more figurative expreſſion: And addreſſes to the paſſions, and the finer feelings of men, give full ſcope to the exerciſe of genius and of taſte. Of theſe different ſpecies of writing, the examples are numerous in the works of the COUNT DE BUFFON. The tranſlator has endeavoured to follow the original, as far as his abilities would permit. The degree of ſucceſs he has attained muſt be ſubmitted to the impartial determination of the public. He ſhall only ſay, that his apprehenſions, though he is conſcious of no voluntary negligence, are much greater than his hopes.

N. B. Since the firſt edition was printed, the Count de Buffon has publiſhed another ſupplementary volume. It conſiſts chiefly of curious and intereſting facts with regard to the hiſtory of the earth. Theſe the Tranſlator has added in a ſeparate volume, which, to accommodate the purchaſers of the former edition, he has directed to be ſold by itſelf.

*** In the dimenſions of animals, the tranſlator has retained the French meaſures. The differences between the foot or inch of England and France are ſo inconſiderable, when applied to individual animals, that he thought it unneceſſary to reduce them to the preciſe Engliſh ſtandard, eſpecially as the dimenſions are Engliſh in the deſcriptions added in the notes.

THE

HISTORY AND THEORY

OF THE

EARTH.

THE figure of the earth*, its motions, or the external relations which ſubſiſt between it and the other parts of the univerſe, belong not to our preſent inquiry. It is the internal ſtructure of the globe, its form and manner of exiſtence, which we here propoſe to examine. The general hiſtory of the earth ought to precede that of its productions. Details of particular facts relating to the oeconomy and manners of animals, or to the culture and vegetation of plants, are not, perhaps, ſo much the objects of natural hiſtory, as general deductions from the obſervations that have been made upon the different materials of which the earth itſelf is compoſed; as its heights, depths, and inequalities; the motions of the ſea, the direction of mountains, the ſituation of rocks and quarries, the rapidity and effects of currents in the ocean, &c.

* See ſubſequent proofs of the theory of the earth, art. I.

This is the hiſtory of Nature at large, and of her principal operations, by which every other inferior or leſs general effect is produced. The theory of theſe effects conſtitutes what may be called the primary ſcience, upon which a preciſe knowledge of particular appearances, as well as of terreſtrial ſubſtances, ſolely depends. This ſpecies of ſcience may be conſidered as appertaining to phyſics; but, is not all phyſical knowledge, where ſyſtem is excluded, a part of the hiſtory of nature?

In ſubjects of an extenſive kind, the relations of which it is difficult to trace, where ſome facts are but partially known, and others obſcure, it is more eaſy to form a fanciful ſyſtem, than to eſtabliſh a rational theory. Thus the theory of the earth has never hitherto been treated but in a vague and hypothetical manner. I ſhall, therefore, exhibit a curſory view only of the notions of ſome authors who have written upon this ſubject.

The firſt hypotheſis I ſhall mention is more conſpicuous for its ingenuity than ſolidity. It is the production of an Engliſh aſtronomer*, who was an enthuſiaſtic admirer of Sir Iſaac Newton's ſyſtem of philoſophy. Convinced that every poſſible event depends upon the motions and direction of the ſtars, he endeavours to prove, by means of mathematical calculations,

* Whiſton. See the proofs, art. II.

that

that all the changes this earth has undergone have been produced by the tail of a comet.

For another hypotheſis we are indebted to a heterodox divine*, whoſe brain was ſo fully impregnated with poetical illuſions, that he imagined he had ſeen the univerſe created. After telling us the ſtate of the earth when it firſt ſprung from nothing, what changes have been introduced by the deluge, what the earth has been, and what it now is, he aſſumes the prophetic ſtyle, and predicts what will be its condition after the deſtruction of the human kind.

A third writer†, a man of more extenſive obſervation than the two former, but equally crude and confuſed in his ideas, explains the principal appearances of the globe by the aid of an immenſe abyſs in the bowels of the earth, which, in his eſtimation, is nothing but a thin cruſt incloſing this vaſt ocean of fluid matter.

Theſe hypotheſes are all conſtructed on tottering foundations. The ideas they contain are indiſtinct, the facts are confounded, and the whole is a motley jumble of phyſics and fable. They, accordingly, have never been adopted but by men who embrace opinions without examination, and who, incapable of diſtinguiſhing the degrees of probability, are more deeply impreſſed with marvellous chimeras than with the genuine force of truth.

* Burnet. See proofs, art. III.

† Woodward. See proofs, art. IV.

My

My ideas on this ſubject will be leſs extraordinary, and may even appear unimportant, when compared with the grand ſyſtems of ſuch hypothetical writers. But it ſhould not be forgotten, that it is the buſineſs of an hiſtorian to deſcribe, not to invent; that no gratuitous ſuppoſitions are to be admitted in ſubjects which depend upon fact and obſervation; and that, in hiſtorical compoſitions, the imagination cannot be employed, except for the purpoſe of combining obſervations, of rendering facts more general, and of forming a connected whole, which preſents to the mind clear ideas, and probable conjectures: I ſay, probable; for it is impoſſible to give demonſtrative evidence on this ſubject. Demonſtration is confined to the mathematical ſciences. Our knowledge in phyſics and natural hiſtory depends entirely on experience, and is limited to the method of reaſoning by induction.

With regard to the hiſtory of the earth, therefore, we ſhall begin with ſuch facts as have been univerſally acknowledged in all ages, not omitting thoſe additional truths which have fallen within our own obſervation.

The ſurface of this immenſe globe exhibits to our obſervation heights, depths, plains, ſeas, marſhes, rivers, caverns, gulfs, volcano's; and, on a curſory view, we can diſcover, in the diſpoſition of theſe objects, neither order nor regularity. If we penetrate into the bowels of the earth,

earth, we find metals, minerals, ſtones, bitumens, ſands, earths, waters, and matter of every kind, ſeemingly placed by mere accident, and without any apparent deſign. Upon a nearer and more attentive inſpection, we diſcover ſunk mountains*, caverns filled up, ſhattered rocks, whole countries ſwallowed up, new iſlands emerged from the ocean, heavy ſubſtances placed above light ones, hard bodies incloſed within ſoft bodies; in a word, we find matter in every form, dry and humid, warm and cold, ſolid and brittle, blended in a chaos of confuſion, which can be compared to nothing but a heap of rubbiſh, or the ruins of a world.

Theſe ruins, however, we inhabit with perfect ſecurity. The different generations of men, of animals, and of plants, ſucceed one another without interuption: The productions of the earth are ſufficient for their ſuſtenance; the motions of the ſea, and the currents of the air, are regulated by fixed laws †; the returns of the ſeaſons are uniform, and the rigours of winter invariably give place to the verdure of the ſpring. With regard to us, every thing has the appearance of order: The earth, formerly a chaos, is now a tranquil, an harmonious, a delightful habitation, where all is animated and governed by

* See Senec. Quaeſt. lib. 6. cap. 21. Strab. Geog. lib. 1. Oroſius, lib. 2. cap. 18. Plin. lib. 2. cap. 19. Hiſt. de l'acad. des ſciences, année 1708, p. 23.

† See the proofs, art. XIV.

ſuch amazing diſplays of power and intelligence, as fill us with admiration, and elevate our minds to the contemplation of the great Creator.

