs round that part of the globe, by his heat rarefying one part of the air, while the cooler and heavier air behind preſſes after.

In Thunder-Storms there are often two currents of air, the under-current contrary to the upper. Hence the wind near the earth blows one way, and the clouds more above the other way.

ſtead of refreſhing, it would ſuffocate all the world. But the motion it receives from the gales and ſtorms, keeps it pure, and healthy ſtill.

Without theſe gales to fan us alſo, in the heat of ſummer, even in our temperate climate, men would hardly be able to go through their daily labour, without endangering their health. † Theſe are perpetual in the torrid zone, and make what the antients imagined, to be not habitable to any but wild beaſts, an healthful and pleaſant habitation.

Of what uſe likewiſe are the winds, to tranſport men to the diſtant regions of the world? Particularly, the general and coaſting trade-winds, the ſea and the land breezes; the one ſerving to carry the mariners in long voyages from eaſt to weſt; the other, to waft him to particular places: the one ſerving to carry him into his harbour, the other to bring him out. Sea-breezes commonly riſe in the morning, about nine o'clock. They firſt approach the ſhore gently, as if they were afraid to come near it. The breeze comes in a fine, ſmall, black curl upon the water, whereas all the ſea between it and the ſhore, is as ſmooth and even as glaſs. In half an hour after it reaches the ſhore, it fans pretty briſkly, and ſo increaſes gradually till twelve o'clock: then it is commonly the ſtrongeſt. It laſts ſo till two or three.

† July 8, 1707, called for ſome time after, The Hot Tueſday, was ſo exceſſively hot and ſuffocating, by reaſon of there being no wind at all, that divers perſons died in their harveſt-work. An healthy, luſty, young man, near Upminſter in particular, was killed on the ſpot by the heat, and ſeveral travellers on the road dropt down and died.

three. At three it begins to die away, till about five it is lulled asleep. As the sea-breezes blow in the day, and rest in the night; the land-breezes blow in the night, and rest in the day. They spring up between six and twelve at night, and last till six, eight, or nine in the morning.

The clouds and rain are no less useful meteors than the winds, as is manifest in the refreshing shade which the clouds afford, and the fertile dews and showers, which they pour down on the trees and plants, which would languish and die with perpetual drought, but are hereby made verdant and flourishing; so that as the Psalmist saith, *The little hills rejoice on every side, and the valleys shout for joy, and sing.*

A farther improvement of these remarks I subjoin in the words of Mr. Hervey.

" If we turn our thoughts to the *atmosphere*, we find a most curious and exquisite apparatus of *air*. This is a source of innumerable advantages; all which are fetched from the very jaws of ruin. To explain this. The *pressure* of the air on a person of a moderate size is equal to the weight of *twenty thousand* pounds. Tremendous consideration! Should an house fall upon us with half that force, it would break every bone of our bodies. Yet so admirably has the Divine Wisdom contrived the air, and so nicely counterpoised its dreadful power, that we suffer no manner of inconvenience; we even *enjoy* the load. Instead of being as a mountain on our loins, it is as wings to our feet, or sinews to our limbs. Is not this *common* ordination of Providence, somewhat like the miracle

miracle of the burning bush? Well may we say unto God, O how terrible, yet how beneficent, art thou in thy works!

"The air, though too weak to support *our* flight is a thoroughfare for innumerable wings. Here the whole commonwealth of birds expatiate, beyond the reach of their adversaries. Were they to run upon the earth, they would be in ten thousand dangers, without strength to resist, or speed to escape them: whereas by mounting the skies, they are secure from peril, they *scorn the horse and his rider*. Some of them perching on the boughs, or soaring aloft, entertain us with their notes. Many of them yield us wholesome and agreeable food, and yet give us no trouble, put us to no expence, but till the time we want them, are wholly out of the way.

"The air is charged also with several offices, absolutely needful for mankind. In our lungs it *ventilates* the blood, qualifies its warmth, promotes the animal secretions. We might live even months, without the light of the sun, yea, or the glimmering of a star. Whereas, if we are deprived but a few minutes of this, we sicken, we faint, we die. The same *universal nurse* has a considerable share in cherishing the several tribes of plants. It transfuses vegetable vigour into the trunk of an oak, and a blooming gaiety into the leaves of a rose.

"The air likewise conveys to our nostrils the extremely subtle Effluvia which exale from odoriferous bodies: particles so small, that they elude the most careful hand. But this receives and

and tranſmits the inviſible vagrants, without loſing even a ſingle atom; entertaining us with the delightful ſenſations that ariſe from the fragance of flowers, and admoniſhing us to withdraw from an unwholeſome ſituation, to beware of pernicious food.

" The air by its undulating motion conducts to our ear all the diverſities of *Sound*. While danger is at a conſiderable diſtance, this advertiſes us of its approach; and with a clamorous but kind importunity, urges us to provide for our ſafety.

" The air wafts to our ſenſe all the modulations of muſic, and the more agreeable entertainments of converſation. It diſtributes every muſical variation with the utmoſt exactneſs, and delivers the meſſage of the Speaker with the moſt punctual fidelity: whereas, without this internuntio, all would be ſullen and unmeaning ſilence. We ſhould neither be charmed by the harmonious, nor improved by the articulate accents.

" How gentle are the breezes of the air when unconfined! but when collected, they act with ſuch immenſe force, as is ſufficient to whirl round the hugheſt wheels, though clogged with the moſt incumbering loads. They make the ponderous millſtones move as ſwiftly as the dancers heel; and the maſſy beams play as nimbly as the muſician's fingers.

" In the higher regions there is an endleſs ſucceſſion of Clouds, fed by evaporations from the ocean. The clouds are themſelves a kind of ocean, ſuſpended in the air. They travel in detached

tached parties, over all the terreſtial globe. They fructify by proper communications of moiſture, the ſpacious paſtures of the wealthy, and gladden with no leſs liberal ſhowers the cottager's little ſpot. Nay, they *ſatisfy the deſolate and waſte ground, and cauſe the bud of the tender herb to ſpring forth:* that the natives of the lonely deſert, the herds which know no maſter's ſtall, may nevertheleſs experience the care of an all-ſupporting parent.

" How wonderful! That *pendant Lakes* ſhould be diffuſed, fluid mountains heaped over our heads, and both ſuſtained in the thinneſt part of the atmoſphere. How ſurpriſing is the expedient which without veſſels of ſtone or braſs, keeps ſuch loads of water in a buoyant ſtate? Job conſidered this with holy admiration. *Doſt thou know the balancings of the clouds?* How ſuch ponderous bodies are made to hang in even poiſe, and hover like the lighteſt down? *He bindeth up the waters in his thick cloud: and the cloud,* though nothing is more looſe and fluid, becomes by his order tenacious, as caſks of iron, *is not rent* under all the weight.

" When the ſluices are opened and the waters deſcend, one would think they ſhould pour down in torrents. Whereas inſtead of this, which would be infinitely pernicious, they coaleſce into globules, and are diſpenſed in gentle *ſhowers.* They ſpread themſelves as if ſtrained through the orifices of the fineſt watering-pot, and form thoſe *ſmall drops of rain* which the clouds *diſtil upon man abundantly.* Thus inſtead of drowning the earth, and ſweeping away its fruits, they cheriſh univerſal nature, an (like their great maſter) diſtribute their ſtores, to

men,

animals, vegetables, *as they are able to bear them.*

" But beſide waters, here are cantoned various parties of winds, mild or fierce, gentle or boiſterous, furniſhed with breezy wings, to *fan* the glowing firmament, or elſe fitted to act as an univerſal *beſom*, and by ſweeping the chambers of the atmoſphere to cleanſe the fine aëreal fluid. Without this wholeſome agency of the winds, the air would ſtagnate and become putrid: ſo that all the great cities in the world, inſtead of being ſeats of elegance, would degenerate into ſinks of corruption.

" At ſea, the winds ſwell the mariner's ſails, and ſpeed his courſe along the watery way. By land they perform the office of an immenſe *ſeeds-man*, ſcattering abroad the ſeeds of numberleſs plants, which, though the ſupport of many animals, are too ſmall for the management, or too mean for the attention of man.

" Here are lightnings ſtationed, in act to ſpring whenever their piercing flaſh is neceſſary, either to deſtroy the *ſulphureous* vapours, or diſlodge any other *noxious* matter, which might prejudice the delicate temperature of the Ether, and obſcure its more than chryſtalline tranſparency.

" Above all is ſituate a radient and majeſtic orb, which enlightens and chears the inhabitants of the earth: while the air, by a ſingular addreſs, amplifies its uſefulneſs. Its *reflecting* power augments that heat, which is the life of nature: its *refracting* powers prolongs that ſplendor, which is the beauty of the creation.

" I ſay, *augments the heat.* For the air is a *cover* which, without oppreſſing us with any perceivable weight, confines, reflects, and thereby increaſes the vivifying heat of the ſun. The air increaſes this, much in the ſame manner as our cloaths give additional heat to our body: whereas when it is leſs in quantity, when it is attenuated, the ſolar heat is very ſenſibly diminiſhed. Travellers on the lofty mountains of America, ſometimes experience this to their coſt. Though the clime at the foot of thoſe vaſt mountains, is extremely hot and ſultry, yet at the top the cold is ſo exceſſive, as often to freeze both the horſe and rider to death. We have therefore great reaſon to praiſe GOD, for placing us in the commodious concavity, the cheriſhing wings of an atmoſphere.

" The emanations of Light, though formed of inactive matter, yet (aſtoniſhing power of divine wiſdom!) are refined almoſt to the ſubtility of ſpirit, and are ſcarce inferior even to thought in *ſpeed*. By which means they ſpread with almoſt inſtantaneous ſwiftneſs, through an whole hemiſphere: and though they fill whatever they pervade, yet they ſtraiten no place, embarraſs no one, incumber nothing.

" Every where indeed, and in every element we may diſcern the footſteps of the Creator's wiſdom. The ſpacious canopy over our heads is painted with blue; and the ample carpet under our feet is tinged with green. Theſe colours, by their ſoft and chearing qualities, yield a perpetual refreſhment to the eye. Whereas had the face of nature gliſtered with white, or glowed with ſcarlet, ſuch dazling hues, inſtead of chearing, would have fatigued the ſight. Beſides, as the ſeveral brighter colours

colours are interſperſed, and form the pictures in this magnificent piece, the green and the blue make an admirable *ground*, which ſhews them all to the utmoſt advantage.

"Had the air been much *groſſer*, it would have dimmed the rays of the ſun and darkened the day. Our lungs would have been clogged in their vital function, and men drowned or ſuffocated therein. Were it much more *ſubtle*, birds would not be able to wing their way through the firmament: neither could the clouds be ſuſtained, in ſo thin an atmoſphere. It would elude likewiſe the organs of reſpiration: we ſhould gaſp for breath with as much difficulty, and as little ſucceſs as fiſhes do, when out of their native element.

"The ground alſo is wrought into the moſt proper temperature. Was it of a firmer conſiſtence it would be impenetrable to the plough, and unmanageable by the ſpade. Was it of a more *looſe* compoſition, it would be incapable of ſupporting its own furniture. The light mould would be ſwept away by whirling winds, or ſoaked into ſloughs by the deſcending rains. Again, becauſe every place ſuits not every plant, but that which nouriſhes one, deſtroys another: the qualities of the earth are ſo abundantly diverſified as to accommodate every ſpecies. We have a variety of intermediate ſoils, from the *looſe* ſand to the *ſtiff* clay: from the rough projection of the craggy rock, to the ſoft bed of the ſmooth paterre.

"The Sea carries equal evidences of a moſt wiſe and gracious ordination. Was it *larger*, we ſhould have wanted land for paſturage and huſbandry. We ſhould not have had room for mines and forefts, our fubterranean warehoufes and aëreal timber-yards. Was it *fmaller*, it could not recruit the fky with a proper quantity of exhalations: nor fupply the earth with the neceffary quota of fructifying fhowers.

" May we not difcover as exquifite ftrokes of wifdom in each individual object? All that fhines in the heavens, and all that fmiles on the earth, fpeak their infinitely wife Creator. Need we launch into the praife of the vallies cloathed with grafs, or of the fields replenifhed with corn? Even the ragged rocks, which frown over the flood, the caverned quarries which yawn amidft the land, together with the fhapelefs and enormous mountains, which feem to load the ground, and encumber the fkies; even thefe contribute to increafe the general pleafure, and augment the general ufefulnefs. They add new charms to the wide level of our plains, and fhelter, like a fcreen the warm lap of our vales.

" Who is not charmed with the delicious fruits of fummer and autumn? But were all our trees and fhrubs to produce fuch fruits, what would become of the birds? How fmall a part would voracious man refign to their enjoyment? To provide therefore for each vagrant of the air, as well as for the fovereign of a nation, there is in all places a large growth of fhrubs, annually covered with coarfe and hardy berries: fo coarfe in their tafte, that they are unworthy of the acceptance of man: fo hardy in their make, that they endure the utmoft feverity of the weather, and furnifh the feathered tribes with a ftanding repaft amidft all the defolations of winter.

" The

" The fir, the beech, the elm, are ſtately decorations of our rural ſeats. But if there were no entangling thickets, no prickly thorns, where would the farmer procure fences? How could he ſecure his vegetable wealth, from the flocks and the herds? Thoſe roving plunderers, which ſubmit to no laws, but thoſe of the coercive kind.

" We ſpare no toil, to have uſeful herbs and plants in our gardens, and upon our tables. But there are innumerable herbs, which paſs under the contemptable character of Weeds, and yet are full as deſireable to other claſſes of creatures, as theſe are to mankind. Yet who will be at the pains to plant, to water, to cultivate, ſuch deſpicable productions? Man would rather *extirpate* than propagate, theſe incumbrances of his land. Therefore Providence vouchſafes to be their gardener, and has wrought off their ſeeds with ſuch a lightneſs, that they are tranſported to and fro, by the mere undulations of the air. Or, if too heavy, to be wafted by the breeze, they are faſtened to wings of down: or elſe incloſed in a ſpringy caſe, which forcibly burſting, ſhoots them out on every ſide. By ſome ſuch means, the re-producing principle of every one is diſſeminated, the univerſal granary filled, and the univerſal board furniſhed. The buzzing inſect and the creeping worm, have each his bill of fare. Each enjoys a never-failing treat, equivalent to our greateſt delicacies.

" If Graſs was ſcarce as the Guernſey-lilly, and as difficultly raiſed as the Tuberoſe, how certainly, and how ſpeedily, muſt many millions of animals periſh by famine? But as all the cattle owe their chief ſubſiſtence to this, by a ſingular wiſdom in the divine œconomy, *it waiteth not*, like the corn field, and the garden-bed, *for* the annual labours of *Man*. When once ſown, though ever ſo frequently cropt, it revives with the returning ſeaſon. With a kind of perennial verdure, it covers our meadows, diffuſes itſelf over the plains, ſprings up in every glade of the foreſt, and ſpreads a ſide-board in the moſt ſequeſtered nook.

" Such is the care of a wiſe and condeſcending Providence, even over theſe loweſt formations of nature!"

PART

PART the FIFTH.

Of the Syſtem of the WORLD; Of the HEAVENLY BODIES; AND OF THE Properties & Cauſes of NATURAL BODIES.

CHAP. I.

Of the Syſtem of the WORLD.

1. *The General Phænomena of the Sun and Moon,*
2. *Of Mercury and Venus.*
3. *Of the other Planets.*
4. *Of the Comets and fixed Stars.*
5. *The Ptolemaic Syſtem.*
6. *The Copernican.*
7. *The Syſtem of Tycho Brahe.*
8. *The Hutchinſonian Syſtem.*
9. *Advantages from the rotation of the Earth.*

1. HAVING conſidered the earth, with the bodies that are therein, let us now look up to thoſe that ſurround it. The world is

 a congeries

a congeries of innumerable bodies, many of which are supposed to equal or exceed the size of the earth: yet by reason of their distance, most of them are invisible to the naked eye.