But let us not decide precipitantly concerning the irregularities on the ſurface of the earth, and the apparent diſorder in its bowels: We ſhall ſoon perceive the utility, and even the neceſſity of this arrangement. With a little attention, we ſhall perhaps diſcover an order of which we had no conception, and general relations that cannot be apprehended by a ſlight examination. Our knowledge, indeed, with regard to this ſubject, muſt always be limited. We are entirely unacquainted with many parts of the ſurface of this globe *, and have partial ideas only concerning the bottom of the ocean, which, in many places, has never been ſounded. We can only penetrate the rind of the earth. The greateſt caverns †, the deepeſt mines ‡, deſcend not above the eight thouſandth part of its diameter. Our judgment is therefore confined to the upper ſtratum, or mere ſuperficial part. We know, indeed, that, bulk for bulk, the earth is four times heavier than the ſun: We likewiſe know the proportion its weight bears to that of the other planets. But ſtill this eſtimation is only relative. We have no ſtandard. Of the real weight of the materials we are ſo ignorant, that the internal part of the globe may be either

* See proofs, art. VI. † Phil. tranſ. abridged, vol. ii. p. 323. ‡ Boyle's works, vol. iii. p. 232.

a void

a void ſpace, or it may be compoſed of matter a thouſand times heavier than gold. Neither is there any method of making farther diſcoveries on this ſubject. It is even with difficulty that rational conjectures can be formed *.

We muſt therefore confine ourſelves to an accurate examination and deſcription of the ſurface of the earth, and of ſuch inconſiderable depths as we have been able to penetrate. The firſt object which attracts attention, is that immenſe collection of waters with which the greateſt part of the globe is covered. Theſe waters occupy the loweſt grounds; their ſurface is always level; and, notwithſtanding their uniform tendency to equilibrium and reſt, they are kept in perpetual agitation by a powerful agent †, which counteracts their natural tranquillity, which communicates to them a regular periodic motion, alternately elevating and depreſſing their waves, and which produces a concuſſion or vibration in the whole maſs, even to the moſt profound depths. This motion of the waters is coëval with time, and will endure as long as the ſun and moon, by which it is produced.

In examining the bottom of the ſea, we perceive it to be equally irregular as the ſurface of the dry land ‡. We diſcover hills and valleys, plains and hollows, rocks and earths of every

* See proofs, art. I. † Proofs, art. XII. ‡ Proofs, art. XIII.

kind:

kind*: We diſcover, likewiſe, that iſlands are nothing but the ſummits of vaſt mountains, whoſe foundations are buried in the ocean †; we find other mountains whoſe tops are nearly on a level with the ſurface of the water; and rapid currents which run contrary to the general movement ‡. Theſe currents ſometimes run in the ſame direction; at other times their motion is retrograde ‖; but they never exceed their natural limits, which ſeem to be as immutable as thoſe which bound the efforts of land-rivers. On one hand, we meet with tempeſtuous regions, where the winds blow with irreſiſtible fury, where the heavens and the ocean, equally convulſed, are mixed and confounded in the general ſhock; violent inteſtine motions, tumultuous ſwellings §, water-ſpouts**, and ſtrange agitations, produced by volcano's, whoſe mouths, though many fathoms below the ſurface, vomit forth torrents of fire, and puſh, even to the clouds, a thick vapour, compoſed of water, ſulphur, and bitumen; and dreadful gulphs or whirlpools††, which ſeem to attract veſſels for no other purpoſe than to ſwallow them up. On the other hand, we diſcover vaſt regions of an oppoſite nature, always ſmooth and calm, but

* See M. Buache's chart of the depths of the ocean between Africa and America. † Varenii Geog. gen. p. 218.
‡ Proofs, art. XIII. ‖ Varen. p. 140. and Voyages de Pirard, p. 137. § Shaw's travels. ** Proofs, art. XVI.
†† The Maleſtroom in the Norwegian ſea.

equally

equally dangerous to the mariner *. Here the winds never exert their force; the nautical art is of no utility; the becalmed voyagers muſt remain immoveably fixed, till death relieve them from miſery. To conclude, directing our eyes toward the ſouthern or northern extremities of the globe, we diſcover huge maſſes of ice †, which, detaching themſelves from the polar regions, advance, like floating mountains, to the more temperate climates, where they diſſolve and vaniſh from our view ‡.

Beſide theſe grand objects, the ocean preſents us with myriads of animated beings, almoſt infinite in variety: Some, clothed in light ſcales, ſwim with amazing ſwiftneſs; others, loaded with thick ſhells, trail heavily along, leaving their traces in the ſand: To others Nature has given fins reſembling wings, with which they ſupport themſelves in the air, and fly before their enemies to conſiderable diſtances. Laſtly, the ſea gives birth to other animals, which, totally deprived of motion, live and die immoveably fixed to the ſame rocks: All, however, find abundance of food in this fluid element. The bottom of the ocean, and the ſhelving ſides of rocks, produce plentiful crops of plants of many different ſpecies; its ſoil is compoſed of ſand, gravel, rocks, and ſhells; in ſome places, it is a fine clay, in others, a compact earth; and, in general, the bottom of the ſea has an

* The calms and tornados in the Æthiopan ſea.
† Proofs, art. VI. and X. ‡ See Buache's chart, 1739.

exact

exact reſemblance to the dry land which we inhabit.

Let us next take a view of the land: What prodigious differences take place in different climates! What a variety of ſoils! What inequalities in the ſurface! But, upon a more attentive obſervation, we ſhall perceive, that the great chains of mountains lie nearer the equator than the poles *; that, in the Old Continent, their direction is more from eaſt to weſt than from ſouth to north; and that, on the contrary, in the New Continent, they extend more from north to ſouth than from eaſt to weſt. But, what is ſtill more remarkable, the figure and direction of theſe mountains, which have a moſt irregular appearance †, correſpond ſo wonderfully, that the *prominent* angles of one mountain are conſtantly oppoſite to the *concave* ‡ angles of the neighbouring mountain ‖, and of equal dimenſions, whether they be ſeparated by an extenſive plain, or a ſmall valley. I have further remarked, that oppoſite hills are always nearly of the ſame height; and that mountains generally occupy the middle of continents, iſlands, and promontories, dividing them by their greateſt lengths §. I have likewiſe traced the courſes of the principal rivers, and find that their direction is nearly perpendicular to the ſea-coaſts into which they empty themſelves; and that, during the

* Proofs, art. IX. † Ibid. art. IX. XII. ‡ *Saliant* and *re-entering* angles; Muller's fortification. ‖ Lettres Phil. de Bourguet, p. 181. § Varen. Geog. p. 69.

greateſt

greateſt part of their courſes, they follow the direction of the mountains from which they derive their origin *. The ſea-coaſts are generally bordered with rocks of marble and other hard ſtones, or rather with earth and ſand accumulated by the waters of the ſea, or brought down and depoſited by rivers. In oppoſite coaſts, ſeparated only by ſmall arms of the ſea, the different ſtrata or beds of earth are of the ſame materials †. I find that volcano's never exiſt but in high mountains ‡; that a great number of them are entirely extinguiſhed; that ſome are connected with others by ſubterranean paſſages, and their eruptions not unfrequently happen at the ſame time ‖. There are ſimilar communications between certain lakes and ſeas. Some rivers ſuddenly diſappear §, and ſeem to precipitate themſelves into the bowels of the earth. We likewiſe find certain mediterranean or inland ſeas, which conſtantly receive, from many and great rivers, prodigious quantities of water, without any augmentation of their bounds, probably diſcharging, by ſubterraneous paſſages, all theſe extraneous ſupplies. It is likewiſe eaſy to diſtinguiſh lands which have been long inhabited, from thoſe new countries where the earth appears in a rude ſtate, where the rivers are full of cataracts, where the land is either nearly overflowed with water, or burnt up with drought, and where every place

* Proofs, art. X. † Ibid. art. VII. ‡ Ibid. art. XVI. ‖ Kircher Mund. ſubter. in praef. § Varen. Geog. p. 43.

capable

capable of producing trees is totally covered with wood.

Proceeding in our examination, we diſcover that the upper ſtratum of the earth is univerſally the ſame ſubſtance *; that this ſubſtance, from which all animals and vegetables derive their growth and nouriſhment, is nothing but a compoſition of the decayed parts of animal and vegetable bodies, reduced into ſuch ſmall particles that their former organic ſtate is not diſtinguiſhable. Penetrating a little deeper, we find the real earth, beds of ſand, lime-ſtone, clay, ſhells, marble, gravel, chalk, &c. Theſe beds are always parallel to each other †, and of the ſame thickneſs through their whole extent. In neighbouring hills, beds or ſtrata of the ſame materials are uniformly found at the ſame levels, though the hills be ſeparated by deep and large valleys. Strata of every kind, even of the moſt ſolid rocks, are uniformly divided by perpendicular fiſſures ‡. Shells, ſkeletons of fiſhes, marine plants, &c. are often found in the bowels of the earth, and on the tops of mountains ||, even at the greateſt diſtances from the ſea. Theſe ſhells, fiſhes, and plants, are exactly ſimilar to thoſe which exiſt in the ocean: Petrified ſhells are to be met with, almoſt every where, in prodigious quantities: They are not only incloſed in rocks of marble and lime-ſtone, as well

* Proofs, art. VII. † Ibid. and Woodward, p. 41. &c.
‡ Proofs, art. VIII. || Proofs, art. VIII.

well as in earths and clays, but are actually incorporated and filled with the very ſubſtances in which they are incloſed. In fine, I am convinced, by repeated obſervation, that marbles, lime-ſtones, chalks, marles, clays, ſand, and almoſt all terreſtrial ſubſtances, wherever ſituated, are full of ſhells and other ſpoils of the ocean *.

Having enumerated theſe facts, let us try what concluſions can be drawn from them.

The changes which the earth has undergone during the laſt two or three thouſand years are inconſiderable, when compared with the great revolutions which muſt have happened in thoſe ages that immediately ſucceeded the creation. For, as terreſtrial ſubſtances could only acquire ſolidity by the continued action of gravity, it is eaſy to demonſtrate, that the ſurface of the earth was at firſt much ſofter than it is now; and, conſequently, that the ſame cauſes, which at preſent produce but ſlight and almoſt imperceptible alterations during the courſe of many centuries, were then capable of producing very great revolutions in a few years. It appears, indeed, to be an incontrovertible fact, that the dry land which we now inhabit, and even the ſummits of the higheſt mountains, were formerly covered with the waters of the ſea; for ſhells, and other marine bodies, are

* Steno, Woodward, Ray, Bourguet, Scheuchzer, Phil. Tranſ. Mem. de l'Acad. &c.

ſtill

ſtill found upon the very tops of mountains. It likewiſe appears, that the waters of the ſea have remained for a long track of years upon the ſurface of the earth; becauſe, in many places, ſuch immenſe banks of ſhells have been diſcovered, that it is impoſſible ſo great a multitude of animals could exiſt at the ſame time. This circumſtance ſeems likewiſe to prove, that, although the materials on the ſurface of the earth were then ſoft, and, of courſe, eaſily diſunited, moved, and tranſported, by the waters; yet theſe tranſportations could not be ſuddenly effected. They muſt have been gradual and ſucceſſive, as ſea-bodies are ſometimes found more than 1000 feet below the ſurface. Such a thickneſs of earth or of ſtone could not be accumulated in a ſhort period. Although it ſhould be ſuppoſed, that, at the deluge, all the ſhells were tranſported from the bottom of the ocean, and depoſited upon the dry land; yet, beſide the difficulty of eſtabliſhing this ſuppoſition, it is clear, that, as ſhells are found incorporated in marble and in the rocks of the higheſt mountains, we muſt likewiſe ſuppoſe, that all theſe marbles and rocks were formed at the ſame time, and at the very inſtant when the deluge took place; and that, before this grand revolution, there were neither mountains, nor marbles, nor rocks, nor clays, nor matter of any kind, ſimilar to what we are now acquainted with, as they all, with few exceptions, contain ſhells, and

and other productions of the ocean. Beſides, at the time of the univerſal deluge, the earth muſt have acquired a conſiderable degree of ſolidity, by the action of gravity for more than ſixteen centuries. During the ſhort time the deluge laſted, therefore, it is impoſſible that the waters ſhould have overturned and diſſolved the whole ſurface of the earth, to the greateſt depths that mankind have been able to penetrate.

But, not to inſiſt longer on this point, which ſhall afterwards be more fully canvaſſed, I ſhall confine myſelf to known and eſtabliſhed facts. It is certain, that the waters of the ſea have, at ſome period or other, remained for a ſucceſſion of ages upon what we now know to be dry land; and, conſequently, that the vaſt continents of Aſia, Europe, Africa, and America, were then the bottom of an immenſe ocean, replete with every thing which the preſent ocean produces. It is likewiſe certain, that the different ſtrata of the earth are horizontal, and parallel to each other*. This parallel ſituation muſt, therefore, be owing to the operation of the waters, which have gradually accumulated the different materials, and given them the ſame poſition that water itſelf invariably aſſumes. The horizontal poſition of ſtrata is almoſt univerſal: In plains, the ſtrata are exactly horizontal. It is only in the mountains that they are inclined to the horizon; becauſe they have originally

* Proofs, art. VII.

ginally been formed by ſediments depoſited upon an inclined baſe. Now, I maintain, that theſe ſtrata muſt have been gradually formed, and that they are not the effect of any ſudden revolution; becauſe nothing is more frequent than ſtrata compoſed of heavy materials placed above light ones, which never could have happened, if, according to ſome authors, the whole had been blended and diſſolved by the deluge, and afterwards precipitated. On this ſuppoſition every thing ſhould have had a different aſpect from what now appears. The heavieſt bodies ſhould have deſcended firſt, and every ſtratum ſhould have had a ſituation correſponding to its ſpecific gravity. In this caſe we ſhould not have ſeen ſolid rocks or metals placed above light ſand, nor clay under coal.

Another circumſtance demands our attention. No cauſe but the motion and ſediments of water could poſſibly produce the regular poſition of the various ſtrata of which the ſuperficial part of this earth is compoſed. The higheſt mountains conſiſt of parallel ſtrata, as well as the loweſt valleys. Of courſe, the formation of mountains cannot be imputed to the ſhocks of earthquakes, or to the eruptions of volcano's. Such ſmall eminences as have been raiſed by volcano's or convulſions of the earth, inſtead of being compoſed of parallel ſtrata, are mere maſſes of weighty materials, blended together in the utmoſt

utmoſt confuſion*. But this parallel and horizontal poſition of ſtrata muſt neceſſarily be the operation of a uniform and conſtant cauſe.

We are, therefore, authoriſed to conclude, from repeated and incontrovertible facts and obſervations, that the dry and habitable part of the earth has for a long time remained under the waters of the ſea, and muſt have undergone the ſame changes which are at preſent going on at the bottom of the ocean. To diſcover what has formerly happened to the dry land, let us examine what paſſes in the bottom of the ſea; and we ſhall ſoon be enabled to make ſome rational concluſions with regard to the external figure and internal conſtitution of the earth.