The nearest to us is the Moon, which moves round the earth in something more than twenty-eight days from west to east. The Sun likewise seems to move from east to west, and shines successively on all parts of the globe. It appears also to us to move every year obliquely from west to east, coming twenty-three degrees and a half to the north, and then going just as far to the south.

2. Some of the Stars keep always the same distance, with respect to each other, and are termed fixed. Others are continually changing their situation, whence they are termed Planets. Two of these, Mercury and Venus, are frequently between the earth and the Sun: of which the former being generally hid by the rays of the sun, is seldom visible: but Venus, commonly called the Evening Star, is very conspicuous. The earth is never between them and the sun. They are sometimes between us and him. Sometimes the sun is interposed between us and them.

3. The upper planets are Mars, Jupiter, and Saturn. The sun is sometimes between these and the earth. But none of them is ever interposed between the earth and the sun. Mars has different appearances, like the moon, as it is differently situated, with regard to the sun: whereas Jupiter and Saturn always appear with the same aspect, and have smaller planets revolving round them.

All

All these revolve round the sun, in their several stated periods.

4. Beside these, there is another kind of stars called Comets, vulgarly Blazing Stars. These do not revolve round the sun, in so regular orbits as the planets. The *fixed Stars* are above these: about 2200 are visible to the naked eye. These have a vivid light, and always appear with the same face towards us: they seem to have a two-fold motion, a slow one from east to west in a year, and a swift one round the earth with all the other stars in four and twenty hours. But there are some of them which never set, namely those near the north or south pole.

5. To explain these phænomena of the heavenly Bodies, various systems have been invented. The Ptolemaic supposes the earth to be fixed in the center of the universe, round which all the heavenly Bodies move, each affixed to a solid sphere which moves with that: first the Moon, then Mercury, thirdly, Venus, next the Sun, fifthly Mars, then Jupiter, seventhly, Saturn. In the eighth place is the Firmament or sphere of Fixed Stars: then the Chrystalline Heaven, and last of all the Primum Mobile, which is supposed to move from east to west in twenty-four hours, whirling all the other spheres with it. But this system being in some respects obviously false, in others utterly improbable, and likewise insufficient to account for many phænomena, is now universally exploded.

6. In the room of this, the Copernican system is now generally received, which supposes the

ſun to be fixed in the center, without any other motion, than that round his own axis. Next him is Mercury, then Venus, thirdly the Earth, (round which the Moon revolves) above the earth. Mars, then Jupiter, and Saturn, with their attendant Moons. This ſyſtem is extremely ſimple and natural, and eaſily accounts for moſt phænomena. As to the objection, that it is contrary to the teſtimony of our ſenſes, it is eaſily anſwered. They who are in a ſhip ſeem to ſee the ſhore and the land moving along, although it is really the ſhip that moves. Yet let it move ever ſo ſwiſtly, it diſplaces nothing, provided it move ſmoothly. So neither does the motion of the earth diſplace any thing on its ſurface, becauſe it is equable and regular.

Not that Copernicus was the inventor of this ſyſtem. It was in great part known long ago. Pythagoras taught, " that the earth was carried about the ſun among the ſtars, and by turning round its axis, cauſed day and night." Yet by degrees it ſunk into oblivion, till it was revived by Cardinal Cuſa. However, the Ptolemaic ſyſtem ſtill prevailed, till Nicholas Copernicus, a canon of Thorn, in Poliſh Pruſſia, born in the year 1473, had reſolution to examine it throughly, and learning enough to explain and defend it. Some of the reaſons on which this ſyſtem is founded are, 1. This is moſt ſimple and agreeable to the whole tenure of nature: for by the two motions of the earth all the phænomena of the heavens are reſolved, which on any of the other hypotheſis are utterly inexplicable. 2. It is more rational to ſuppoſe the earth moves round the ſun, than that the huge bodies of the planets and of the ſun itſelf, and the immenſe firmament of ſtars, ſhould all move round the inconſiderable body of earth every four and twenty

twenty hours. 3. The earth's moving round the ſun is agreeable to that general harmony and univerſal law, which all other moving bodies of the ſyſtem obſerve, namely, that the ſquares of the periodical times are as the cubes of the diſtances. But if the ſun move round the earth, that law is deſtroyed, and the general order and ſymmetry of nature interrupted; becauſe according to that law the ſun would be ſo far from revolving about the earth in 365 days, that it would require no leſs than 5196 years, to finiſh one revolution. 4. The ſun is the fountain of light and heat, which it darts through the whole ſyſtem, and therefore it ought to be placed, as the heart in the center, that ſo all the planets may at all times have them, in an uniform and equal manner. 5. If the ſun be placed in the center of the ſyſtem, we have then the rational hypotheſis of the planets being all moved about the ſun, by the univerſal law of gravity: and every thing will anſwer to that law; but otherwiſe we are wholly in the dark. 6. But we need not rely upon conjectures. We have demonſtrative proofs, that the ſun poſſeſſes the center, and that the planets move round it, in the order above mentioned. For example. Mercury and Venus are ever obſerved to have two conjunctions with the ſun, but no oppoſition, which could not happen unleſs the orbits of thoſe planets lay within the orbit of the earth. And in the ſame manner it may be demonſtrated, that the orbits of Mars, Jupiter, and Saturn, lie without the orbit of the earth.

7. After Copernicus came Tycho Brahe, a noble Dane, who endeavoured to compound a ſyſtem of the Ptolemaic and Copernician put together.

But it was quickly found by all unprejuciced judges, to be so intricate and perplexed, that it had not many assertors even while he lived, and is now well nigh sunk into oblivion.

8. Mr. Hutchinson (not the professor of Glasgow, but a private English Gentleman) supposes the constituent parts of heaven to be, 1. The *darkness*, or dark air, which is no other than the fine ether in a state of stagnation: 2. The *spirit*, or the air in a sensible motion: 3. The *light*, the finest part of the heavens, the pure ether in motion: 4. The *luminaries* and their *fluxes*. Understand by the *luminaries*, the *bodies* of the sun, moon, and stars: by their *fluxes*, the flow of light that comes from each of them. Revelation constantly distinguishes these. Therefore it is very improper for us to confound them together. Indeed every one knows, that though the bodies of the sun, moon, and stars, take up but a small part of the heavens, yet the fluxes of light from them diffuse themselves throughout all nature.

The springing forth of the solar light causes the morning; its going off, the evening. Its being intercepted by the body of the earth causes *night*; its shining causes *day*. It acts in a mechanical way, and is part of the great machine of nature. It is in continual motion to and from the body of the sun: going out from the center to the circumference of the heavens, and returning to the center again. The solar light, along with the spirit, which continually attends it, is the cause of the regular returns of morning and evening, summer and winter. The spirit and light are properly the agent, and the earth only the patient. Its motion round its axis, and round the sun, and its inclining

inclining northward and ſouthward at different times, are all produced by the action of the light going outward, and the ſpirit returning inward. 5. The Denſities, which form the extremity of the whole ſyſtem of nature; the denſe, groſs air, out of which the fine ether is extracted, and into which it returns. The heavens will naturally be groſſer and groſſer, the farther from the ſun, till perhaps at the utmoſt extremity, they are condenſed into an immoveable ſolid.

These are the conſtituent parts of the heavens. And hence we have reaſon to conceive, that all theſe parts, (the ſun, moon and ſtars excepted) are no other than the different ſtates into which the ethereal fluid does or may paſs. For the *darkneſs* is the fine atoms of the heaven in a ſtate of inactivity. The *ſpirit* is the groſſer parts of the heavens or maſſes compreſſed together; while the *light* is the atoms or fineſt part of the ether in ſwift motion. At the center, the commotion is greateſt, and gradually decreaſes towards the circumference, where the ether is very much condenſed, and this is called the *denſity*.

He farther ſuppoſes, that the Sun is the center of the whole univerſe; that the fixed ſtars are all placed in the denſity, not far from each other, and abundantly nearer the earth, than common aſtronomers imagine, and that their uſe is not to perform the office of ſuns to other planets, but to aſſiſt in that cold region, to ſupply in ſome degree, the want of the ſolar fire.

Perhaps it may not be unacceptable to the ſerious reader, to give a more particular account of this ingenious hypotheſis, in the words of a later writer. The ſum of what Mr. Hutchinſon avers,

avers, is, That beside the differently formed particles of which the earth, and the several solid substances in it, and in the other orbs, are composed, God at first created all that subtle fluid which now is, and from the creation has been, in the condition of *fire*, *light* or *air*, and goes under the name of *the heavens*.

The particles of this fluid (which he calls atoms) when they are single and uncompounded, are inconceivably minute, and so subtle as to pervade the pores of all substances whatever, whether solid or fluid. When they are pushed forward in strait lines, by the action of fire, or are reflected or refracted in strait lines, they produce *light*, and are so called. When the interposition of opake *bodies* hinders their progress in strait lines, they pass, but cease to produce light.

These particles, which when moving in strait lines produce light, and when collected and put into another sort of motion, produce fire, when the force impelling them ceases to act with vigour, and when their motion is retarded, cohere in small masses or grains, which Mr. Hutchinson calls *spirit* or *air*, and is of the same kind and texture, with that air, which we daily breathe.

The sun, fixed at the center of this system, is included in a vast collection of this subtle matter, in the form of fire, which continually melts down all the air that is brought into it from all parts of the system, into atoms, and with an immense force sends it forth, in perpetual streams of light, to the circumference. The whole space comprehended within this, is absolutely full.

The matter thus melted down at the orb of the sun, moves outward to the circumference, and being

being forced by the particles which are concreted into air at the utmoſt extremeties, returns toward the ſun, where the fluid, being moſt ſubtle, gives leaſt reſiſtance, and takes up the place that the light left.

And therefore this uninterrupted flux of matter from the ſun in light, in place of being an expence which would neceſſarily deſtroy that orb (an inſupportable objection, Mr. Hutchinſon thinks, to Sir Iſaac Newton's ſcheme,) is the very means of preſerving it, and every thing elſe in this ſyſtem, in its action and vigour, by preſſing back perpetual ſupplies of air, to be melted down into light, which produces a continual circulation. Theſe perpetual tides of matter outwards and inwards, in every point, from the center to the circumference, produce that conſtant gyration in the earth, and the planets round their own center, and round the ſun.

Beſides the rotation of the orbs, the adverſe motion of the light puſhing toward the circumference, and the air puſhing toward the center with immenſe force, brings that compreſſure on all the bodies it meets, that binds together ſolids, keeps fluids as they were, cauſes the riſing of water, the production of vegetables and animals, and in ſhort produces all the effects uſually aſcribed to gravitation or attraction; continues motion without the aſſiſtance of the unmechanical principle of projection, and is indeed the real cauſe of almoſt all the effects and phænomena in nature.

As immenſely different as this is, from all the other ſyſtems of aſtronomy, very probable arguments are alledged in confirmation of it. And more than probability, I doubt, we ſhall never attain,

attain, with regard to things at so great a distance from us.

But what a strange discovery is that, which has been lately communicated by an eminent professor to the Royal Society? " Having carefully examined, the modern observations of the sun, with those of some centuries past, though I have gone no farther back than the fifteenth century, yet I have observed that the motion of the sun, (or of the earth) is sensibly accelerated since that time, so that the years are shorter now than formerly. The reason of this is very natural. For if the earth in its motion suffers some resistance (which cannot be doubted since the space through which the planets pass, is full of some subtle matter, were it no other than light) this resistance will gradually bring the planets nearer and nearer the sun. And as their orbits thereby become less, so their periodical times will be diminished. Thus in time the earth would come within the regions of Venus, then of Mercury, where it would necessarily be burnt. Hence it is manifest, that the planetary system cannot last for ever in its present state; as also that this system must have had a beginning; otherwise there must have been a time when the earth was at the distance of Saturn: consequently no living creature could subsist there. This then is a clear proof, that the world in its present state had a beginning, and must have an end."

We may likewise find reason to think, from the action of Jupiter on the earth, that the earth's revolution round its axis, continually becomes more and more rapid. For the force of Jupiter so accelerates the motion of the earth round the sun,

ſun, that the diminution of the years would be ſenſible, if the diurnal motion had not been accelerated nearly in the ſame proportion.

It is another obſervation of Aſtronomers, that the ſun does not ſhine as long on one ſide the line as on the other: that he ſtays longer in the ſix northern ſigns, than in the ſix ſouthern: ſo much longer, as to make no leſs a difference, than that of nine days. How is this? Did the earth always obvert her northern hemiſphere to the ſun ſo much longer than the ſouthern? Or has ſhe gradually warped ſo much to one ſide, in a courſe of near 6000 years?

But over and above the Sun's motion round his own axis, in 25 days, 15 hours, he has another motion. There is a certain point, which is the true or common center of all the planetary motions, not quite a ſemi-diameter of the ſun diſtant from its center. About this point, the ſun and all the planets move; but in what time is uncertain.

9. Let us conſider more cloſely, the advantages ariſing to us by the *Rotation* of the Earth about its own axis. We are ſo made, that once in ſixteen or twenty hours at moſt, we require a time for relaxation. And generally in healthful people this time is pretty equal, between ſix and eight hours. The ſtorehouſes of our ſpirits, will not permit a longer application than twenty hours, without injury to our conſtitutions. And at leaſt ſix hours are required to fill them again.

It was likewiſe neceſſary that the air ſhould be cool and temperate, during the time of this reſt; for

for we generally find those that sleep while the sun is above the horizon, the worse for it, the sun and the heat exhaling the natural perspirations too violently, and raising too quick a motion in the blood. And though we generally perspire more in the night, yet the perspiration is more natural and less violent, and more according to the necessities of our constitutions in the night than in the day. Besides, the darkness is less subject to noise and disturbance than the day. Now all these things are wonderfully provided for, by the Rotation of the Earth about its axis. For thereby we have the vicissitudes of day and night, the day for spending our spirits, the night to recruit them; as also for nourishing the muscles, bones, channels, and other parts of the body; for the business of nutrition is mostly, if not altogether, performed in the time of rest. Likewise, how comfortable and refreshing are the cool breezes of the night; and the trade-winds to those that live under the equatorial parts? Without which, life would both be exceeding short, and very grievous.

These winds, are the necessary effect of the Rotation of the earth about its axis, which under the line makes the rays of the sun direct and equal all the year round; so that these parts being constantly under the sun's influence, his heat rarifies one part of the air, and the cooler and heavier part presses upon the hotter, and so makes a continual wind in his course from east to west.

Moreover, let us reflect upon our vegetables, which are the support of animals; the sun rarifies and consequently raises the sizy vegetable juices,

juices, at the roots of the tender feeds, and thereby forces the folded branches to expand and enlarge. Now, were the fun conftantly fhining upon them, thefe juices would not be at liberty to fettle, and confolidate in the fit places of the branches; but would be ftill rifing higher and higher, till at laft they burft the canals; whereas by this viciffitude of heat and cold, what is raifed in the day time, has time to fettle and confolidate in the night. Its cold turns the thin juices into fizy fubftances, which the fupervening heat, by exhaling the watry parts, hardens and fixes. On the other hand, had not the earth moved upon its axis, but only turned round the fun in its annual period, we had not only loft all thefe advantages, which are fo neceffary for both animals and vegetables, but had fuffered alfo fuch inconveniences, as neither of thefe could poffibly bear. For near half the year, we fhould have been in perpetual darknefs, the confequence of which would have been, that baleful damps, by the preceding heat, generated and raifed, would have fallen, which would have ftifled all animals. Or had they furvived that, fnow, ice, and froft, would not only have locked up all fluids, but would have froze the blood and fpirits in the channels of all the animals we are acquainted with.

Again, in the enlightened half of the year, we fhould have had huge deluges of water, from the preceding fnow, which likewife would have produced fuffocating mifts. Next, all our ground would have turned into a ftiff, ftinking puddle, being in a manner diffolved by the fnow water. Then would fultry heats and a burning air, have fcorched, ſcorched and chapped the earth, and galled the animal tribes, ſo that they would have found reſt, neither in houſes nor dens, till at laſt, the blood and ſpirits of all the animals of our globe, would be quite exhaled, or by the violent agitation thereof, they would turn delirious.