The ocean, from the creation of the ſolar ſyſtem, has been conſtantly ſubject to a regular flux and reflux. Theſe motions, which happen twice in twenty-four hours, are principally occaſioned by the action of the moon, and are greater in the equatorial regions than in other climates. The earth likewiſe performs a rapid motion round its axis, and, conſequently, has a centrifugal force, which is alſo greateſt at the equator. This laſt circumſtance, independent of actual obſervations, proves, that the earth is not a perfect ſphere, but that it muſt be more elevated under the equator than at the poles. From theſe two combined cauſes, the tides, and the motion

* Proofs, art. XVII.

of the earth, it may be fairly concluded, that, although this globe had been originally a perfect ſphere, its diurnal motion, and the ebbing and flowing of the tides, muſt neceſſarily, in a ſucceſſion of time, have elevated the equatorial parts, by gradually carrying mud, earth, ſand, ſhells, &c. from other climates, and depoſiting them at the equator*. On this ſuppoſition, the greateſt inequalities on the ſurface of the earth ought to be, and, in fact, are found, in the neighbourhood of the equator. Beſides, as the alternate motion of the tides has been conſtant and regular ſince the exiſtence of the world, is it not evident, that, at each tide, the water carries from one place to another a ſmall quantity of matter which falls to the bottom as a ſediment, and forms thoſe horizontal and parallel ſtrata that every where appear? The motion of the waters, in the flux and reflux, being always horizontal, the matter tranſported by them muſt neceſſarily take the ſame parallel direction after it is depoſited.

To this reaſoning, it may be objected, that, as the flux is equal to, and regularly ſucceeded by, the reflux, the two motions will balance each other; or, that the matter brought by the flux will be carried back by the reflux; and, conſequently, that this cauſe of the formation of ſtrata muſt be chimerical, as the bottom of the ocean can never be affected by a uniform alternate motion

* Proofs, art. XII.

of

of the waters; far leſs could this motion change its original ſtructure, by creating heights, and other inequalities.

But, in the firſt place, the alternate motion of the waters is by no means equal; for the ſea has a continual motion from eaſt to weſt: Beſides, the agitations occaſioned by the winds produce great inequalities in the tides. It will likewiſe be acknowledged, that, by every motion in the ſea, particles of earth, and other materials, muſt be carried from one place, and depoſited in another; and that theſe collections of matter muſt aſſume the form of parallel and horizontal ſtrata. Farther, a well-known fact will entirely obviate this objection. On all coaſts, where the ebbing and flowing are diſcernible*, numberleſs materials are brought in by the flux, which are not carried back by the reflux. The ſea gradually increaſes on ſome places, and recedes from others, narrowing its limits, by depoſiting earth, ſand, ſhells, &c. which naturally take a horizontal poſition. Theſe materials, when accumulated and elevated to a certain degree, gradually ſhut out the water, and remain for ever in the form of dry land.

But, to remove every doubt concerning this important point, let us examine more cloſely the practicability of a mountain's being formed at the bottom of the ſea, by the motion and ſe-

* Proofs, art. XIX.

diments

diments of the water. On a high coaſt which the ſea waſhes with violence during the flow, ſome part of the earth muſt be carried off by every ſtroke of the waves. Even where the ſea is bounded by rock, it is a known fact, that the ſtone is gradually waſted by the water*; and conſequently, that ſmall particles are carried off by the retreat of every wave. Thoſe particles of earth or ſtone are neceſſarily tranſported to ſome diſtance. Whenever the agitation of the water is abated, the particles are precipitated in the form of a ſediment, and lay the foundation of a firſt ſtratum, which is either horizontal, or inclined, according to the ſituation of the ſurface upon which they fall. This ſtratum will ſoon be ſucceeded by a ſimilar one, produced by the ſame cauſe; and thus a conſiderable quantity of matter will be gradually amaſſed, and diſpoſed in parallel beds. In proceſs of time, this gradually accumulating maſs will become a mountain in the bottom of the ſea, exactly reſembling, both in external and internal ſtructure, thoſe mountains which we ſee on the dry land. If there happened to be ſhells in that part of the bottom of the ſea where we have ſuppoſed the ſediments to be depoſited, they would be covered, filled, and incorporated, with the depoſited matter, and form a part of the general maſs. Theſe ſhells would be lodged in different parts of the mountains, correſponding

* See Shaw's travels.

ing to the times they were depoſited. Thoſe which lay at the bottom, before the firſt ſtratum was formed, would occupy the loweſt ſtation; and thoſe which were afterwards depoſited, would be found in the more elevated parts.

In the ſame manner, when the bottom of the ſea, at particular places, is troubled by the agitation of the waters, earth, clay, ſhells, and other matter, muſt neceſſarily be removed from theſe parts, and depoſited elſewhere. For we are aſſured by divers, that the bottom of the ſea, at the greateſt depths to which they deſcend*, is ſo ſtrongly affected by the agitation of the water, that earth, clay, and ſhells, are removed to great diſtances. Tranſportations of this kind muſt, therefore, be conſtantly going on in every part of the ocean; and the matters tranſported, after ſubſiding, muſt uniformly raiſe eminences ſimilar, in every reſpect, to the compoſition and ſtructure of our mountains. Thus the motions produced by the flux and reflux, by winds and currents, muſt uniformly create inequalities in the bottom of the ocean.

Farther, we muſt not imagine that theſe matters cannot be carried to great diſtances, ſince we daily find grain, and other productions of the Eaſt and Weſt Indies, arriving on our coaſts†. Theſe bodies are, indeed, ſpecifically lighter than water; and the other ſubſtances

* Boyle's works, vol 3. p. 232. † Particularly on the coaſts of Scotland and of Ireland. See Ray's Diſcourſes.

are

are ſpecifically heavier. Still, however, as they are reduced to an impalpable powder, they may be kept long ſuſpended in the water, and, of courſe, tranſported to any diſtance.

It has been conceived, that the agitation produced by the winds and tides is only ſuperficial, and affects not the bottom, eſpecially when it is very deep. But it ought to be remembered, that, whatever be the depth, the whole maſs is put in motion by the tides at the ſame time; and that, in a fluid globe, this motion would be communicated even to the centre. The power which occaſions the flux and reflux is penetrating; it acts equally upon every particle of the maſs. Hence the quantity of its force, at different depths, may be determined by calculation. Indeed, this point is ſo certain, that it admits not of diſpute.

We cannot, therefore, heſitate in pronouncing, that the tides, the winds, and every other cauſe of motion in the ſea, muſt produce heights and inequalities in its bottom; and that theſe eminences muſt uniformly be compoſed of regular ſtrata, either horizontal or inclined. Theſe heights will gradually augment; like the waves which formed them, they will mutually reſpect each other; and if the extent of the baſe be great, in a track of years they will form a vaſt chain of mountains. Whenever eminences are formed, they interrupt the uniform motion of the waters, and produce new motions, known by

by the name of currents. Between two neighbouring heights in the bottom of the ocean, there muſt be a current*, which will follow their common direction, and, like a river, cut a channel, the angles of which will be alternately oppoſite through the whole extent of its courſe. Theſe heights muſt continually increaſe; for, during the flow, the water will depoſite its ordinary ſediment upon their ridges, and the waters which are impelled by the current will force along, from great diſtances, quantities of matter, which will ſubſide between the hills, and, at the ſame time, ſcoop out a valley with correſponding angles at their foundation. Now, by means of theſe different motions and ſediments, the bottom of the ocean, though formerly ſmooth, muſt ſoon be furrowed, and interſperſed with hills and chains of mountains, as we actually find it at preſent. The ſoft materials of which the eminences were originally compoſed, would gradually harden by their own gravity. Such of them as conſiſted of ſandy and cryſtalline particles, would produce thoſe enormous maſſes of rock and flint in which we find cryſtals and other precious ſtones. Others compoſed of ſtony particles mixed with ſhells, give riſe to thoſe beds of lime-ſtone and marble, in which vaſt quantities of ſea ſhells are ſtill found incorporated. Laſtly, all our beds of marble and chalk have derived their origin from particles of ſhells mix-

* Proofs, art. XIII.

ed with a pure earth, collected and depoſited at particular places in the bottom of the ſea. All theſe ſubſtances are diſpoſed in regular ſtrata; they all contain heterogeneous matter, and vaſt quantities of ſea-bodies ſituated nearly in proportion to their ſpecific gravities. The lighter ſhells are found in chalk; the heavier in clay and lime-ſtone. Theſe ſhells are uniformly filled with the matter in which they are found, whether it be ſtone or earth. This is an inconteſtible proof, that they have been tranſported along with the matter that fills and ſurrounds them, and that this matter was then in the form of an impalpable powder. In a word, all thoſe ſubſtances, the horizontal ſituation of which has ariſen from the waters of the ſea, invariably preſerve their original poſition.

It may here be objected, that moſt hills, the ſummits of which conſiſt of ſolid rocks, or of marble, are founded upon ſmall eminences, compoſed of leſs heavy materials, ſuch as clay or light ſand, the ſtrata of which commonly extend over the neighbouring plains. If the above theory be juſt, what could bring about an arrangement ſo ſingular ſo contrary, to the laws of gravity? But this phænomenon admits of a natural and eaſy explication. The waters would operate firſt upon the upper ſtratum either of coaſts or the bottom of the ſea: This upper ſtratum conſiſts generally of clay or ſand; and theſe light ſubſtances, being carried off

off and depoſited previous to the more denſe and ſolid, they would of courſe form ſmall eminences, and become foundations for the more heavy particles to reſt upon. After the light ſuperficial ſubſtances were removed, the harder and more ponderous would next be ſubjected to the attrition of the water, reduced to a fine powder, and carried off and depoſited above the hillocks of ſand or clay. Theſe ſmall ſtony particles would, in a ſucceſſion of ages, form thoſe ſolid rocks which we now find on the tops of hills and mountains. As particles of ſtone are heavier than ſand or clay, it is probable that they were originally covered and preſſed by ſuperior ſtrata of conſiderable depth; but that they now occupy the higheſt ſtations, becauſe they were laſt tranſported by the waves.

To confirm this reaſoning, let us inveſtigate more minutely the ſituation of thoſe materials which compoſe the ſuperficial part of the globe, the only part of which we have any adequate knowledge. The different ſtrata of ſtones in quarries are almoſt all horizontal, or regularly inclined. Thoſe founded upon hard clay, or other ſolid matter, are evidently horizontal, eſpecially in plains. The diſpoſition of quarries, where flint or browniſh free-ſtone are found in detached portions, is indeed leſs regular. But even here the uniformity of nature is not interrupted; for the horizontal or regularly inclining poſition of the ſtrata is apparent in granite and brown

brown free-ſtone, wherever they exiſt in large connected maſſes. This poſition is univerſal, except in flint and brown free-ſtone in ſmall detached portions, ſubſtances the formation of which we ſhall demonſtrate to have been poſterior to thoſe juſt now mentioned. The ſtrata of granite, vitrifiable ſand, clays, marbles, calcareous ſtones, chalk, and marls, are always parallel or equally inclined. In theſe the original formation is eaſily diſcoverable; for the ſtrata are exactly horizontal, and very thin, being placed above each other like the leaves of a book. Beds of ſand, of ſoft and hard clay, of chalk, and of ſhells, are likewiſe either horizontal or uniformly inclined. Strata of every kind preſerve the ſame thickneſs through their whole extent, which is often many leagues, and might, by proper obſervations, be traced ſtill farther. In a word, the diſpoſition of ſtrata, as deep as mankind have hitherto penetrated, is the ſame.

Thoſe beds of ſand and gravel which are waſhed down from mountains, muſt, in ſome meaſure, be excepted from the general rule. They are ſometimes of a conſiderable extent in valleys, and are ſituated immediately under the ſoil or firſt ſtratum. In plains, they are level, like the more antient and interior ſtrata. But near the bottom, or upon the ridges of hills, they have an inclination correſponding to that of the ground upon which they have been depoſited. As theſe beds of ſand and gravel are

formed by rivers and brooks, which, eſpecially in the valleys, often change their channels, it is not ſurpriſing that ſuch beds ſhould be ſo frequent. A ſmall rivulet is ſufficient, in a courſe of time, to ſpread a bed of ſand or gravel over a very large valley. In a champaign country, ſurrounded with hills, whoſe baſes, as well as the upper ſtratum of the plain, conſiſted of a hard clay, I have often obſerved, that, above the origin of the brooks or rivers, the clay was ſituated immediately under the vegetable ſtratum; but, in the low grounds, there was a ſtratum of ſand, about a foot thick, above the clay, and extending to a great diſtance from the banks of the rivers. The ſtrata formed by rivers are not very antient; they are eaſily diſtinguiſhed by their frequent interruptions, and the inequality of their thickneſs. But the antient ſtrata uniformly preſerve the ſame dimenſions through their whole extent. Beſides, theſe modern ſtrata may be diſtinguiſhed, with certainty, by the form of the ſtones and gravel they contain, which bear evident marks of having been rolled, ſmoothed, and rounded, by the motion of water. The ſame obſervation may be made with regard to thoſe beds of turf, and corrupted vegetables, which are found in marſhy grounds, immediately below the ſoil: They have no claim to antiquity, but have derived their exiſtence from ſucceſſive accumulations of decayed trees, and other plants. The ſtrata of ſlime, or mud, which occur in many

places, are alſo recent productions, formed by ſtagnating waters, or the inundations of rivers. They are not ſo exactly horizontal, nor ſo uniformly inclined, as the more antient ſtrata, produced by the regular motions of the ſea. In ſtrata formed by rivers, we meet with river, but ſeldom with ſea-ſhells; and the few which occur are broken, detached, and placed without order. But, in the antient ſtrata, there are no river-ſhells; the ſea-ſhells are numerous, well preſerved, and all placed in the ſame manner, having been tranſported and depoſited at the ſame time, and by the ſame cauſe. From whence could this beautiful regularity proceed? Inſtead of regular ſtrata, why do we not find the matters compoſing the earth huddled together without order? Why are not rocks, marbles, clays, marls, &c. ſcattered promiſcuouſly, or joined by irregular or vertical ſtrata? Why are not heavy bodies uniformly found in a lower ſituation than light ones? It is eaſy to perceive, that this uniformity of nature, this ſpecies of organization, this union of different materials by parallel ſtrata, without regard to their weights, could only proceed from a cauſe equally powerful and uniform as the motions of the ſea, produced by regular winds, by the tides, &c.

Theſe cauſes act with ſuperior force under the equator than in other climates; for there the tides are higher, and the winds more uniform.

form. The moſt extenſive chains of mountains are likewiſe in the neighbourhood of the equator. The mountains of Africa and Peru are the higheſt in the world, often extending through whole continents, and ſtretching to great diſtances under the waters of the ocean. The mountains of Europe and Aſia, which extend from Spain to China, are not ſo elevated as thoſe of Africa and South America. According to the relations of voyagers, the mountains of the north are but ſmall hills, when compared with the mountains of the equatorial regions. Beſides, in the northern ſeas, there are few iſlands; but, in the Torrid Zone, they are innumerable. Now, as iſlands are only the ſummits of mountains, it is apparent, that there are more inequalities on the ſurface of the earth near the equator, than in northerly climates.