Upon all theſe accounts, the Rotation of the Earth, about her axis, is one of the moſt ſignal inſtances of Divine Wiſdom.

CHAP.

CHAP. II.

Of the HEAVENLY BODIES, in particular.

1. THE very ſame effects which we obſerve daily in Fire, we obſerve alſo in the Sun. It ſhines, it warms, it burns. Viewed with a teleſcope it appears like an ocean of fire or melted metal. Hence many ſuppoſe, that the ſpots appearing thereon and changing continually, are as it were the droſs and ſcum of that metal, which it throws out from time to time. But it is more probable, ſome of thoſe ſpots are clouds, formed out of the ſolar exhalations. And if exhalations riſe out of his body, and are ſuſpended at a certain height from it, then the ſun muſt be encompaſſed with a fluid, analogous to our atmoſphere. Some of theſe ſpots diſſolve and diſappear, in the very middle of the Sun's diſk: that is, the exhalations ſometimes riſe, ſometimes fall back to the Sun.

But

But there is another kind of ſpots which regularly revolve, once in ſeven and twenty days. Or to ſpeak more properly, the Sun himſelf revolves nearly in that time, round his own axis, together with his atmoſphere.

But over and above this motion on his own axis, "We are not ſure, ſays Mr. Huygens, whether the Sun be a ſolid or liquid globe. I rather think it liquid, which the equal diſtribution of his light to all parts is an argument for. That very ſmall inequality on his ſurface, diſcovered by the teleſcope, which has made ſome men imagine they ſaw huge mountains of fire, is entirely owing to the trembling motion of the vapours our atmoſphere is full of, particularly near the earth. And this is likewiſe the cauſe of the ſtars twinkling.

"The dark ſpots in the Sun I have often ſeen: but thoſe bright ſpots of which many ſpeak, I never was able to diſcover: ſo that I cannot but doubt of their exiſtence. Nor do I apprehend there is any thing in or upon the Sun, brighter than the Sun itſelf. Indeed it is not pretended that theſe bright ſpots are any where, but juſt about the dark ones. And it is no wonder, the parts which are near the dark, ſhould appear ſomewhat brighter than the reſt."

And hence it is, that thoſe ſpots being viewed obliquely, near the edge of the Sun. appear narrow and oblong. He is ſuppoſed to be abundantly larger than the earth. When the moon paſſes between the earth and the Sun, ſo as to intercept his rays, he is ſaid to be *eclipſed*. This happens only at the time of the new moon, becauſe it is then only ſhe paſſes between the ſun and the earth. Yet not at every new moon, be-

cauſe

cause she generally declines either to the north or south.

No solar eclipse can be universal, the moon being too little to overshadow the whole earth. Nor does any eclipse appear the same in all places, but is total in one, and partial in another. In most solar eclipses, the moon is covered with a faint, dawning light, which is owing to the reflection of the light from the illuminated parts of the earth. In total eclipses the moon's edge is seen surrounded by a pale circle of light, which is at least a probable indication of a lunar atmosphere.

When the earth is interposed between the moon and the Sun, then the moon is eclipsed. This is only at the time of the full moon. Even in the midst of the eclipse, the moon has a faint light which is reflected by the atmosphere of the earth. And to the shadow of this it is owing, that she grows paler and dimmer, before she enters into the shadow of the earth.

2. The planet nearest to the sun is Mercury, which is the smallest of all, supposed to be twelve times less than the earth. It moves round the sun in about three months, and is believed to be the most dense of all the heavenly bodies. It sometimes moves between the earth and the sun. And from its various appearances we may certainly infer, that it has no light of its own, but shines by reflection only.

3. The next to Mercury is Venus, whose appearances likewise change in the same manner as the moon's. It is supposed to be something less than the earth, and compleats its period round the sun, in nearly seven months. From its situation

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we may judge, it is more denſe than the earth, but more rare than Mercury.

4. Next to Venus is the Earth, which moves round its own axis from weſt to eaſt in twenty-four hours, and round the ſun in three hundred and ſixty-five days five hours and near forty-nine minutes.

The difference of ſeaſons, as well as the different degrees of heat and cold, depend on the different poſitions of the earth with reſpect to the ſun. The natural ſtate of this globe ſeems to be what we call temperate. This is what ſecures ſprings and other bodies from being frozen. But the obliquity and perpendicularity with which the rays of the ſun fall on the air, are varying continually, according to which the warmth of the air is continually leſſening or encreaſing. Likewiſe the continuance of the ſun's preſence, with the ſlowneſs of his motion, naturally increaſe heat; as his abſence and the ſwiftneſs of his motion, naturally increaſe cold. Yet this rule does not always hold. There are many accidents that prevent it: ſuch as the ſituation of hills, and the declivity of land, towards the north or ſouth. Clouds alſo ſometimes reflect heat, and water-clouds cool the air. South or ſouth weſt winds, if without rain, increaſe warmth; eaſt or northerly winds occaſion cold. Whenever ſmooth water reflects the ſun's rays, it much increaſes heat. And indeed all ſmooth bodies which reflect light, reflect heat along with it, and that more or leſs, according to the cloſeneſs of the pores, and the extent convexity or concavity of their ſurface.

All parts of the earth enjoy nearly the ſame quantity of the ſun's preſence in the ſame ſpace of a year. And yet how widely different

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is the quantity of heat, in ſome from that in others? But it is not, as any one would imagine greateſt under the line. This is prevented by the ſwiftneſs of his motion. For the nearer he approaches to it, the ſwifter is his motion from eaſt to weſt, from north to ſouth, and from ſouth to north. He paſſes ſeven degrees, from three and a half ſouth latitude to three and a half north, in eighteen days: whereas at twenty degrees north latitude, he ſpends an whole month in going three degrees and a half, and another month in returning: ſo that he is as near the tropic for ſixty-ſeven days, as he was to the line for eighteen. And hence the heat is conſiderably greater under the tropic, than it is under the line.

5. The Moon moves round the earth in about twenty-eight days, and with the earth round the ſun in a year. Yet it always turns nearly the ſame ſide to the earth, whence we always obſerve the ſame inequalities in its ſurface. It does not appear that ſhe moves at all round her own axis. None now doubts of the moon's being an opake body: and the ſpots and uneveneſſes, which conſtantly appear upon it, have been judged by ſome to be vallies, mountains, lakes, and ſeas.

Her days and months are of an equal length, which we do not obſerve of any other body in the heavens. That her day is equal to her month, appears hence. Since in whatever part of her orbit ſhe is, the ſame face and the ſame ſpots are always obſerved, without the leaſt variation, ſhe muſt have ſuch a motion round her own axis as turns every moment ſo much of her ſurface from our view, as is turned to us by her periodical motion: that is, ſhe muſt move in the ſame time about her axis, as ſhe does about the earth.

Half at leaſt of the Moon is always inlightened by the ſun, but as it is continually changing its ſituation, the whole of the enlightened part is not always toward us, and therefore ſhe exhibits to us various appearances. When ſhe begins to recede from her conjunction with the ſun, and to emerge out of his rays, a ſmall portion of her enlightened part is ſeen, and appears as it were horned. But the farther ſhe recedes from the ſun, the more of the enlightened part appears, till about the fourteenth day, being juſt oppoſite to him, ſhe ſhews us her entire hemeſphere. In the ſame manner ſhe appears to decreaſe, while ſhe is approaching the ſun. The Moon is ſuppoſed to be forty-five times ſmaller than the earth.

The Moon has ſometimes diſappeared in a clear ſky, ſo as not to be diſcoverable by the beſt glaſſes. This Kepple obſerved in the year 1580 and in 1583: Hevelius in 1620, as did Ricciolus and many others at Bologna. Many people throughout Holland obſerved the ſame, April 14, 1642. December 23, 1703, there was another total obſcuration. A little before it, ſhe appeared at Arles of a yellowiſh brown, at Avignon, ruddy and tranſparent. At Marſeilles one part was ruddy, the other duſky, till ſhe wholly diſappeared. I do not find that the boldeſt philoſophers attempt to account for this.

It is now almoſt univerſally ſuppoſed, that the Moon is juſt like the earth, having mountains and valleys, ſeas with iſlands, peninſula's and promontories, and a changeable atmoſphere, wherein vapours and exhalations riſe and fall. And hence

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it is generally inferred, that ſhe is inhabited like the earth, and by parity of reaſon, that all the other planets, as well as the earth and moon, have their reſpective inhabitants. But after all comes the celebrated Mr. Hugens, and brings ſtrong reaſons why the Moon is not and cannot be inhabited at all, nor any ſecondary planet whatever. Then I doubt we ſhall never prove that the primary are: and ſo the whole ingenious hypotheſis, of inumerable ſuns and worlds moving round them, vaniſhes into air.

It may not be unacceptable to the reader, to ſee the ſum of his reaſonings on this head. " One would think that the Moon which is ſo near us, and may by a teleſcope be ſo accurately obſerved, ſhould afford us matter of more probable conjecture, than any of the remoter planets. But it is quite otherwiſe. Only this we may venture to ſay, that all the attendants of Jupiter and Saturn are of the ſame nature with our Moon, as going round them, and being carried with them round the ſun, juſt as the Moon is with the earth. Therefore whatever we may reaſonably affirm or conjecture, with regard to our Moon, muſt be ſuppoſed with very littly alteration to belong to the Satellites of Jupiter and Saturn.

" The ſurface of the Moon is found, even when we uſe the ſhorteſt teleſopes, to be diverſified with long tracts of mountains, and again with broad valleys, For in thoſe parts oppoſite to the ſun, you may ſee the ſhadows of the mountains, and often the round valleys between them, with an hill or two riſing out of them. But I cannot find any thing like ſea there

there, notwithſtanding what many affirm. For thoſe vaſt countries which appear darker than the others, commonly taken for ſeas, are diſcovered with a good long teleſcope, to be full of little round cavities: the ſhadow of which, falling within themſelves, makes them appear of that colour. And thoſe large champains, if you look carefully upon them, you will find not to be always ſmooth and even. Now neither of theſe things can agree to the ſea. Therefore it is far more probable, that thoſe plains in her which ſeem brighter than the other parts, conſiſt of a whiter ſort of matter. Nor do I believe, that there are any rivers: for if there were, they could never have eſcaped our obſervations. Eſpecially if they run between the hills, as our rivers do. Nor have they any clouds to furniſh rivers with water. For if they had, we ſhould ſometimes ſee one part of the Moon darkened by them and ſometimes another, whereas we have always the ſame proſpect of her.

It is certain moreover that the moon has no air or atmoſphere ſurrounding it. For then we could never ſee the very outermoſt rim of the Moon ſo exactly as we do when any ſtar goes under it, but its light would terminate in a faint, gradual ſhade, and there would be a ſort of down as it were about it. Not to mention, that the vapours of our atmoſphere conſiſt of water; and conſequently where there are no ſeas, there can be no ſuch atmoſphere. This is the grand difference between the Moon and us. Were there ſeas and rivers therein, we might eaſily believe that it had all the other furniture which belong to our earth. But how can plants or animals, all whoſe nouriſhment comes from liquid bodies, thrive, in a dry waterleſs ſoil?"

"Does

"Does then the Moon ſerve for nothing but to give us light in the night? And do all theſe moons round Jupiter and Saturn, anſwer no other purpoſe? I do not know what to ſay, becauſe I know of nothing like them to found a conjecture upon. Perhaps they may have ſome plants and animals, which have ſome nouriſhment of a different kind from ours. Perhaps they may have moiſture enough to cauſe a miſt or dew, which may ſuffice for the herbs that grow there. But theſe are mere gueſſes, or rather doubts. And yet they are the beſt we can make, concerning either our own Moon or thoſe which attend Jupiter and Saturn."

What benefits do we receive from our Moon? Firſt, the ſupplying light in the night-time, for at leaſt three fourths of the year. Now how comfortable and delightful a thing this is, travellers and voyagers can beſt tell. Curioſity, ambition, luxury, and ſometimes neceſſity have made it unavoidable, that ſome part of mankind ſhould be travelling by land and ſea, in the night ſeaſons. How pleaſant then is it, to have a light held out from Heaven, to guide our ſteps, to direct us in our courſe, and to point out to us how our time wears out.

Secondly, ſhe raiſes our tides twice in twenty-four hours, which is abſolutely neceſſary towards the ſubſiſtence both of animals and vegetables. Every body knows that a lake that has no freſh water running into it, will by the heat of the ſun in a few months, and its ſtagnation, turn into a ſtinking, rotten puddle, ſending forth nauſeous and poiſonous ſteams. And though many thouſand rivers daily run into the ſea, yet they are very inconfiderable in refpect of the vaft ocean of falt-water; and would by no means hinder its ftagnation, and confequently its corruption and ftinking. Now fuppofe the ocean ftagnated, the firft effect would be, all the places towards the fhores, would be wrought upon by the fun, and turned to a memphitis. Then it would get farther till the whole were become more baneful and poifonous than the lake of Sodom and Gomorrah. Hereby the fifhes would firft be deftroyed, and afterwards the plants and animals; but by this action of the Moon, the waters are lifted up on a heap, as it were, and then let fall again, whereby the waters near the fhores are conftantly fecured from ftagnation and corruption, and the beginning of malady ftifled. This perpetual change of new water on the fhores, keeping any one portion thereof, from being expofed to the fun long enough to have its mixture corrupted. Now what a noble contrivance have we here. By appointing an attendant to our earth, all the animals and vegetables are preferved from certain deftruction. Though indeed to the full effect of this wife defign, the falt of the fea does very much contribute; as there are many faline rocks and mountains difperfed over the foundations of the great ocean. Befides this, how many conveniencies for our navigation in rivers and harbours does this ebbing and flowing of the fea afford? Yet if our earth had more than one Moon attending it, we fhould receive more damage than advantage by it; for though hereby our light in the night might be augmented, yet at their conjunctions and oppofitions with one another, and with the fun, we fhould have tides that would raife the waters over too much of our dry land; and in their quad-

ratures

ratures we ſhould have no tide at all. Again, if our Moon were bigger or nearer the earth, or if we had more than one, at any tolerable diſtance from us, we ſhould be every now and then in hazard of being ſtifled by the noxious ſtreams ariſing from the ocean. From all which it is evident, how wiſely our ſtatelite has been contrived for our purpoſes.

6. Mars, as well as Venus, Mercury, and the Moon, has various appearances, more or leſs full, as it is variouſly placed, with regard to the ſun and the earth. Spots are obſerved on his ſurface alſo, from the regular motion of which we learn, that he revolves round his axis from weſt to eaſt, in twenty-four hours and forty minutes. He moves round the ſun in two years, and it is thought to be eight times ſmaller than the earth.

7. Jupiter is incompaſſed from weſt to eaſt with two or three lucid Belts, not always appearing alike. In one of them a ſpot is conſtantly obſerved; and they regularly move from weſt to eaſt. Hence we learn, that he revolves round his axis, which he does in nine hours and fifty-ſix minutes. He is likewiſe attended by four ſmaller planets or Satellites, like our Moon. Each of theſe move round him in its ſtated period, and all move with him round the ſun in twelve years. Jupiter is ſuppoſed by ſome to be twenty-five, by others 4096 times larger than the earth.

8. The higheſt planet Saturn is incompaſſed with a broad Ring, which is not contiguous to his body, but is ſuſpended over him equally diſtant from every part of his ſurface. He has five

satellites or moons, moving round him in their stated periods. The brightest of these, which is the fourth, was first discovered by Mr. Huygens, in the year 1655. The rest were discovered by Cassini. And I have reason to think, says Mr. Huygens, there are one or two more still behind. For between the fourth and fifth there is a distance not at all proportionable to that between all the others. Here it is propable, there may be a fixth. And there may not improbably be another, without the fifth, which has hitherto escaped us. For we can never see the fifth but in that part of its orbit, which is towards the west.

Saturn himself revolves with them round the sun in about thirty years. He is supposed to be fifteen times bigger than the earth.

If we compute the magnitude of the planets in number of miles, the diameter of the moon is supposed to be 2175 miles, that of Mercury, 2748, that of Mars 4875, of the Earth, (and nearly of Venus) 7967, of Saturn 93451, of Jupiter 130653; and that of the sun 822148.