Thoſe prodigious chains of mountains which run from weſt to eaſt in the Old Continent, and from north to ſouth in the New, muſt have been formed by the general motion of the tides. But the origin of the leſs conſiderable mountains and hills muſt be aſcribed to particular motions, occaſioned by winds, currents, and other irregular agitations of the ſea: Their formation may, indeed, be owing to a combination of all theſe motions, which are capable of infinite variations; for the winds, and the ſituation of different iſlands and coaſts, conſtantly change the natural courſe of the tides, and oblige them to

to run in every poſſible direction. It is not, therefore, ſurpriſing to ſee conſiderable eminences which have no determined direction in their courſes. But, for our preſent purpoſe, it is ſufficient to have ſhown, that mountains have not been produced by earthquakes, or other accidental cauſes, but that they are effects equally reſulting from the general laws of nature, as well as their peculiar ſtructure, and the ſituation of the materials of which they are compoſed.

But how has it happened, that this earth, which we and our anceſtors have inhabited for ages, which, from time immemorial, has been an immenſe continent, dry, compact, and removed from the reach of the water, ſhould, if formerly the bottom of an ocean, be now exalted to ſuch a height above the waters, and ſo completely ſeparated from them? Since the waters remained ſo long upon the earth, why have they now deſerted it? What accident, what cauſe, could introduce a change ſo great? Is it poſſible to conceive a cauſe poſſeſſed of power ſufficient to operate ſuch an amazing effect?

Theſe are difficult queſtions. But, as the facts are incontrovertible, the preciſe manner in which they have happened may remain a ſecret, without prejudice to the concluſions that ought to be drawn from them. A little reflection, however, will furniſh us at leaſt with plauſible ſolutions *. We daily obſerve the ſea

* See proofs, art. XIX.

gaining

gaining ground on certain coaſts, and loſing it on others. We know, that the ocean has a general and uniform motion from eaſt to weſt; that it makes violent efforts againſt the rocks and the low grounds which encircle it; that there are whole provinces which human induſtry can hardly defend from the fury of the waves; and that there are inſtances of iſlands which have but lately emerged from the waters, and of regular inundations. Hiſtory informs us of inundations and deluges of a more extenſive nature. Should not all theſe circumſtances convince us, that the ſurface of the earth has experienced very great revolutions, and that the ſea may have actually given up poſſeſſion of the greateſt part of the ground which it formerly occupied? For example, let us ſuppoſe, that the Old and New worlds were formerly but one continent, and that, by a violent earthquake, the antient Atalantis of Plato was ſunk. What would be the conſequence of ſuch a mighty revolution? The ſea would neceſſarily ruſh in from all quarters, and form what is now called the Atlantic Ocean; and vaſt continents, perhaps thoſe which we now inhabit, would, of courſe, be left dry. This great revolution might be effected by the ſudden failure of ſome immenſe cavern in the interior part of the globe, and an univerſal deluge would infallibly ſucceed. I ſhould rather incline to think,

that

that ſuch a revolution would not be ſuddenly accompliſhed, but that it would require a very long period. However theſe conjectures ſtand, it is certain, that ſuch a revolution has happened, and I even believe that it happened naturally; for, if a judgment of the future is to be formed from the paſt, we have only to attend carefully to what daily paſſes before our eyes. It is a fact, eſtabliſhed by the repeated obſervation of voyagers, that the ocean has a conſtant motion from eaſt to weſt. This motion, like the trade-winds, is not only perceived between the tropics, but through the whole temperate climates, and as near the poles as navigators have been able to approach. As a neceſſary conſequence of this motion, the Pacific Ocean muſt make continual efforts againſt the coaſts of Tartary, China, and India; the Indian Ocean muſt act againſt the eaſt coaſt of Africa; and the Atlantic muſt act in a ſimilar manner againſt all the eaſtern coaſts of America. Hence the ſea muſt have gained, and will always continue to gain, on the eaſt, and to loſe on the weſt. This circumſtance alone would be ſufficient to prove the poſſibility of the change of ſea into land, and of land into ſea. If ſuch is the natural effect of the ſea's motion from eaſt to weſt, may it not reaſonably be ſuppoſed, that Aſia, and all the eaſtern continent, is the moſt antient country in the world? and that Europe, and part of Africa, eſpecially the weſt parts of theſe continents, as Britain, France, Spain, &c. are

are countries of a more recent date? Both hiſtory and phyſics concur in eſtabliſhing this hypotheſis.

But, beſide the conſtant motion of the ſea from eaſt to weſt, other cauſes concur in producing the effect juſt mentioned. There are many lands lower than the level of the ſea, and are defended by a narrow iſthmus of rock only, or by banks of ſtill weaker materials. The action of the waters muſt gradually deſtroy theſe barriers; and, conſequently, ſuch lands muſt then become part of the ocean. Beſides, the mountains are daily diminiſhing, part of them being conſtantly carried down to the valleys by rains. It is likewiſe well known, that every little brook carries earth, and other matters, from the high grounds into the rivers, by which they are at laſt tranſported to the ocean. By theſe means the bottom of the ſea is gradually filling up, the ſurface of the earth is approaching to a level, and nothing but time is wanting for the ſea's ſucceſſively changing places with the land.

I ſpeak not here of cauſes removed beyond the ſphere of our knowledge, of thoſe convulſions of nature, the ſlighteſt effort of which would be fatal to the globe. The near approach of a comet, the abſence of the moon, or the introduction of a new planet into the ſyſtem, &c. are ſuppoſitions upon which the imagination may rove at large. Cauſes of this kind will produce any effect we chooſe. From a ſingle hy-

 potheſis

potheſis of this nature, a thouſand phyſical romances might be compoſed, and their authors might dignify them with the title of *Theory of the Earth*. As an hiſtorian, I reject theſe vain ſpeculations: They depend upon mere poſſibilities, which, if called into action, neceſſarily imply ſuch a devaſtation in the univerſe, that our globe, like a fugitive particle of matter, eſcapes obſervation, and is no longer worthy of our attention. But, to give conſiſtency to our ideas, we muſt take the earth as it is, examine its different parts with minuteneſs, and, by induction, judge of the future, from what at preſent exiſts. We ought not to be affected by cauſes which ſeldom act, and whoſe action is always ſudden and violent. Theſe have no place in the ordinary courſe of nature. But operations uniformly repeated, motions which ſucceed one another without interruption, are the cauſes which alone ought to be the foundation of our reaſoning.

Some examples ſhall be given: We ſhall combine particular effects with general cauſes, and give a detail of facts, which will illuſtrate and explain the different alterations that the earth has undergone, whether by irruptions of the ſea upon the land, or by the ſea's retiring from lands which it formerly covered.

That irruption which gave riſe to the Mediterranean * is undoubtedly the greateſt †. The

* Proofs, art. XI. and XIX. † Ray's Diſcourſes, p. 209.; Plot. Hiſt. Nat. &c.

ocean

ocean runs with prodigious rapidity through a narrow paſſage between two promontories *, and then forms a vaſt ſea, which, excluſive of the Black Sea, is about ſeven times larger than the kingdom of France. The motion through the Straits of Gibraltar is contrary to the motion in every other ſtrait. The general motion of the ſea is from eaſt to weſt; but, in the Straits of Gibraltar, it is from weſt to eaſt; an inconteſtible proof, that the Mediterranean Sea is not an ancient gulf, but that it has been formed by an irruption, produced by ſome accidental cauſe, ſuch as an earthquake ſwallowing up the barrier, or a violent effort of the ocean, occaſioned by the wind, and forcing its way through the bank between the two promontories of Gibraltar and Ceuta. This opinion is ſupported by the teſtimony of the ancients †, who inform us, that there was a time when the Mediterranean had no exiſtence. It is likewiſe confirmed by natural hiſtory, and by obſervations upon the ſtrata on the oppoſite coaſts of Africa and Spain, where, as in neighbouring mountains, the beds of earth and ſtone are preciſely the ſame at equal levels.