With regard to their distance from the earth, there is such an immense difference in the calculations of astronomers, even with respect to the distance of the sun (which some *demonstrate* to be ninety millions of miles, others to be not three millions from the earth: that it is wisest to confess our ignorance, and to acknowledge we have nothing to rest on here, but mere uncertain conjecture.

9. Comets are opake bodies, which emit numerous rays sometimes forwards, sometimes backwards, sometimes all round the body of the comet. Now they sink near the body of the sun: then they rise far beyond the orb of Saturn. Some suppose

ſuppoſe them to be imperfect planets, or ſuch a chaos of unformed matter, as may hereafter be formed into an earth like ours. Probably thoſe rays which they emit, are only vapours, by which the rays of the ſun are refracted to us.

Hence they have a different appearance, according as they are differently ſituated with regard to the comet: which is hereby confirmed that the nearer they are to the ſun, the more thoſe rays are increaſed, and the farther they recede from it, the more thoſe are diminiſhed. And hence ſome imagine that fixed ſtars, covered with vapours and ſpots, become comets. It is more probable that comets, like planets have their regular periods: although they frequently eſcape our obſervations, as not revolving but in a long term of years.

They are diſtinguiſhed from other ſtars by a large train of light, which is always oppoſite to the ſun, and grows fainter and fainter the farther it is from the body of the comet. When a comet moves from the ſun it is ſaid to be *bearded*, becauſe that light is ſeen before it. When it moves toward the ſun, the train follows it, and is called its *tail*. When the comet and ſun are oppoſite, (the earth being between them) the train is hid behind the body of the comet, except a little that appears round it, and is termed its *hair*.

Sir Iſaac Newton has proved, that the heat of the ſun to the Comet in December 1680, was to his heat with us at Midſummer, as 28000 to one: and that the heat of the body of the Comet was near 2000 times greater than that of red-hot iron.

After having acquired ſo immenſe an heat, it muſt be a long time in cooling. Sir Iſaac computes, that a globe of red-hot iron 200 times as large as the earth, would ſcarce be cool in 50,000 years. If then the Comet be ſuppoſed to cool an hundred times as faſt as red-hot iron, yet ſince its heat was two thouſand times greater, ſuppoſing it of the bigneſs of the earth, it would not be cool in a million of years.

Comets ſeem to be a peculiar kind of planets, which move in very oblique orbits, and perſevere in their motions, even againſt the courſe and direction of the other Planets. Their tails are doubtleſs vapours emitted by the comet when heated by the ſun. Yet they do not aſcend ſwiftly from it, and then preſently diſappear; but are permanent columns of exhalations, gathered from the Comet by a gentle motion, and in a great ſpace of time, which then move with it through the celeſtial regions.

One great uſe of Comets probably is, to give moiſture to the planets. By their vapours the water ſpent in them, may be ſupplied and recruited. All vegetables grow from fluids. But when they putrify, great part of them turn into dry earth: hence the quantity of dry earth muſt continually increaſe, and the moiſture of the globe decreaſe. Add to this, that immenſe quantities of watry vapours, are continually arreſted in the polar regions, and falling down form mountains of eternal ſnow, and rocks of ice that thaw no more. By both theſe means the moiſture of the planets continually decreaſing, muſt in proceſs of time entirely fail, if it had not a ſeaſonable ſupply, from ſome other part of the univerſe. Comets therefore are ſo far from being ſuperfluous, much more from being blemiſhes in the univerſe, that it may be doubted whether either the animals or vegetables

vegetables of the earth could long ſubſiſt without them.

And indeed, if the uſes aſigned to the Comets by Sir Iſaac Newton be real, as they are not improbable, nature by the ſupplying the defficiency and expences of all ſorts of fluids neceſſary to the earth: I mean not only light and heat to the ſun, and watery vapours to our atmoſphere, but the moſt ſubtle, moſt uſeful, and neceſſary part (towards life and vegetation) to the air; then theſe wandering frightful bodies, may be juſtly conceived joining in the chorus, and loudly reſounding the common Hallelujah.

But the aſtronomy of Comets, ſays Mr. Brydon is clogged with very great difficulties, and even ſome ſeeming abſurdities. It is difficult to conceive, that theſe immenſe bodies, after being drawn to the ſun, with the velocity of a million of miles in an hour, when they have at laſt come almoſt to touch him, ſhould then fly off from his body, with the ſame velocity they approached it, and that too, by the power of this very motion, that his attraction has occaſioned. The demonſtration of this, I remember is very curious and ingenious; but I wiſh it may be entirely free from ſophiſtry. No doubt, in bodies moving in curves round a fixed center, as the centripetal motion increaſes, the centrifugal one increaſes likewiſe: but how this motion, which is only generated by the former, ſhould at laſt get the better of the power that produces it, and that too, at the very time this power has acquired its utmoſt force and energy, ſeems ſomewhat difficult to conceive. It is the only inſtance I know, wherein the effect increaſing regularly with the cauſe; at laſt, whilſt the caufe is ftill acting with full vigour, the effect entirely gets the better of the caufe, and leaves it n the lurch. For the body attracted, is at laft carried away with infinite velocity from the attracting body. By what power is it carried away? Why, fay our philofophers, by the very power of this attraction, which has now produced a new power fuperior to itfelf: to wit, the centrifugal force. However, perhaps all this may be reconcileable to reafon; far be it from me to prefume to attack fo glorious a fyftem as that of attraction. The law that the heavenly bodies are faid to obferve, in defcribing equal æreas in equal times, is fuppofed to be demonftrated, and by this it would appear, that the centripetal and centrifugal forces alternately get the maftery of one another.

However, I cannot help thinking it fomewhat hard to conceive, that gravity fhould always get the better of the centrifugal force, at the very time that its action is the fmalleft, when the Comet is at the greateft diftance from the fun; and that the centrifugal force fhould get the better of gravity, at the very time that its action is the greateft, when the Comet is at its neareft point to the fun.

To a common obferver it would rather appear, that the fun, like an electric body, after it had once charged the objects that it attracted, with its own effluvia or atmofphere, by degrees lofes its attraction, and at laft even repels them, and that the attracting power, like what we likewife obferve in electricity, does not return again till the effluvia imbibed from the attracting body are difpelled or diffipated; when it is again attracted, and fo on alternately. For it (appears at leaft to an unphilofophical obferver) fomewhat repugnant to reaſon, to ſay, that a body flying off from another body ſome thouſands of miles in a minute, ſhould all the while be violently attracted by that body: and that it is even by virtue of this very attraction that it is flying off from it. He would probably aſk, What more could it do, pray, were it really to be repelled?

Had the ſyſtem of electricity, and of repulſion, as well as attraction, been known and eſtabliſhed in the laſt age, doubtleſs the profound genius of Newton would have called it to his aid, and perhaps accounted in a more ſatisfactory manner for many of the great phænomena of the heavens.

To the beſt of my remembrance, we know of no body that poſſeſſes, in any conſiderable degree, the power of attraction, that in certain circumſtances does not likewiſe poſſeſs the power of repulſion: the magnet, the tourmalin, amber, glaſs, and every electrical ſubſtance. Now from analogy, as we find the ſun ſo powerfully endowed with attraction, why may we not likewiſe ſuppoſe him to be poſſeſſed of repulſion? Indeed this very power ſeems to be confeſſed by the Newtonians, to reſide in the ſun in a moſt wonderful degree; for they aſſure us he repels the rays of light with ſuch amazing force, that they fly upwards of 80 millions of miles in ſeven minutes. Now why ſhould we confine this repulſion to the rays of light only? As they are material, may not other matter brought near his body, be affected in the ſame manner? Indeed one would imagine, that their motion alone would create the moſt violent repulſion; and that the force with which they are perpetually flowing from the ſun, would moſt effectually prevent every other body from approaching

approaching him; for this we find is the constant effect of a rapid stream of any other matter. But let us examine a little more his effects upon Comets. The tails of these bodies are probably their atmospheres, rendered highly electrical, either from the violence of their motion, or from their proximity to the sun. Of all the bodies we know, there is none in so constant and so violent an electrical state, as the higher regions of our own atmosphere. Of this I have long been convinced; for send up a kite with a small wire about its string, only to the height of twelve or thirteen hundred feet, and at all times it will produce fire, as I have found by frequent experience; sometimes when the air was perfectly clear, without a cloud in the hemisphere; at other times, when it was thick and hazy, and totally unfit for electrical operations below. Now as this is the case at so small a height, and as we find the effect still grows stronger, in proportion as the kite advances (for I have sometimes observed, that a little blast of wind, suddenly raising it about an hundred feet, has more than doubled the effect) what must it be in very great elevations? Indeed we may often judge of it from the violence with which the clouds are agitated, from the meteors formed above the region of the clouds, and particularly from the aurora borealis, which has been observed to have much the same colour and appearance as the matter that forms the tails of Comets.

There is a species of Comets, says the same gentleman, that have not tails: these are certainly bodies of a very different nature from those with tails, to which indeed they appear even to bear a much less resemblance than they do to planets: and

and it is no ſmall proof of the little progreſs we have made in the knowledge of the univerſe, that they have not as yet been diſtinguiſhed by a different name.

This is the third kind of body that has been diſcovered in our ſyſtem, that all appear eſſentially different from each other, that are probably regulated by different laws, and intended for very different purpoſes. How much will poſterity be aſtoniſhed at our ignorance, and wonder that this ſyſtem ſhould have exiſted for ſo many thouſand years, before we were in the leaſt acquainted with one half of it, or had even invented names to diſtinguiſh its different members.

I have no doubt, that in future ages the number of the Comets, the form of their orbits, and time of their revolutions, will be as clearly demonſtrated, as that of the planets. It is our countryman Dr. Halley, who has begun this great work, which may be conſidered juſt now as in its earlieſt infancy. Theſe bodies too, with thick atmoſpheres, but without tails will likewiſe have their proper places aſcertained, and will no longer be confounded with bodies to which they bear no reſemblance or connection.

Comets with tails have ſeldom been viſible, but on their receſs from the ſun. It is he that kindles them up, and gives them that alarming appearance in the heavens. On the contrary, thoſe without tails, have ſeldom, perhaps never, been obſerved but on their approach to him. I do not recollect any whoſe return has been tolerably well aſcertained. I remember indeed, a few years ago a ſmall one, that was ſaid to have been diſcovered by a teleſcope, after it had paſſed the ſun, but never

ver more became viſible to the naked eye. This aſſertion is eaſily made, and nobody can contradict; but it does not at all appear probable, that it ſhould have been ſo much leſs luminous after it had paſſed the ſun, than before it approached him; and I will own, when I have heard that the return of theſe Comets had eſcaped the eyes of the moſt acute Aſtronomers, I have been tempted to think that they did not return at all, but were abſorbed in the body of the ſun, which their violent motion toward him ſeemed to indicate. Indeed, I have often wiſhed that this diſcovery might be made, as it would in ſome meaſure account for what has as yet been looked upon as unaccountable; that the ſun, notwithſtanding his daily waſte from enlightening the univerſe, never appears diminiſhed either in ſize or light. Surely this waſte muſt be immenſe, and were there not in nature ſome hidden proviſion for ſupplying it, in the ſpace of ſix thouſand years. Suppoſing the world to be no older, the planets muſt have got to a much greater diſtance from his body, by the vaſt diminution of his attraction: they muſt likewiſe have moved much ſlower, and conſequently the length of our year muſt have been increaſed. Nothing of all this ſeems to be the caſe; he neither appears diminiſhed nor our diſtance from him increaſed; his light, heat, and attraction ſeem to be the ſame as ever; and the motion of the planets round him is performed in the ſame time; of conſequence, his quantity of matter ſtill continues the ſame. How then is this vaſt waſte ſupplied? May there not be millions of bodies attracted by him from the boundleſs regions of ſpace, that are never perceived by us? Comets on their road to him, have ſeveral times

been

been accidentally discovered by telescopes that were never seen by the naked eye. Indeed the number of black spots on the sun, seems to indicate, that there is always a quantity of matter there, only in preparation to give light, but not yet refined and pure enough to throw off rays like the rest of his body. For I think we can hardly conceive, that any matter can remain long on the body of the sun without becoming luminous; and so we find these spots often disappear; that is to say, the matter of which they are composed is then perfectly melted, and has acquired the same degree of heat and light as the rest of his body. Even in glass houses and other very hot furnaces; most sorts of matter very soon acquire the same colour and appearance as the fire, and emit rays of light like it. But how much more must this be the case at the surface of the sun. When Newton computes, that even at many thousand miles distance from it, a body would acquire a degree of heat two thousand times greater than that of red hot iron. It has generally been understood, that he said the great Comet really did acquire this degree of heat: but this is certainly a mistake: Sir Isaac's expression, to the best of my remembrance, is; that it might have acquired it. And if we consider the very great size of that body, and the short time of its perihelion, the thing will appear impossible; nor indeed do I think we can conceive; that a body only as large as our earth, (and the spots on the sun are often much larger,) could be reduced to fusion even on his surface, but after a considerable space of time.

Now it seems to be universally supposed, that the rays of light are really particles of matter, proceeding from the body of the sun. If so it is ab-

solutely

ſolutely neceſſary that we ſhould fall upon ſome ſuch method of ſending him back a ſupply of thoſe rays, otherwiſe let his ſtock be ever ſo great, it muſt be exhauſted.

10. It is commonly ſuppoſed, that the fixed Stars are ſo many ſuns, ſhining with their own light: and that each of them has a ſet of planets moving round it: as the earth, and the other planets do round our ſun. It may be ſo, or it may not; for we know nothing about them: nor is it poſſible we ſhould know more. For even when viewed with the beſt teleſcopes, they appear no larger than they do to the naked eye. They are divided, according to their ſize, into ſtars of the firſt, ſecond, and ſo on to the ſixth magnitude.

Even a good eye ſeldom ſees more than an hundred Stars, at a time in the cleareſt heaven. The appearance of vaſt numbers in winter nights is a mere deception of our ſight, occaſioned by our viewing them confuſedly, not in any regular order.

Yet are they really almoſt infinite. For a good teleſcope directed to almoſt any part of the heavens, diſcovers numbers unſeen by the naked eye, particularly in the *milky way:* which is indeed nothing elſe but an aſſemblage of Stars, too remote to be ſeen ſingly, but ſo cloſe to each other, as to give that brightneſs to ſo large a part of the heavens.

There are ſix or ſeven of theſe *nebulous Stars*, as they are called. They are indeed compound ſtars, conſiſting of multitudes of ſingle ones. In ſome of theſe appears a bright lucid part, in which

which ſome ſtars appear, as from a white cloud. and theſe are reckoned to be regions of a peculiar nature, enjoying an uninterrupted, everlaſting day.

The *ſeven Stars* ſo called, probably were ſeven once; but one of them became extinct, even before the time of Auguſtus Cæſar: and no more than ſix have appeared ever ſince. But theſe likewiſe, when viewed through a good teleſcope, are more than can eaſily be numbered.

An hundred and twenty five years before Chriſt Hipparchus diſcovered a new ſtar. In 1572 Tycho Brahe obſerved another. Its magnitude at firſt exceeded the biggeſt of our ſtars. It equalled that of Venus when neareſt the earth, and was ſeen in fair day light. It continued ſixteen months, toward the end of which it grew leſs till it totally diſappeared. We have an account of one appearing at leaſt thrice before, at the interval of 150 years. Probably it was the ſame ſtar, and will return at the ſtated time.

Many other new Stars have been obſerved in this century to appear and diſappear; and it is certain from the old catalogues, that many of the antient Stars are not now viſible.

There are now wanting two ſtars of the ſecond magnitude in the ſhip Argo, which were ſeen till the year 1664. But there was not the leaſt ſign of them in 1668. Accurate Aſtronomers have obſerved many more ſuch changes in the fixed Stars, to the number of an hundred.

Are theſe temporary Stars a ſort of planets? Are they fixed Stars, which being covered with

ſpots

ſpots like thoſe obſerved on the ſun, loſe their brightneſs, and conſequently diſappear? Or are they Comets, which take ſo vaſt a time to perform their revolutions, as ſeldom to have their returns perceived?

11. It remains only to make ſome improvement of what has been obſerved, concerning the ſyſtem of the univerſe. And Firſt, we may obſerve the due *ſituation* of the heavenly bodies. 1, none of them interfere with each other. Had the univerſe been the work of any but the wiſe architect. there would have been many inconveniences in the ſituation of ſuch a prodigious number of immenſe globes. Some would have been too near or too far off: ſome would have incommoded others. But inſtead of this, all the globes which fall under our notice, are ſet at ſuch a due diſtance, as not only to avoid all violent concourſe, but not to ſhade each other, ſo as to hinder each other's kindly influence, or to occaſion noxious ones. 2, as it is one great inſtance of the ſkill of an architect, to give due *proportion* to his works, ſo this abundantly appears in all the heavenly bodies that come under our cognizance. Curious order, and due and nice proportions are obſerved in their ſituations. The ſun is placed in the center of his ſyſtem, to give all his planets heat and light. Then follow the ſeveral planets ſurrounding him, not ſcattered at all adventures, but at due diſtances from the ſun, as well as from one another. And this is diſcernable, not only the primary, but the ſecondary planets too: in the five moons that attend Saturn, and the four that accompany Jupiter.

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The wiſdom of the Creator appears, Secondly; from the *motions* of the heavens and the earth. That theſe vaſt globes ſhould move at all, proves ſome being that has power to put them in motion: ſeeing matter cannot move itſelf. And ſuppoſe them moved by the ſun, the ether, or ſome other primary mover, ſtill we muſt recur to ſome firſt Cauſe who was able to put the mover into motion. And this could be no other than the hand of the Almighty. What farther ſhews both his power and wiſdom, is that thoſe motions are not at random, or in inconvenient lines and orbs, but ſuch as manifeſt the deepeſt counſel. That every planet ſhould have as many and various motions. as the world and its inhabitants have occaſion for, muſt be the work of a wiſe and kind, as well as omnipotent Creator.

In particular, the *diurnal* motion of theſe globes ſhews the wiſdom of the Creator. Of what prodigious uſe is this? Were the planets always to ſtand ſtill, half of each globe would be dazzled and parched with unceaſing day, and the other half wrapt in everlaſting darkneſs. Were this the caſe with our globe, a great part of it at leaſt would ſcarce be habitable. It would neither agree with the ſtate of man or other animals, nor of vegetables. How could the vapours be raiſed to ſupply the earth with cooling clouds and fruitful ſhowers? How could the winds be excited to fan the atmoſphere with their pleaſant and healthful gales? How could vegetables be raiſed up by the kindly heat of the day, and tempered by the dews and cool of the night? How could men and other animals gather their food, and perform the various labours of the day, and then under

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the ſalutary influences of the night recruit themſelves with reſt and ſleep?

And as the diurnal, ſo the *annual* motion of the heavenly bodies, is a clear manifeſtation of the Creator's wiſdom: eſpecially when we conſider the different paths of their diurnal and annual motions. Theſe lie not in a very different plane, nor in the ſame, but a little croſſing one another: the diurnal, lying in or parallel, to the equator, the annual, at an inclination of twenty-three degrees and an half. A glorious contrivance this for the good of our globe, and for all the reſt that have the ſame annual motion. For were the earth's annual motion to be always in the ſame plane with the diurnal, we might indeed be ſometimes nearer to the ſun than we now are. But we ſhould miſs of thoſe kindly increaſes of day and night, which the approach of earth to one or the other pole occaſions. This is likewiſe the great cauſe of ſummer and winter. Indeed one cauſe of them is, the longer or ſhorter continuance of the ſun above the horizon. As it continues longer in ſummer, it increaſes the heat, as much as it lengthens the day: and juſt the contrary in winter. But the chief cauſe is, the oblique or perpendicular direction of the ſun's rays. For 1. Perpendicular rays ſtrike on any plane, with greater force than oblique. And 2. A greater number of rays fall within the ſame compaſs, in a perpendicular rather than in an oblique direction.

A farther manifeſtation of the Creator's wiſdom we have in the *perpetuity*, *conſtancy*, and *regularity* of thoſe motions. How without an Almighty guide

guide ſhould thoſe vaſt bodies continue their courſes throughout all ages? How ſhould they perform their uſual ſtages, without the leaſt intermiſſion or diſorder? What piece of clock-work under heaven, was ever comparable to this? How ſteadily do all theſe motions conſpire, to anſwer the ends of divide providence, to diſpatch the noble offices of the ſeveral globes, to comfort and cheriſh every thing reſiding on them, by the uſeful change of day and night, and the ſeveral ſeaſons of the year.

We may learn the wiſdom of God, Thirdly, from the Figure of the heavenly bodies, ſo well ſuited to the motions, and to the whole ſtate and covenience of them. And 1. They are all nearly ſpherical: I ſay, nearly, to allow for their difference between their polar and equatorial diameter. Now this figure is both more capacious than any other, and more agreeable to a maſs in motion, each part of it being at a due diſtance from the center of motion and gravity: beſides, without this, there could have been no ſuch agreeable alterations of day and night, of heat and cold. And as to our own globe, the winds could not have fanned the air, as now, but muſt have been greatly retarded, if not wholly ſtopt, by the angles and jettings out of other figures. Laſtly, the waters would have had intolerable confluences; here too much, there none at all. So that inſtead of an habitable world, far the greateſt part would have been a deſart, or an uſeleſs bed of waters.

And all the parts of the earth are ſo diſtributed as may beſt miniſter to their ſeveral uſes. Thus the two grand parts, the Solids and Fluids, inſtead of being jumbled into one maſs, are admirably parted

parted, and as nicely difpofed of in proper places. The ftrata conveying fweet water in all or moft part of the world, confift of proper, pervious matter, remain diftinct from the other ftrata, and lie at fuch due depths, as either to break out in fountains, or to be dug into for wells: all which is a manifeft demonftration of the concern of a Wife Agent.

And not only the Planets are a demonftration of this, but the very *Comets* alfo: though their motions are fo far from being always the fame way, that they move fometimes contrary to each other. Their planes and directions lie every way, and their orbits are exceeding eccentrical. But this very eccentricity is an admirable contrivance of the Creator, to prevent their difturbing either the planets, or one another, by mutual attractions. By this means they have fufficient room to revolve in: and by afcending to very great heights, and fpending almoft all their time in the remote regions of the univerfe, at vaft diftances both from the planets and each other, they incommode neither. Whereas had they moved in the fame plane with the planets, they would fometimes have come too near them: and poffibly have difturbed *their* motions, or even dafhed againft them.

But what would all the planets have done, had they not been fupplied with light and heat? And what an indulgent provifion of thefe is made even for the moft diftant of them? See the fun, fuch a prodigious mafs of fire, placed in the center of the fyftem, to fcatter his light throughout the whole, and to warm and cherifh us by day:

and

and ſuch a noble retinue of moons and ſtars, attending and aſſiſting us by night! And we ſee the ſame care of the Creator, extended to all the other planets. According to their ſeveral diſtances, they have proportionably a great number of moons, and Saturn a ſtupendous ring beſides, to ſupply the decreaſe of light and heat. Who can help being amazed at ſuch well-contrived, ſuch ſtately works of God? Who can partake of their beneficial influences, and not adore the wiſdom and kindneſs of their Maker?

One or two points, which have been lightly mentioned already, deſerve a more particular conſideration.

That he who diſpenſes exiſtence at his will, ſhould multiply, extend, enlarge, and add a kind of immenſity to his works, is not properly what ſurprizes me; at leaſt my amazement is chiefly founded on my own extreme littleneſs. But what aſtoniſhes me moſt, is to ſee, that notwithſtanding this my extreme littleneſs, he has vouchſafed to regulate his immenſe works, by the advantages I was to receive from them! Thus he has placed the ſun juſt at ſuch a diſtance from the earth on which I was lodged, that it might be near enough to warm me, yet not ſo near, as to ſet it on fire.

The rays that proceed from a globe of fire, many thouſand times bigger than the earth, muſt needs have an inconceivable force, while they remain cloſe to each other. But they are more and more diſtant from each other, as they advance from their common center. toward the vaſt circumference they are to enlighten, and their force dimnishes in proportion. Had the earth been placed, where these rays were still too numerous, and too near each other, it could never have borne their burning heat. Had it been placed farther off than it is, it would have received but a faint warmth, such as was insufficient for its usual productions. It stands in that very place where it is secured from all these inconveniences, and within the reach of every advantage,

The Heavens declare the grandeur and glory of God, from one end of the world to the other. But the sun alone affects us more than all the beauties the heavens can display to our sight: the heavens are only a pavillion to the sun. The richly embroidered veil which seemed to hide him from us for a season, is removed, when he advances. At first, he appears as a young bridegroom, coming out of his chamber. His splendor is then full of mildness, and he is easy of access. But he is commissioned to convey the heat and the life, as well as the light, every where. He darts more and more fire as he ascends. He passes from one end of the heavens to the other. There is nothing can either be hid from his light, or subsist without his heat. And by his penetrating fires he reaches those very places which are inaccessible to his rays.

And yet we need his absence at proper intervals, no less than we do his presence. For *night* and sleep are so connected, that when we want repose, we generally procure a kind of artificial night. Our senses are seldom unbent, but by the removal

removal of that which agitates them. And this is the service for which night is appointed, and which it excellently well performs. It does not come in a blunt and abrupt manner, to extinguish the light of the day, and all on a sudden to rob us of the sight of the objects we are intent on: but advances only by slow steps, and brings on darkness by degrees. It is not till after reminding us of the necessity of taking rest, that it covers the face of nature.

During the time of man's repose, night hushes every noise. It indeed suffers a few animals, whose grim aspect might scare him, to go forth, and silently seek their food. It permits however, the animal that stands centinel by him, to give him notice of what concerns him. But it keeps the horse, the ox, and all his domestics fast asleep around him. It disperses the birds, and sends each to his respective abode. As it comes on, it gradually hushes the winds, to secure the lord of nature's rest. It causes his repose to be reverenced every where: the moment of which is no sooner come, but all creatures retire, and for several hours, an universal silence reigns.

Nor yet is nature's palace wholly void of light. As some may be constrained to travel by night, several flambeaux are scattered through the firmament. But these, though they prevent total darkness, yield only a gentle light. Nor ought those who then wake to be supplied with such a light, as would interrupt the repose of others.

But it is not by its darkness only, that night is useful to us. Its coolness likewise is of use: and this increaſing the ſpring of the air, makes it capable of working with greater activity, and giving new vigour both to the dry plants and the enfeebled animals. It is to preſerve this cool, that the moon reflecting the light of the ſun, gives it without any ſenſible heat. In vain do we collect her rays by the ſtrongeſt burning glaſs. An admirable caution of the Divine Artificer, who has reſerved for the night ſeaſon, a light ſtrong enough to remove darkneſs, yet too weak to alter the coolneſs of the air.

When man is inclined to have the benefit of this, he ſees no more the proſpects of the day; but night, in her turn, favours him with another, that has charms to itſelf.

We cannot doubt but theſe immenſe globes of fire, which inlighten our night, have all their peculiar appointments, which anſwers, in God's purpoſes, the magnificence of their appearance. But who ſhall preſume to explain, what the Almighty has thought fit to conceal? The ſmall glimpſes which a few are permitted to have, being quite unknown to the bulk of mankind. It is not in the particular deſtination of each ſtar, nor in the general harmony of all, that we are to look for the means of inſtructing man, or regulating his affections. But yet what we do ſee, and know concerning them, is matter for the deepeſt admiration. We ſee innumerable fires hung up in the magnificent ceiling of our abode: and the dark azure which ſerves them as a ground, ſtill heightens their beauty and brightneſs. But their rays are diſperſed through ſpaces ſo immenſe, that when they come to us, they are quite deſti-

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tute of heat. Thus by the Creator's providence we enjoy the ſight of a multitude of fiery globes, without any danger of deſtroying the coolneſs of our night, or the quiet of our repoſe.

The ſum of what has been ſaid, with ſome farther improvements, I add in the words of Mr. Hervey.

" The earth is, in fact, a round body, though in ſome parts raiſed into hills, or ſunk into valleys, in others ſpread out into wide and immeaſurable plains. For the loftieſt mountains bear no more proportion to the whole ſurface of the ball, than a particle of duſt on the aſtronomers globe, bears to its whole circumference. We may fancy that it has deep foundations, and reſts on ſome ſolid baſis. But it is pendent in the wide tranſparent ether, without any viſible ſupport either from above or beneath. It may ſeem to remain ſtill and motionleſs: but it is continually *ſailing* through the depths of the ſky, and in the ſpace of twelve months finiſhes the mighty voyage. This periodical rotation produces the ſeaſons, and completes the year. And all the time it proceeds in its annual circle, it *ſpins* upon its own center, and turns its ſides alternately to the great fountain of light. By this means the day dawns in one hemiſphere, while the night ſucceeds in the other. Without this expedient, one part of its regions, would during half the great revolution, be ſcorched with exceſſive heat, and languiſh under an uninterrupted glare: while the other would be frozen to ice, and buried under diſmal and deſtructive darkneſs.

" The earth in the revolution which it performs daily on its own axis, *whirls about* at the rate of above a thouſand miles an hour. What an amazing force muſt be requiſite, to protrude ſo vaſt a globe, and wheel it on, loaded with huge rocks and mountains, with ſuch a prodigious degree of rapidity!

" Meantime the ſun, which ſeems to perform its daily ſtages, is *fixed* and *immoveable*. It is the great axle of heaven, about which the earth and many larger orbs wheel their ſtated courſes. And ſmall as it ſeems, it is far larger than the earth: Sir Iſaac Newton ſuppoſes, 900,000 times. Are we ready to cry out, How mighty is the Being who kindled ſuch a prodigious fire? And keeps alive from age to age, ſuch an enormous maſs of flame? And yet this ſun, with all its attendant planets, are but a very ſmall part of that grand machine, the univerſe. Every ſtar is really a vaſt globe, like the ſun in ſize and in glory. Nay, every ſtar, as ſome ſuppoſe, is not barely a world, but the center of a magnificent ſyſtem; has a retinue of worlds enlightened by its beams, and revolving round its orb: all which are loſt to our ſight, in immeaſurable wilds of ether.†

" But could you ſoar farther yet, could you wing your way to the higheſt apparent ſtar, you would there ſee other ſkies expanded, another ſun diſtributing his beams by day, with other ſtars, that gild the horrors of the alternate night: and other, perhaps nobler, ſyſtems eſtabliſhed, through the boundleſs dimenſions of ſpace. Nor does the dominion of the great Sovereign, terminate even here

† All this is ſpoken on the Newtonian Hypotheſis.

here. Even at the end of this vaſt tour, you would find yourſelf advanced no farther than the *ſuburbs* of creation: arrived only at the *frontiers* of the great Jehovah's kingdom.

" Think on this. When innumerable bodies, many of them more than an hundred thouſand miles in diameter, are ſet in *motion*: when the *orbits* in which they move are extended, to hundreds of millions of miles: when each has a *diſtinct* and *ſeparate* ſphere, for finiſhing his vaſt circuit: when none is *cramped*, but each *freely expatiates* in his unbounded career: when every one is ſo immenſely diſtant from the others that they appear each to other, as only ſo many ſpots of light: how aſtoniſhing is the expanſe which yields room for them all, and their widely diffuſed operations! To what lengths did the Almighty Builder ſtretch his line, when he marked out the ſtupendous platform! I wonder at ſuch an immeaſurable extent: my thoughts are loſt in this abyſs of ſpace.

" To go one ſtep farther ſtill: when I contemplate thoſe ample and amazing ſtructures, erected in endleſs magnificence, over all the ethereal plains: when I look on them as ſo many repoſitories of light, or fruitful abodes of life: when I remember there are orbs vaſtly more remote, than thoſe which appear to our unaided ſight: when I ſtretch my thoughts to the innumerable orders of beings, which inhabit all thoſe ſpacious ſyſtems, from the higheſt ſeraph to the puny nations that tinge the plumb with blue, or mantle the ſtanding pool with green. How various are the links in this immenſe chain, the gradations in this universal scale of existence! Yet all these are the work of God's hand, and are full of his presence!