When the ocean forced this paſſage, it ran through the Straits with much more rapidity than at preſent, and inſtantly deluged that large tract of land which formerly joined Europe to

* Phil. Tranſ. abridged, vol. 2. p. 289. † Diodorus Siculus, Strabo.

Africa. The waters covered all the grounds which were lower than the level of the ocean; and no part of them is now to be ſeen, except the tops of ſome of the mountains, ſuch as part of Italy, Sicily, Malta, Corſica, Sardinia, Cyprus, Rhodes, and the iſlands of the Archipelago.

I have not mentioned the Black Sea as an effect of this irruption; becauſe the quantity of water it receives from the Danube, the Nieper, the Don, and other rivers, is more than ſufficient both to form and ſupport this ſea. Beſides, it runs with great rapidity through the Boſphorus into the Mediterranean *. It may even be ſuppoſed that the Black and Caſpian Seas were only two large lakes, which were perhaps joined by a narrow communication, or rather by a moraſs, or ſmall lake, uniting the Don and the Wolga about Tria, where theſe two rivers run very near each other. It is likewiſe probable, that theſe two ſeas, or lakes, were formerly of a much greater extent; for the large rivers which fall into the Black and Caſpian Seas muſt have gradually brought down a quantity of earth and ſand ſufficient to ſtop up the communication, and to form that neck of land by which theſe two ſeas are divided. We know, that large rivers, in a courſe of time, block up ſeas, and form new lands, as in the province at the mouth of the Yellow River in China; Louiſiana at the

* Phil. Tranſ. abridged, vol. 2. p. 289.

mouth

mouth of the Miſſiſippi; and the northern part of Egypt, which derived its exiſtence * from the inundations of the Nile †. Such quantities of earth are brought down, by the rapidity of the Nile, from the interior parts of Africa, and depoſited during the inundations, that you may dig fifty feet deep before you can reach the bottom of the ſlime and mud. Louiſiana, and the province of the Yellow River, have, in the ſame manner, been originally formed by the ſlime of rivers.

Farther, the Caſpian Sea is a real lake. It has no communication with any other ſea, not even with the Lake Aral, which appears to have been a part of it, being only ſeparated by a large tract of ſand, in which neither river nor canal for carrying off the waters have been diſcovered. This ſea, therefore, has no external communication with any other; and I doubt much if there is any reaſon to ſuſpect a ſubterraneous communication with the Black Sea, or with the Gulf of Perſia. The Caſpian, it is true, receives the Wolga, and ſeveral other rivers, which appear to furniſh as much water as is loſt by evaporation. But, independent of the difficulties attending ſuch calculations, if it communicates with any other ſea, a uniform and rapid current towards the place of communication would be an infallible conſequence; but nothing of this kind has yet been diſcovered. Travellers of the beſt

* Shaw's Travels. † Proofs, art. XIX.

 credit

credit aſſure us of the contrary. We, therefore, conclude, that the Caſpian Sea receives juſt as much water from the rivers and clouds as it loſes by evaporation.

It is not improbable, that the Black Sea will, in time, be entirely divided from the Mediterranean; and that the Boſphorus will be choked up, whenever the rivers ſhall have accumulated a ſufficient quantity of materials to bring about that effect. It is impoſſible to fix the æra of this event; but time, and the diminution of waters in rivers, in proportion as the mountains are lowered by the cauſes mentioned above, will one day exhibit this phænomenon to the world.

The Caſpian and Black Seas ſhould, therefore, be conſidered rather as lakes than as gulfs of the ocean; becauſe they exactly reſemble other lakes which receive a number of rivers without any viſible outlet, as the Dead Sea, ſeveral lakes in Africa, and elſewhere. Beſides, the ſaltneſs of theſe two ſeas is not nearly equal to that of the Mediterranean or of the ocean; and, it is an agreed point, that the navigation in the Caſpian and Black Seas, on account of their numberleſs ſhoals, rocks, and banks, is ſo extremely hazardous, that ſmall veſſels only can be uſed in them with ſafety. This circumſtance farther proves, that theſe ſeas ought not to be conſidered as gulfs of the ocean, but as vaſt collections of water amaſſed by large rivers.

If

If the iſthmus which ſeparates Africa from Aſia were cut, it would neceſſarily create a great irruption of the ſea upon the land. This junction was formerly projected by the Kings of Egypt, and adopted ſince by the Califs. I doubt whether the pretended communication between the Red Sea and Mediterranean be ſufficiently eſtabliſhed. The Red Sea is a narrow branch of the ocean: Through its whole extent, not a ſingle river runs into it from the Egyptian ſide, and very few from the oppoſite. This ſea will not, therefore, be ſubject to diminution, like thoſe ſeas or lakes which are actually impaired by the ſlime and ſand brought down by large rivers. The Red Sea receives all its waters directly from the ocean, and the motion of the tides in it are very diſcernible; of courſe, it muſt be affected by the general motions of the ocean. The Mediterranean, on the other hand, muſt be lower than the ocean; becauſe the current through the Straits is exceedingly rapid. Beſides, it receives the Nile, which runs parallel to the weſt coaſt of the Red Sea, and paſſes through the longeſt extent of Egypt, which is a very low country. From theſe circumſtances, it is at leaſt probable, that the Red Sea is higher than the Mediterranean, and, conſequently, that, if the iſthmus of Suez were cut, a great inundation, and a conſiderable augmentation of the Mediterranean, would enſue; eſpecially if the waters were not reſtrained by dikes and ſluices, placed

at proper diſtances. This precaution was probably uſed, if ever the ancient canal ſubſiſted.

But, not to ſpend time on conjectures, which, however well founded, may perhaps appear raſh, we ſhall give ſome certain and recent examples of the changes of ſea into land, and of land into ſea*. At Venice, the bottom of the ſea is conſtantly riſing: If the canals had not been carefully kept clean, the moats and city would, long ere now, have formed a part of the continent. The ſame thing may be ſaid of moſt harbours, bays, and mouths of rivers. In Holland, the bottom of the ſea is elevated in many places; the gulf of Zuderzee and the ſtraits of the Texel cannot receive ſuch large veſſels as formerly. At the mouth of almoſt every river, we find ſmall iſlands, and banks of earth and ſand brought down from the higher grounds; and it is incontrovertible, that the ſea is conſtantly dammed up, wherever great rivers empty themſelves. The Rhine is loſt in the ſands which itſelf has accumulated. The Danube, the Nile, and all large rivers, after having tranſported great quantities of ſlime, ſand, &c. never more arrive at the ſea by a ſingle channel; they ſplit into branches, the intervals of which conſiſt of the materials which they themſelves have tranſported. Marſhes are daily drained; lands, abandoned by the ſea, are now plowed and ſown; we navigate whole countries now covered by the

* Proofs, art. XIX.

waters;

waters; in a word, we ſee ſo many inſtances of land changed into water, and water into land, that we muſt be convinced of the continual, though ſlow, progreſs of ſuch changes in all places. Hence the gulfs of the ocean will in time become continents; the iſthmuſes will be changed into ſtraits; and the tops of the mountains will be metamorphoſed into ſhoaly rocks in the ſea.