"He rounded in his palm those dreadfully large globes, which are pendulous in the vault of heaven. He kindled those astonishingly bright fires, which fill the firmament with a flood of glory. By him they are suspended in fluid ether, and never can be shaken: by him they dispense a perpetual tide of beams, and never are exhausted. He formed that exquisitely fine collection of tubes, that unknown multiplicity of subtle springs, which organize and actuate the frame of the minutest insect. He bids the crimson current roll, the vital movements play, and joins together a world of wonders, even in an *animated point*. For there are living creatures abundantly smaller than a mite. Mr. Bradly mentions some, which by computation he found to be a thousand times less than the least *visible* grain of sand: at the same time he declares, that this was a bulky being, compared to others discovered by Mr. Lewenhoek. If then we consider the *several limbs*, which composed such an organized particle: the different *springs* which actuate those limbs; the flow of *spirits* which put those springs in motion; the various *fluids* which circulate; the different *secretions* which must necessarily be performed; together with the proportionable minuteness of the solids, before they arrive at their full growth: we shall see the utmost reason to own, that the Creator is greatly glorious even in his smallest works.

"To conclude this head. If the stars are magazines of *fire*, and immense reservoirs of *light*, undoubtedly

undoubtedly they have some grand uses, suited to the magnificence of their nature. To determine what uses, is not possible, in our present state of distance and ignorance. This however is clear, they are disposed in such a manner, as is most pleasing, and serviceable to mankind. They are not placed at such an infinite remove, as to lie beyond our sight: neither are they brought so near to our abode, as to annoy us with their beams."

12. A year or two after the preceding volumes were published, the little sketch of Astronomy therein given, (or rather my doubts concerning it) was warmly attacked in the London Magazine. The substance of those objections, and of my answer, I have here subjoined.

SIR,

I am obliged to you for your queries and remarks; and so I shall be to any who will point out any thing wherein they think I have been mistaken. It would not be strange, if there should be many mistakes in the "Compendium of Natural Philosophy:" as Philosophy is what for many years I have only looked into at leisure hours. Accordingly in the preface of that treatise I said, "I am thoroughly sensible, there are many, who have more ability, as well as leisure, for such a work than me. But as none of them undertakes it, I have myself made some little attempt in the following volumes."

Q. 1. "You say, The sun is *supposed* to be abundantly larger than the earth? Is it not *demonstrable*, that he is so."

 I do

I do not know whether it is, or no.

Q. 2. " Why do you ſay, the moon is *ſuppoſed* to be forty-five times ſmaller than the earth, when the moon's bulk is nicely known ?"

It is not *known* by me, nor, I doubt, by any man elſe.

Q. 3. " You ſay, Jupiter is ſuppoſed to be twenty-five times larger than the earth : and in the next page, that his diameter is ſuppoſed to be 130,655 miles. If ſo, is he not 4096 times larger than the earth ?"

Undoubtedly. But I do not undertake to defend either one ſuppoſition or the other.

Remark 1. " You ſay, p. 148. Even with reſpect to the diſtance of the ſun, it is wiſeſt to confeſs our ignorance, and to acknowledge we have nothing to reſt upon here, but mere uncertain conjecture."

I did not ſay this of the diſtance of the ſun in particular. My words, p. 146 are, " With regard to their *diſtance* from the earth, (the diſtance of all the bodies in the ſolar ſyſtem) there is ſuch an immenſe difference in the calculations of Aſtronomers, even with reſpect to the diſtance of the ſun —that it is wiſeſt to confeſs our ignorance," namely, with regard to *their* diſtance.

To prove that we are not ignorant hereof, you ſay, " The knowledge of the ſun's diſtance depends on finding its parallax, or the angle that the ſemi-diameter of the earth appears under at the ſun, which angle is ſo very minute, that an error of but a ſingle ſecond, will give the diſtance very

very confiderably greater or lefs than the true diftance." It will: and therefore I doubt, whether the diftance of any heavenly body can ever be known by this means.

"But Dr. Keil fays, we are affured by various methods made ufe of to obferve the fun's parallax, that his diftance from us is more than twenty-eight millions of miles." He may be affured: but I am not. "He fays farther, two eminent aftronomers have fince determined the fun's diftance to be about feventy fix millions of miles: now if the leaft diftance poffible is *abfolutely determined*, how can it be wifeft to confefs our ignorance?" If it be—But I doubt, it cannot be determined at all: at leaft, not by the fun's parallax: "feeing this is fo very minute that an error of a fingle fecond will give the diftance very confiderably greater or lefs than the true."

R. 2. In p. 143, you tell us. —— The whole paragraph runs thus. "It is now almoft univerfally fuppofed, that the moon is juft like the earth, having mountains and valleys, feas with iflands, peninfulas and promontories, with a changeable atmofphere, wherein vapours and exhalations rife and fall. And hence it is generally inferred, that fhe is inhabited like the earth, and by parity of reafon, that all the other planets as well as the earth and moon, have their refpective inhabitants." [I take this to be the very ftrength of the caufe. It was this confideration chiefly, which induced me to think for many years, that all the planets were inhabited.] "But after all comes the celebrated Mr. Huygens, and brings ftrong reafons why the moon is not, and cannot be inhabited at all, nor any fecondary planet whatever. Then"

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(if the firſt ſuppoſition ſinks, on which all the reſt are built) " I doubt we ſhall never prove that the primary are. And ſo the whole hypotheſis, of innumerable ſuns and worlds moving round them, vaniſhes into air."

In order to prove, that there are innumerable ſuns, you ſay, 1. " It is found by obſervations on the parallax of the earth's orbit, that a fixed ſtar is ten thouſand times farther from the ſun than we are."

" I can build nothing on theſe obſervations, till parallaxes can be taken with greater certainty than they are at preſent. Therefore I ſtill want proof, that any one fixed ſtar is one thouſand times farther from the ſun than we are."

2. " They are fiery bodies." I ſuppoſe they are. But this cannot be proved from their diſtance, till that diſtance itſelf is proved.

3. " It is demonſtrable, that Sirius is as big as the ſun."

Demonſtrate it who can.

4. " Seeing the fixed ſtars are not much leſs than the ſun, they are to be eſteemed ſo many ſuns."

Not much leſs! How is this proved? To argue from the diſtance, is to prove *ignotum per æque ignotum.*

" You ſee, Sir, the hypotheſis of innumerable ſuns, is ſo far from vaniſhing into air, that it is *almoſt altogether* founded on demonſtration."

Indeed I do not ſee one tittle of demonſtration yet from the beginning to the end.

In

In order to prove that the planets are inhabited, you ſay, 1. "The earth is ſpherical, opake, enlightened by the ſun, caſting a ſhadow oppoſite thereto, and revolving round it, in a time exactly proportioned to its diſtance. The other planets reſemble the earth in all theſe particulars. Therefore they likewiſe are inhabited." I cannot allow the conſequence.

2. "The earth has a regular ſucceſſion of day and night, ſummer and winter. So probably have all the planets. Therefore they are inhabited." I am not ſure of the antecedent. But however that be, I deny the conſequence.

3. "Jupiter and Saturn are much bigger than the earth." Does this prove that they are inhabited?

4. "The earth has a moon, Jupiter has four, Saturn five, each of them larger than ours. They eclipſe their reſpective planets, and are eclipſed by them."

All this does not prove that they are inhabited.

5. "Saturn's ring reflects the light of the ſun upon him."

I am not ſure of that. And till the fact is aſcertained, no certain inference can be drawn from it.

6. "But is it probable God ſhould have created planets like our own, and furniſhed them with ſuch an amazing apparatus, and yet have placed no inhabitants therein."

Of their apparatus I know nothing: however if all you aſſert be the *probability* of their being inhabited, I contend not.

7. "They

7. "They who affirm, that God created thofe great bodies, the fixed ftars, only to gives us a fmall dim light, muft have a very mean opinion of the Divine Wifdom."

I do not affirm this, neither can I tell, for what other ends he created them: he that created them knows. But I have fo high an opinion of the Divine Wifdom, that I believe no child of man can fathom it. It is our wifdom to be very wary how we pronounce concerning things which we have not feen.

R. 10. "Suppofe fome intelligent beings in one of the planets, who were

Slaves to no fect, who fought no private road,
But look'd thro' nature up to nature's God:

viewed the earth from thence, they would argue, it muft be inhabited, as we argue that the other planets are. But the fuperftitious would oppofe this doctrine, and call it mere uncertain conjecture."

I fee no argument in this: but perhaps I do not underftand it. Are you applauding the fuppofed inhabitants of Venus, for not being *flaves* to the *chriftian fect?* Otherwife, what has fuperftition to do in the cafe? Why is this dragged in by the head and fhoulders? If there be fuperftition here, it is on *your* fide, who believe becaufe you *will* believe: who affent to what you have no evidence for, and maintain what you cannot prove. At prefent you are the *volunteer* in faith: *you* fwallow what choaks my belief.

R. 11. "You quote Dr. Rogers," — But I do not undertake to defend his hypothefis, or any other. "Our beft obfervators could never find the

the parallax of the ſun to be above eleven ſeconds." But I cannot depend on their obſervations: eſpecially when I find one of the chief of them, in computing the diſtance of the ſun, to ſtride from twenty-eight millions of miles, to ſeventy-ſix: near fifty millions of miles at once! After this let any impartial man judge what ſtreſs is to be laid on parallaxes!

"But Dr. Rogers ſuppoſes the parallax of the ſun to be five minutes, which others cannot find to be above eleven ſeconds. Why Doctor, if this be true," (namely, that the parallax which was lately but eleven ſeconds, is now increaſed to five minutes) "the earth has *approximated* thirty times *nearer*" (a little harmleſs tautology) "to the ſun." That is, if both the computation of Mr. Keil, and that of Doctor Rogers be true! But whoever ſuppoſed this? If the one be true, the other is undoubtedly falſe.

"To conclude. Since there is no arguing againſt facts, and ſince the ſun's parallax is found not to exceed eleven ſeconds, ought you not to give up that hypotheſis as abſurd and ridiculous?"

Yes, as ſoon as any of thoſe facts appear: till then I neither eſpouſe nor give it up. But I ſtill look upon it as extremely ingenious, and full as probable as any other.

Before I conclude, permit me, Sir, to give you one piece of advice. Be not ſo *poſitive*: eſpecially with regard to things which are neither eaſy nor neceſſary to be determined. I ground this advice on my own experience. When I was young I was *ſure* of every thing. In a few years, having been miſtaken a thouſand times, I was not half ſo ſure of moſt things as before. At preſent I am hardly ſure of any thing, but what God has revealed to man.

Upon

Upon the whole, an ingenious man may easily flourish on this head. How much more glorious it is for the great God to have created innumerable worlds, than this little globe only! But after all, I would ask one plain question. Suppose there are more worlds than there are sands on the sea-shore? Is not the universe finite still? It must be, unless it be God. And if it be finite, it can still bear no proportion to him that is infinite: no more than this ball of earth does. How large so ever it be, still compared to him it is as nothing, as the small dust of the balance. Do you ask then what is this spot to the great God? Why, as much as millions of systems. *Great* and *little* have place, with regard to us: but before him they vanish away. Inlarge the bounds of creation as much as you please, still it is but a drop to the Creator.

And still the power of his Almighty hand,
Can form another world from every sand!

Yet were this done, there would be no more proportion between the world and its Creator, than there is now!

It will easily be observed that I do not *deny*, but only *doubt* of the present system of astronomy. But the ingenious Mr. Kennedy goes much farther in his Astronomical Chronology. I beg leave to present the impartial searchers after truth, with a short extract from it.

" Although many persons of great abilities have thought sacred chronology worthy their most diligent researches, yet they have all failed in the main point. They have taken it for granted, that the scriptural computations are quite unastronomical.

nomical. The title of *The World's Chronology*, has been fixed to very different collections of years, without looking for any aſtronomical æra, to ſupport the title. This is the firſt attempt of that kind which has been made.

"I have largely proved the fundamental propoſition of the following ſcheme, namely, That Moſes fixes the poſition of the ſun and moon with regard to each other at the creation. And this revealed poſition of the ſun and moon, with reſpect to each other at the creation, I call the ſcriptural, aſtronomical æra.

By means of this æra we may keep even pace with the two great luminaries, from the firſt year of the world till now. And till now my concluſions are confirmed, by the joint atteſtations of the ſun and moon, the two *faithful witneſſes in heaven*.

"By theſe it is fully proved, that time commenced at our autumnal equinox, at the fourth day of the creation, at the full-moon, or the fifteenth day of the firſt month of the firſt lunar year.

"From the autumnal equinox at the creation to the ſame in 1761, have elapſed 5768 years. Indeed, Capellus ſuppoſes time to commence 2 years, Archbiſhop Uſher four years later. But could the errôr of a ſingle year be diſcovered in the ſeries I have collected, all would fall to the ground.

"Touching the common aſtronomy, I obſerve, 1. Aſtronomers ſtill divide the ecliptic into 360 degrees. But how unnaturally? Three hundred and ſixty degrees, and near one fourth, are undeniable more correſpondent to the ſuns annual motion. And upon this diviſion we can make a truer calculation, than can be made upon any other.

"2 The

" 2. The inequality of solar tropical years, and the inequality of the equations of natural days, are established doctrines. But whoever computes the times of equinoxes and solstices, and submits his calculations to the test of the latest and best observations, will find no room for any equations at all.

" 3. Astronomers unanimously maintain, that at the end of nineteen lunisolar years, the mean new moons, and the mean full moons happen, about an hour and a half sooner than they did at the beginning of the cycle. On the contrary, I undertake to evince, that the very reverse of this is true. I allow, that at the end of nineteen lunisolar years, the moon departs from the sun: but it departs from it, not by a retrocession westward, but by a progression eastward. That is, the mean new moons and the mean full moons fall out, not an hour and a half sooner, but almost two hours later. Therefore the doctrine of lunar anticipations has no foundation in nature.

" 4. Although the quantity of a *solar tropical year* is a conclusion in astronomy, yet such an unhappy fatality has attended this research, for almost two thousand years past, that whoever examines the vast variety of opinions, must see nothing has yet been determined with certainty. So that instead of a precise and established definition, he finds little more than this general account, that the quantity of the natural year has been long and much sought after, but with small success: so that it seems at this day to remain among the yet undiscovered secrets of nature.

" Indeed

"Indeed to know this with all exactness, one would think no more is needful than to examine the tables of obfervations. Let us then examine that made by Tycho Brahe, in Queen Elizabeth's time, and that by Doctor Bradley an hundred and feventy years after. But in Tycho's table of twelve terminations, feven of them differ a minute from the other five. And this difference perplexes the conclufion, and leaves it in a ftate of uncertainty. Proceed we then to Dr. Bradley's tables. But thefe leave a latitude of twenty-one minutes. Thus we fee how imperfect the knowledge even of the folar tropical year ftill is, and that no true judgment can be formed concerning it, either from obfervation or tabular calculation.

"5. It requires no fmall fkill, even to determine the diftances of the fun's four ftations, at the vernal and autumnal equinox, and the fummer and winter folftice. Nay, it is a queftion whether this determination likewife muft not ftill be reckoned among the fecrets of nature.

"And if we would correct the tables of thefe by Dr. Keil's Rule, yet this very correction leaves us four different meafures according to the majority of Tycho Brahe's corrections, according to Sir Ifaac Newton's, Dr. Halley's, and Dr. Bradley's corrections. So that ftill we come to no certainty, even as to the folar ftations. We are at a ftand, like a traveller, who arriving at a place where four ways meet, is at a full ftop, for want of a clear diftinction, which of them to take.

"6. The greateft aftronomers are not agreed, even as to the length of a natural day.

Mr.

" Mr. Ferguſon obſerves,

" The fixed ſtars appear to go round the earth in twenty-three hours, fifty-ſix minutes and four ſeconds, and the ſun in twenty-four hours. Therefore in three hundred and ſixty-five days, meaſured by the returns of the ſun to the meridian, there are three hundred and ſixty-ſix days as meaſured by the ſtars returning to it. The former are called Solar days, the latter Sidereal. But whoever will compare this with the determinations of Dr. Keil, will find them flatly contradictory to each other. And the farther he examines the moſt celebrated writings, the more deeply he will be convinced, that neither the preciſe length of a ſidereal day, nor the complement of the ſolar, has yet been determined with certainty."

Whoever deſires to ſee theſe propoſitions proved at large may have recourſe to the book itſelf. But if theſe things are ſo, what becomes of the whole fabric of even Newtonian aſtronomy? How can I depend on the calculations of thoſe concerning the motions of the heavens, who know ſo little about the earth? What inſtruction can they give me concerning other ſyſtems, who are ſo unſkilled with regard to our own? Why does not ſome eminent aſtronomer undertake this daring man, who ſo violently attacks the very foundation of their building? For if his remarks are juſt, ſenſible men will be inclined to think, that after all the parade of mathematical demonſtration, there is little more certainty in aſtronomy itſelf, than even in judicial aſtrology!

And how juſt are the great Mr. Boyle's remarks, upon the whole of Natural Philoſophy? " The moſt, ſays he, even of modern virtuoſi, fancy

fancy more certainty in their phyfical theories than a critical examiner will find. I will touch only on two fubjects, which we commonly think are, and which furely ought to be, moft thoroughly underftood: I mean, the nature of the Body in General, and the nature of Senfation. As to the firft, fince we turn ourfelves no way, but we are invironed by corporeal fubftances, one would think, an object that fo many ways affects our Senfes, fhould be perfectly known to us. And yet the notion of the Body in general, or what it is that difcriminates bodies from other fubftances, is not by any means agreed even among the modern philofophers. And indeed, no account of it, which has yet been given, will extricate us out of the difficulties of that no lefs perplexed than famous difpute, "Of the Compofition of Bodies." But the difficulties attending this, will, till they are removed, fpread a thick night over the notion of Bodies in general. For either a corporeal fubftance is divifible into extended parts, and each of thefe divifible into other parts fmaller and fmaller, *ad infinitum*, or this divifion muft ftop fomewhere. But there are inconveniencies, not to fay abfurdities urged againft either of thefe fuppofitions. The objections on both fide are fo ftrong that the moft fenfible and candid men, after having tired themfelves and their readers with ftriving to folve them, have at length owned them to be infoluble.

"But though we do not underftand the nature of Bodys in general, muft we not perfectly underftand what paffes within ourfelves, in reference to the particular bodies we daily fee, and hear, and fmell, and tafte, and touch? Thefe we know by our fenfes: but how little do we know of the manner

manner wherein our ſenſes inform us of any thing? Senſation we allow is not performed by the organ, but by the mind perceiving the motion produced in the organ. Aſk then a philoſopher how the ſoul comes to be wrought on, and that in ſuch various manners, by thoſe external bodies, which are the objects of our ſenſes? He will tell you, that by the impreſſions on the organs, they variouſly move the nervous fibres, wherewith thoſe parts are endowed, by which the motion is propagated to the brain: where theſe motions being perceived by the ſoul, become Senſations, through the intimate union of the ſoul with the body. But give me leave to take notice that this union of an incorporeal with a corporeal ſubſtance, is a thing ſo difficult to comprehend, that the profoundeſt ſecrets of theology, not to ſay the incarnation itſelf, are not more abſtruſe than this. For how can we conceive that a ſubſtance purely immaterial, ſhould be united without any medium (and in this caſe there can be none) with a body that cannot poſſibly lay hold on it, and which it can pervade, and fly away from at pleaſure? And it is almoſt as difficult to conceive, how any part of the body, without excepting the animal ſpirits of the brain (for theſe are as truly corporeal as the other parts) can make impreſſion on a ſubſtance perfectly incorporeal, and which is not affected by the motions of any parts but the nerves. Nor is it a ſmall difficulty to conceive how a finite ſpirit, can either move, or (which is much the ſame thing) regulate and determine the motion of the body.

" And ſuppoſe the ſoul in the brain does perceive the different motions communicated to the ſenſes, yet this, though it may give ſome account

of

of Senſation in general, does not give us any ſatiſ-factory reaſons of particular ſenſations. For if I demand, for inſtance, when I look on a bell that is ringing, ſuch a motion, in the brain produces in the mind the perception of ſeeing and not hearing, and another motion coming from the ſame bell at the ſame time, produces in the mind, the perception of hearing, not ſeeing: what can be anſwered, but that ſuch is the good pleaſure of the Author of nature? And if we aſk about the differing objects of any one ſenſe, as, Why the light reflected from ſnow, produces a ſenſation of whiteneſs rather than redneſs? Why Caſtor produces a ſtink, and not a perfume? Why ſweet things generally pleaſe, and bitter diſguſt us? Nay, why a little of ſome objects (ſuppoſe fire) will give pleaſure, a little more of them give pain? To theſe and a thouſand other queſtions of the ſame kind, it can only be anſwered, Such is the nature of man. So plain is it, that we are yet to ſeek both for the definition of a corporeal ſubſtance, and for a ſatisfactory account of the manner of our own ſenſations. Yet without the true notion of a body, we cannot underſtand the object of phyſics in general: and without knowing the nature of the ſenſation, we are ignorant of that, from which we derive almoſt all that we know of any body in particular.

" And as our philoſophical knowledge is not very deep, not reaching with any certainty to the bottom of the moſt obvious things, nor penetrating to their inmoſt nature: ſo it is not very wide, not being able to give us with any clearneſs or particularity, an account either of the celeſtial parts, of the world, or of the deeply ſubterraneous parts of which the ſuperficial part is but a ſmall, not to ſay contemptible,

contemptible portion. As to the very globe we inhabit, (not to mention how many plants and minerals we are wholly ignorant of, and how many others we are but ſlenderly acquainted with) the objects about which our enquiries and experiments are converſant all belong to the ſuperficial parts of the globe, of which the earth known to us is but the cruſt. But what the internal part of it is, we no more know, than what is the ſubſtance of the remoteſt ſtars. Even among the moderns ſome think the internal part of it, is pure elementary earth. Others imagine it to be fire, the receptacle of natural or helliſh flames. Others will have the earth to be a ſolid magnet; while others believe it was once a fixed ſtar: and that though it is now degenerated into a planet, yet its internal parts are of the ſame nature as before: the change proceeding only from thick ſpots that cover it, (like thoſe frequently obſerved upon the ſun) by the condenſation whereof the firm earth, which we inhabit, was formed. And it is difficult to demonſtrate the falſhood, as the truth, of each of theſe jarring opinions. For whereas it is at leaſt three thouſand five hundred miles to the center of the earth, it does not appear, that men have been able to penetrate towards it either by land or by ſea, above one, or two miles at the moſt, and that not in above three or four places. So that as yet we have not penetrated any thing deep upon the huſk, without at all reaching the kernel of the globe. And what is this globe, of which itſelf we know ſo little, to thoſe vaſt globes of which we know much leſs? For though the former aſtronomers give us their diſtances and magnitudes as exactly as if they had meaſured them, yet the latter mathematicians give us reaſon

to

to doubt of what thoſe have delivered. For ſince we can obſerve no parallax in the fixed ſtars, (nor perhaps in the higheſt planets) we muſt ſtill be to ſeek for a method to meaſure the diſtance of thoſe bodies. And not only the Copernicans make it many hundred thouſand miles greater than the Ptolemeans, but Ricciolus makes it vaſtly greater than the Copernicans themſelves. Nor can we wonder at theſe huge diſcrepances (though ſome amount to many millions of miles) when we conſider that Aſtronomers do not meaſure the diſtance of the fixed ſtars, by their inſtruments, but each accommodates the diſtance of them to his peculiar hypotheſis. From this uncertainty of the diſtance of the fixed ſtars, it is eaſily inferred, that we are not ſure of their bulk: no, not even in reference to one another; ſince it is doubtful whether the different ſizes they appear to be of, proceed from an inequality of bulk, or only from an inequality of diſtance. But beſides theſe, there are divers things relating to the ſtars, ſo remote from our knowledge, that they are not even enquired into: ſuch as theſe, Why the number of the ſtars is neither greater nor leſs than it is? Why ſo many of them are ſo placed, as not to be viſible to the naked eye? Why of the viſible ones, ſo many are in one part of the ſky, and ſo few in others? Why they are not placed in ſome order, but ſcattered over the ſky, as if it were by chance? Many queſtions might be added, as concerning the ſtars, ſo concerning the interſtellar parts: as whether they are empty, ſave where they are pervaded by light, or filled with ethereal matter? So that our knowledge is much ſhort of what is generally thought. For the earth being but a point, compared to the orb of the ſun: which orb itſelf is but a point in respect of the firmament: of how little extent must our knowledge be, which leaves us totally ignorant of so many things touching the vast bodies which are above us, and penetrates so little a way into the earth beneath us, that it seems confined to but a small share of a superficial part of a physical point."

Perhaps it will be acceptable to calm, dispassionate men, if I add another extract from a very sensible writer, containing a few short observations, on the whole present system of Philosophy.

1. "The first axiom in the present philosophy is, That all *Matter is indifferent to Motion or Rest*. But do we not here stumble at the threshold? laying as a fundamental truth, what is manifestly false? For Motion and Rest are such opposites, that implies a contradiction to suppose an equal disposition to either, inherent in the same body. The one is a *positive*, which necessarily implies power, the other a mere *negative*, which implies no power in any direction.

2. Matter containing in itself no power of any kind, can give no *resistance* to any impression upon it; neither can it of itself *continue* to exert the effects of that impression. Therefore the second axiom, or rather the phænomena, from which it is deduced, must arise, not from matter in itself, but from the relation which all matter bears to the universal system of nature.

3. The third axiom, concerning *re-action* is as exceptionable as the two former. For it may easily be shewn, that the Re-action of matter depends

pends entirely on gravity. If gravity were subtracted, there is no proof or reason to suppose, that bodies would exert either Resistance or Reaction. All these axioms therefore, instead of being absolute laws, are mere phænomena depending on other causes, which causes it is incumbent upon the philosopher to look for.

4. The *projectile power* never can balance that of gravitation, so as to maintain the motion of the planets. It can never recover its force when it is resisted, whereas gravity can. Therefore the constant bending of its direction, which must be equal to a constant proportionable resistance, must uniformly and perpetually weaken its power, and strengthen that of gravitation; so that the direction of motion must necessarily sink more and more, and at last fall wholly into the direction of gravitation. It follows that no power acting upon an orb which gravitates towards its center of motion, can possibly maintain its projectile motion, in the direction of a circle.

5. Even on supposition that projection and gravitation equally retained their propensity to motion though resisted, yet those powers could not move the planets in ellipses, because in the same proportion as the one prevailed over the other, in the same proportion it must alter the tendency of motion towards its own direction. And none can explain how, when a quantity of motion and also of inclination is gained by gravitation over projection, the orb will, while these remain unchanged, leave at any point the direction of the moving power that prevails, and recede into the direction of the weaker power, or *è contra*.

 6. Again

6. Again. From the proportions of the forces required between gravitation and projection, in order to move the orbs in circles, it is evident that these two powers cannot be the cause of their motions. For by comparing the forces of these it appears, that the force of gravitation is not such in proportion to that of projection, as to bend the direction of the projected body sensibly from the right line.

7. The motion of the *moon* along with the earth, cannot be owing to her gravitating towards it, nor to a projection impressed upon her, in common with the earth; because she has a projection of her own round the earth. And she cannot be so projected as to move in two different orbits at one and the same time, by the *vis inertiæ* continuing one projectile motion round the sun, and another round the earth. Therefore the motion of this, and by a parity of reason, that of all the secondary planets, must be guided every moment either by mechanism or by a spiritual power.

Indeed Sir Isaac thought these powers might arise from a subtle, etherial medium, diffused through the whole universe: but this is only retiring a step farther in the dark. For it comes to one, whether the cause of attraction be assigned to grosser bodies themselves, or to the impulse of a medium that penetrates them. If the powers of that supposed medium are unmechanical, they must be spiritual. And seeing the medium is only supposed, it is more natural to assign these unmechanical powers, to bodies which we know disposed to these motions, than to supposed bodies, which we know nothing of.

Farther. If Sir Isaac supposes such a medium for maintaining attraction, gravitation, and elasticity, how

how came he not to ſuppoſe that the ſame is concerned, in ſupporting his axioms or laws of motion? For the knot does not lie in gravitation or attraction, or any *particular kind* of motion, but in finding powers to produce and maintain *motion in general.* If theſe are mechanical, it is eaſy to ſuppoſe, though we ſhould never be able to explain in what manner that the contriver has a adjuſted the mechaniſm to produce all the motion obſervable in the creatures. But if they are unmechanical laws, properties, or whatever we may call them, there is no occaſion for ſuppoſing any cauſe of gravitation, or for taking it amiſs to have it called an occult quality, unknown virtue, charm, law, or any word we have no meaning to.

8. This unmechanical philoſophy has a bad influence in obſtructing our advancement in the knowledge of nature. For how can enquiries into the powers of nature be carried on to any degree of perfection, under the direction of a ſyſtem which muffles our eyes with unmechanical laws of matter, ſuppoſe the baſis of mechaniſm, inſtead of examining whether theſe themſelves are not the production of mechaniſm? Such are the indifference of matter to continue itſelf either in reſt or motion: re-action equal to action: the reſiſtance of matter to a change of ſtate: gravitation, attraction, repulſion, elaſticity: preſſure of fluids in all directions: a fluid with no coheſion of parts, moving in diverging lines; whoſe parts are poſſeſſed of different degrees of attractability by other bodies contrary to that law which makes gravitation ſimply as the quantities of matter: a fluid poſſeſſed of alternate fits of attraction and repulſion! How weak is it, to make theſe the baſis of mechaniſm, rather than the reſult of it?

9. Let us now examine these matters more closely. In the present philosophy, *Space* is always considered in the first place; because without admitting space void of matter, the whole system falls to the ground.

This same infinite Space is the most wonderful thing within the whole range of being. It is neither God nor his creature, and yet is inseparable from the being either of God, or of any thing he can create. It is infinite both in its extension and in its duration. It is immoveable and indivisible. If a compleat definition of it were put into a lady's pocket-book, she would guess it to be an enigma for *nothing:* and would be astonished to hear, that it is the quintessence of a most metaphysical and most subtle argument maintained by a most celebrated divine and philosopher.

The only positive idea applied to space is *Extension*. But we can apply no idea to any subject, which the subject itself does not impress. Matter forces upon our senses the idea of its extension. But how can we invest with this, a subject which never excited any idea in us, and consequently has no existence *to us?* Space is only one of the ideas excited by matter, and by the mind abstracted from its subject, just as we can image a colour to ourselves, without connecting any particular subject with it. A little more of the same metaphysics, which can prove that *nothing* is extended, will prove that space is purple. But why should I say purple? Space is of all colours, if light is reflected by a vacuum. It is an ingenious contrivance, to render *nothing* a subject of conception, by dressing it in a suit of cloaths borrowed from *something*.

To illustrate the doctrine of Space, a common experiment shews, that by an image formed in the

the air, at a certain diſtance between a concave glaſs and any perſon looking into it, extenſion becomes an object of ſenſe, where there is neither ſolidity nor any ſenſible reſiſtance. But this does not prove that an image is formed in empty Space, or where there is no matter: it rather proves that theſe ſpaces which they call empty, are full of matter. For as the ſenſes can be affected only by matter, they infallibly determine where matter is. So that we are as ſure there is matter where we ſee any thing, though we cannot feel it, as that it is there, where we feel, though we cannot ſee it.

10. Let us now more attentively conſider the firſt ſuppoſed law of motion, *Matter is indifferent to continue in Motion or in Reſt.*

Reſt and Motion are the two greateſt oppoſites in nature, as oppoſite as matter and nothing. The mind therefore cannot be ſtruck with a more palpable contradiction, by affirming that a body is equally diſpoſed to hardneſs and ſoftneſs at the ſame time, than by ſaying it is equally diſpoſed to reſt and motion.

Motion is a poſitive thing, which implies action, power, or force, wherever it acts. Reſt is a mere negative, a ſtate wherein body is diveſted of all theſe. It exerts no power; it acts or preſſes, neither backwards nor forwards, neither up nor down. Now the ſame body cannot be indifferent to the exerting of power and to the exerting of none at the ſame time.

Again. It is impoſſible that reſt and motion can be equally indifferent to matter. When matter was created, ſhould we ſuppoſe the Creator to ſay, " Let it be," *without* determining in which of theſe ſtates it ſhould commence being; yet it is impoſſible it could begin to be, both moving and reſting. It could aſſume only one of theſe conditions, and muſt have remained therein for ever, unleſs ſome farther divine energy had given it a new determination. Now in which ever of theſe matter began to exiſt, that muſt be called its *Natural State*. And every alteration of that ſtate muſt be the effect of ſome power ſuperinduced upon it, which muſt ceaſe when the cauſe ceaſes.

Again. Matter may exiſt in reſt: but no *living* matter. All life in nature, whether mineral, vegetable, or animal, depends upon motion and activity. Therefore motion ſeems to be not the natural ſtate of matter, but ſupperadded thereto, and conſtantly ſupported, in order to conſtitute life, variety, and mutability. Now all know, material motion proceeds upon, and is regulated by mechanical laws. And does not motion uniformly conducted by the laws of mechaniſm, imply a conſtant mechanical cauſe? This mechanical ſyſtem is traceable in moſt caſes, even in the moſt ſubtle and elaborate works of nature, ſuch as plants and animals. And may not the ſame heavens which influence every thing on earth, rule the motions of the earth itſelf; and impreſs all matter with theſe general tendencies, which are the baſis of all human mechanics?

11. Proceed we to what is called *the ſecond law of motion*.

We can have no idea of power, but that it is matter in motion, or endeavouring to act. We cannot connect the idea of power with matter at reſt,

rest, unless that rest be the effect of power fixing it in its place, which we may term *mechanical* power. This rest, being an effect of power, will exert a resistance to motion, when it is pressed upon. But otherwise, matter can have no such power in itself, can exert none; because power consists in Motion, or a nisus to it. Therefore matter resting *unmechanically* can have no nisus of any kind. An unmechanical nisus in matter to rest, is in other words an active power exerted by it to do nothing.

The states then of Motion or rest being the result of absolute passiveness in matter, and the effect of no positive nisus, an unmechanical matter can exert no resistance to change the state: and of consequence an atom would have as much power to move a planet, as a planet to move an atom.

An action or tendency to action is plainly implied in a nisus to any state. And as a nisus to passiveness is a contradiction in terms, it follows, that the properties of power or motion, cannot be considered in matter taken abstractedly, but as composed into a system. Therefore, though it must be allowed, that the changes of state in matter are proportioned to the powers that produce them, yet it is impossible to conceive, that the power shall continue in the body acted upon, after the exterior power ceases to act upon it.

12. The *third* supposed *Law of Motion* is this, When matter is put into Motion, it communicates as much resistance toward stopping the motion of the body that moves it, as it receives motion from it.

Philoſophers never had it in their power to make the experiments on which this law is grounded, upon any bodies but ſuch as were under the influence of gravitation. And if this axiom can be proved to depend upon gravitation, it muſt ceaſe to be an axiom, as being only an accident depending upon another acknowledged cauſe.

Reſiſtance or re-action muſt be produced where-ever matter in motion encounters matter moving or tending to move in an oppoſite or a different direction. Now all bodies tend or gravitate toward the earth. Therefore this tendency muſt re-act or reſiſt according to its quantity, every power applied to move a gravitating body in any other direction.

We have no way to eſtimate the quantity of matter contained in any bodies, but the quantity of their gravitation. Hence we muſt neceſſarily infer, that the law of re-action, is not according to the quantity of matter in particular detached parcels thereof, but according to the degree of their gravitation. For were the gravity of a body but the half of what it is now, that body would re-act but half as much as it does; and of courſe, were all its gravitation to ceaſe, it would not re-act at all.

Again. It is ſuppoſed, gravitation is twenty-three times greater on the ſurface of the ſun than on the ſurface of the earth Hence a body which weighs one pound here, would there weigh three and twenty. Conſequently without any addition of matter, it would re-act twenty-three times more than it does here. Therefore this re-action, ſuppoſed an abſolute law of matter, is only a circumſtance depending on the relative law of gravitation.

13. Come

13. Come we now to the doctrine of *Centripetal* and *Centrifugal* forces.

In another age it will be matter of universal wonder, that one of the most profound mathematicians in the world should assume two powers for circulating the planets, and even calculate the quantities of matter therein, from the proportions wherein they must act in producing and maintaining the circuits of the moving stars: while it is demonstrable to common sense, from the admitted nature of these two powers, that it is absolutely impossible they can support one single rotation of an orb.

Gravitation is allowed by all to be a constant power in bodies, which cannot be altered but by change of distance. It cannot be suspended; for though its effect may be resisted, yet its tendency thereto is invariable. It is therefore a proper undestroyable power, uninterruptedly acting in and upon bodies.

The laws assigned to *Projection* are just the reverse. When any proportion of the quantity of projectile motion is destroyed, either by direct opposition, or by change of its direction, it exerts no nisus to recover its first quantity of motion. Consequently as long as any power, such as that of gravitation, is bending the direction of projection, it is a continued resistance of the power of Projection, which is continually diminished thereby. And as it has no tendency to recover this, the smallest continued resistance will at last quite exhaust its power, though originally ever so great. Thus every projectile on the earth, however great the projecting force may be at setting out, is continually retarded till it rests in the direction of a parabolic curve.

Sir Isaac seems not to have reflected on this circumstance of Gravitation and Projection, that the one retains its whole tendency to motion, whether it be retarded or stopped, while the other always loses as much power as it meets with opposition. Neither in balancing these powers, does he seem to have reflected on that obvious truth, That every alteration in the direction of a moving projectile, destroys so much of its motion, which cannot be repaired, but by a continued action of the first moving cause.

Philosophers illustrate the joint effect of centripetal and centrifugal force, in making bodies move in a circle, by the experiment of casting round a weight, suspended by a string in one's hand. But this illustration contains a palpable deception. For the power of the string restraining the body from flying off in a strait line, bears no analogy to a power actually drawing a moving body towards its center of motion. The string resists its flying off, but has not the least tendency to draw it nearer. And whatever is the cause of the revolution of the planets, it must be some cause which simply resists their flying off into eccentric motions. It cannot in the nature of things be one, which is uniformly drawing them into their center of motion.

But suppose both Gravitation and Projection had the same property, of still retaining their original tendency to their respective motions, however they were retarded: still it is impossible that these two powers, acting by immutable laws, can move an orb any otherwise than in a circle: whereas all the planets are allowed by philosophers themselves to move in ellipses.

These powers moving an orb in the figure of an ellipsis, must no less than four times vary the proportion

proportion of their ſeveral impulſes, during every compleat revolution. The power of gravitation is uniformly gaining on that of projection, from the higher point of the ellipſis to the lower. Now (not to aſk how the projectile force recovers itſelf, but ſuppoſing it had this property) I aſk, by what law does Gravitation remit the ſtrength it has gained, in bringing the orb from the higher point to the lower, and at that point allow Projection to recover the force it had loſt, in order to carry it back to the higher point? In like manner ſeeing Projection has been gaining on Gravitation, all the way to that point, how comes it all at once to loſe its ſuperior force there? And how comes Gravitation immediately to preponderate, in order to bring the orb to the lower point again?

It cannot be ſaid, that the increaſed velocity, which brings a planet to the lower, contributes to carry it back to the higher point. For that increaſed velocity was not the effect of Projection but of Gravitation. Therefore the orb can never get outward again, unleſs at that point, Gravitation all at once weakens its pull of the planet inwards.

There is one circumſtance more, which Mathematicians ought to conſider well: namely, that no figure (circle or ellipſis) can be deſcribed by Gravitation and Projection round the center of gravity, where the center of gravity ſhall not be found in the center of the figure. But this is contrary to all aſtronomical obſervation upon the motion of the planets, which determines their center of gravity to be always in one of the foci of their elliptical orbits.

Yet farther. In order to move any body in a circle, the moving powers muſt be equal, or nearly

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so. Now the proportion of the moving powers upon one body to each other, can only be determined by the velocity of the respective motions. Indeed, the quantity of motion in different bodies must be determined by the quantity of matter moving and velocities taken together. But in one and the same body it may be determined solely by the velocity of its motions.

Equal powers then can only be determined by the equal quantities of motion they produce. But as to the powers of Gravitation and Projection, the proportion between them, as ascertained by the ablest mathematicians, is so far from being equal, that the immense disparity between them, can scarce be reduced to a calculation. Therefore it is utterly impossible that these two powers should produce the revolution of the earth.

If the sun and earth were as near each other as the earth and the moon are, and were left to the power of there mutual attraction, they would move toward each other with the same velocity as it is supposed the earth and moon do, which I think is about sixteen feet in a minute: except so far as the proportion of matter in the earth to that in the sun, differs from that of the earth to the moon. If then the earth at that distance from the sun, would gravitate toward him with the velocity of sixteen feet in a minute, and if the decrease of Gravitation, be inversely as the squares of the distances, (that is, at double distances four times less) then the earth being immensely farther from the sun than the moon is from the earth, the velocity with which the earth at her present distance from the sun would move towards him, if left to the power of attraction, must be immensely less than sixteen feet in a minute. But what is

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the force which moves the earth ſixteen feet or a thouſand, to the force of that projection, which is ſuppoſed to move it at the rate of near a thouſand miles in a minute?

In ſhort, if the power of Gravitation draws the earth toward its center of gravity, with the force of ſixteen feet, or ſixteen hundred in a minute, while the power of projection impreſſes it with the force of almoſt a thouſand miles in the ſame time, it is impoſſible for mathematics to demonſtrate, that any orb hurried off by ſuch a Projection, can ever be recalled from its eccentric motion, by ſuch an inconceivably ſmall and diſproportionate reſiſtance: eſpecially as the power of Gravitation, ſmall as it is, muſt be growing ſmaller every moment. Nor can the mathematical properties of an ellipſis, or any figure, ever prove that Gravitation, which is continually waſting and ſpinning out into a cobweb thread, will at any point recover a ſuperiority to the projectile force, and grow at laſt a cable, maſſy and powerful enough to bring home the wandering ſtar again.

14. I would add ſome thoughts on the motion of the *Satellites*. It is no wonder that notwithſtanding all the arguments for the motion of the earth, yet the greateſt part of aſtronomers have not pronounced it abſolutely certain, but only probable in an high degree. Among the perplexities which attend this highly probable ſyſtem, the doctrine of *abſolute motion* is not the ſmalleſt. It is certain all the phænomena of relative motion, are the very ſame as if the earth were at reſt. And it is not eaſy to conceive how this can poſſibly be, on the ſuppoſition of the earth's motion.

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The phænomena of bodies moving in the same direction with the absolute motion of the earth may be comprehended. That motion of bodies cross the absolute motion of the earth is also intelligible. But it is no easy matter to satisfy one's self, about the phænomena of bodies moving westward, or in an opposite direction to that of absolute motion. If we should suppose that a ball fired pointed blank west, does not really move westward, but it is only resisted by the explosion from moving so fast east as the earth goes in her absolute course; may it not be asked, What is it, that keeps the ball suspended, while the earth proceeds in her absolute motion? For the resistance given to the progressive motion of the ball, can be no resistance to its following the course of its gravity: as we have no example to explain how resistance applied horizontally will prevent a body's falling to the ground in the same time as if it was not so resisted. If the ball's absolute motion is only the force of its *vis inertiæ* derived from the earth's motion, and its apparent motion in a contrary direction is only from another *vis inertiæ*, derived from the explosion: what possible conception can be framed of the two opposite *vis inertias*, acting so as to prevent a body for some time from pursuing the course of its gravity?

On the other hand, if the motion westward is *real*, it seems to imply a plain contradiction. For no body can really move eastward and westward at one and the same time.

But though the doctrine of projectiles could be reconciled with the motion of the earth, yet what shall we say of self-moving bodies? That absolute motion which all bodies are supposed to partake of, is not alledged to be maintained in them, after

after they are ſeparated from the earth, by any other means than their *vis inertiæ*, or their retaining the quantity of motion once impreſſed upon them. Now no body can move in a direction oppoſite to its *vis inertiæ*, till that is overcome. How is it conceivable then, that birds, for example, after they are ſeparated from the earth, where they acquired their abſolute motion, ſhould retain it all? Certainly every reluctation of their's in an oppoſite direction, while on the wing, muſt deſtroy part of their abſolute motion, as they cannot then have any freſh abſolute motion communicated to them. This ſhould imply a great change in the phænomena, with regard to the motion of ſelf-moving bodies. But in fact all the phænomena are the ſame, as if the earth were at reſt. In ſhort, the motion which bodies have in common with the earth, is ſomething which no re-action has any effect on. Therefore it does not, cannot depend upon the axioms of the preſent philoſophy.

When we come to apply the theory of abſolute motion to the *ſecondary planets*, in whatever light we conſider it, it becomes a matter utterly inconceivable, nay, impoſſible. In the firſt place, we know of no abſolute motion, communicated from greater to ſmaller bodies, but where they are ſo intimately connected, that gravitation at laſt, yea ſoon deſtroys all their projectile motion. But ſuch is the diſtance of the moon from the earth, and ſo remote is their connexion, that her gravitation has never gained any thing upon her projectile motion.

Again. The moon, ſuppoſe her preſent diſtance from the earth to be her original one, could never by means of the weak connexion of gravitation,

tation, correſpond with the projection of the earth. Suppoſe the moon at her preſent diſtance, and behind the earth, juſt in the courſe of the earth's projection: in this ſituation, ſuppoſe the moon advances toward the earth, at the rate of ſixteen feet in a minute, while the earth is projected away from the moon near a thouſand miles in the ſame time: can any one ſuppoſe, that this imperceptible motion of the moon toward the earth, would draw the moon with the force of the earth's abſolute motion? This ſuppoſition is attended with the ſame manifeſt impoſſibilities, in whatever part of her circle the moon is conſidered, at the moment of projection. Suppoſe her in her firſt quadrature: then the gravitation between them and the projection of the earth lying nearly in the ſame direction, nothing could prevent their colliſion in a few hours: and till they had met, their mutual gravitation could have no effect in communicating the abſolute motion of the earth to the moon. Yet ſuppoſing that the projection of the moon round the earth, commenced at the ſame inſtant with the projection of the earth, does not help: for as it is not that projection which gives the moon her abſolute motion, the whole impoſſibility remains, yea, and is renewed every month in every ſuppoſable circumſtance. For it is as impoſſible her abſolute motion can be maintained by ſuch means, as that it ſhould commence by them.

It is no leſs impoſſible, that the moon's abſolute motion can be owing to a projection given to herſelf, than that it ſhould be owing to her gravitation toward the earth: for this plain reaſon; becauſe ſhe has a projectile motion quite different from this, namely round the earth. For nothing

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is more impoſſible, than for a body to move in two directions at the ſame time. If five hundred projections, all in different directions, were applied at the ſame time, the projectile would fall into one courſe, common to them all.

Add to this, that if there can be no real motion, in an adverſe direction to abſolute motion, unleſs there be a deſtruction, or at leaſt, weakening of that *vis inertiæ*, which is ſuppoſed to be the principle that continues abſolute motion; then the projectile courſe of the moon round the earth, muſt ſoon deſtroy her abſolute motion. For every month the moon for near 500,000 miles, ſtruggles in a courſe, which is in effect, diametrically oppoſite to the *vis inertiæ*, carrying her in another direction. And this cannot happen without continually weakening, and at laſt wholly deſtroying it.

For theſe reaſons, unleſs I can ſee them fairly removed, I muſt conclude, that even ſuppoſing theſe principles, aſſumed by the preſent philoſophy, are real, yet it is impſſible to explain the celeſtial motions by them."

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