The waters, therefore, have covered, and may ſtill cover, every part of the earth which is now dry. Hence our aſtoniſhment at finding the productions of the ſea diſperſed every where, and a compoſition of bodies, which could not be effected by any other means than the operation of the waters, ought for ever to ceaſe. We have already explained how the horizontal ſtrata of the earth were formed. But thoſe perpendicular fiſſures, which are equally diffuſed through rocks, clays, and every conſtituent material of the globe, remain to be conſidered. The perpendicular fiſſures are indeed placed at greater diſtances from each other than the horizontal; and the ſofter the matter, the more diſtant are the fiſſures. In marble and hard ſtone, the perpendicular fiſſures are only a few feet aſunder. If the maſs of rock be extenſive, the diſtance betwixt the fiſſures is ſome fathoms: Sometimes they extend from the ſummit to the baſe of the rock, and ſometimes they terminate after arriving at a horizontal fiſſure. They are uniformly perpendicular in the

ſtrata

ſtrata of all calcareous ſubſtances, as chalk, marls, marble, &c. But they are more oblique, and leſs regularly ſituated, in vitreſcent bodies, brown free-ſtone, and rocks of flint, where they are often adorned with cryſtals and other minerals. In quarries of marble, or of calcareous ſtone, the fiſſures are filled with ſpar, gypſum, gravel, and an earthy ſand, which contains a conſiderable portion of chalk. In marls, and every other ſpecies of earth, except ſand-ſtone, the perpendicular fiſſures are either empty, or filled with ſuch matters as have been tranſported thither by water.

The cauſe of perpendicular fiſſures is eaſily inveſtigated. As the various materials which conſtitute the different ſtrata were tranſported by the waters, and depoſited in the form of ſediments, they would at firſt be in a very diluted ſtate, and would gradually harden and part with the ſuperfluous quantity of water they contained. In the proceſs of drying, they would naturally contract, and of courſe ſplit at irregular diſtances. Theſe fiſſures neceſſarily aſſumed a perpendicular direction; becauſe, in this direction, the action of gravity of one particle upon another is equal to nothing; but it acts directly oppoſite in a horizontal ſituation: The diminution in bulk could have no ſenſible effect but in a vertical line. I ſay, the contraction of the parts in drying, not the contained water forcing an iſſue, as has been alleged, is the cauſe of

of perpendicular fiſſures; for I have often remarked, that the ſides of theſe fiſſures, through their whole extent, correſpond as exactly as the two ſides of a ſplit piece of wood. Their ſurfaces are rude and irregular. But, if they had taken their riſe from the motion of water, they would have been ſmooth and poliſhed. Hence theſe fiſſures muſt have been produced, either ſuddenly or gradually, by drying and contracting, like the cracks and fiſſures in green wood; and the greateſt part of the water the bodies contained muſt have evaporated through the pores. In the chapter upon minerals, we ſhall demonſtrate, that ſome part of the original water ſtill remains in ſtones and ſeveral other ſubſtances; and that cryſtals, minerals, and ſome other bodies, owe their exiſtence to this water.

Perpendicular fiſſures vary greatly as to the extent of their openings. Some are about half an inch, or an inch, others a foot, or two feet; ſome extend ſeveral fathoms, and give riſe to thoſe vaſt precipices which ſo frequently occur between oppoſite parts of the ſame rocks in the Alps and other high mountains. It is plain, that the fiſſures, the openings of which are ſmall, have been occaſioned ſolely by drying. But thoſe which extend ſeveral feet are partly owing to another cauſe; namely, the ſinking of the foundation upon one ſide, while that of the other remained firm. If the baſe ſinks but a line or two, when the height of the rock is conſiderable,

able an opening of ſeveral feet, or even fathoms, will be the conſequence. When rocks are founded on clay or ſand, they ſometimes ſlip a little to a ſide; and the fiſſures are of courſe augmented by this motion. I have not hitherto mentioned thoſe large openings, thoſe prodigious cuts, which are to be met with in rocks and mountains: Theſe could not be produced by any other means than the ſinking of immenſe ſubterraneous caverns which were unable longer to ſuſtain their incumbent load. But theſe cuts or intervals in mountains are not of the ſame nature with perpendicular fiſſures: They appear to have been ports opened by the hand of nature for the communication of nations. This ſeems to be the intention of all large openings in chains of mountains, and of thoſe ſtraits by which different parts of the ocean are connected; as the Straits of Thermopylae, of Gibraltar, &c.; the gaps or ports in Mount Caucaſus, the Cordeliers, &c. A ſimple ſeparation, by the drying of the matter, could not produce this effect: Large portions of earth muſt have been ſunk, ſwallowed up, or thrown down*.

Theſe great ſinkings, though occaſioned by accidental and ſecondary cauſes†, are leading facts in the hiſtory of the earth, and have contributed greatly in changing the appearance of its ſurface. Moſt of them have been produced by ſubterraneous fires, the exploſions of which

* Proofs, art XVII. † Ibid.

give

give riſe to earthquakes and volcano's. The force of inflamed matter, ſhut up in the bowels of the earth, is irreſiſtible*. By the action of ſubterraneous fires, whole cities have been ſwallowed up, mountains, and large tracts of country, have been overturned and rendered unfit for the habitation of men. But, though this force be great, though its effects appear to be prodigious, we cannot aſſent to the opinions of ſome authors, who ſuppoſe that theſe ſubterraneous fires are only branches of an immenſe abyſs of flame in the centre of the earth. Neither do we credit the common notion, that theſe fires have their ſeat at a great depth below the ſurface; for matter cannot begin to burn, or at leaſt the inflammation cannot be ſupported, without air. In examining the materials which iſſue from volcano's, even in their moſt violent eruptions, it is eaſy to perceive that the furnace is not very deep, and that the inflamed ſubſtances are the ſame with thoſe on the top of the mountain, only diſfigured by calcination and the melting of the metallic particles they contain. To be convinced that the matters thrown out by volcano's come not from any conſiderable depth, we need only attend to the height of the mountain, and conſider the immenſe force which would be neceſſary to project ſtones and minerals to the height of half a league; for Ætna,

* Agricola de rebus quæ effluunt e terra. Phil. Tranſ. abrid. vol. ii. p. 391. Ray's Diſcourſes, p. 272.

Hecla,

Hecla, and other volcano's, have at leaſt that elevation.

Now, it is well known that fire acts equally on all ſides; it cannot, therefore, act upwards with a force ſufficient to throw large ſtones half a league high, without an equal re-action on the baſe and ſides. But the ſides of the mountain would very ſoon be pierced and blown to pieces by this re-action; becauſe the materials of which it conſiſts are not more denſe or firm than thoſe which are projected. How, then, can it be imagined, that the cavity, which muſt be conſidered as the tube or cannon, could poſſibly reſiſt a force neceſſary to raiſe ſuch heavy bodies to the mouth of the volcano? Beſides, ſuppoſe the cavity deeper, as the external orifice is not great, it would be impoſſible for ſo large a quantity of liquid and burning matters to iſſue forth at a time, without claſhing againſt each other, and againſt the irregular ſides of the cavity; and, in paſſing through ſo long a ſpace, they would be in danger of cooling and congealing. Rivers of melted ſulphur and bitumen, projected from volcano's along with ſtones and minerals, run from the tops of the mountains into the plains. Is it natural to think, that matter ſo fluid, ſo little able to reſiſt violent action, could be projected from a very great depth? Every obſervation which can be made on this ſubject will tend to prove, that the fire in volcano's is not very diſtant from the tops of

the mountains, and never deſcends ſo low as the level of the plains *.

This account of volcano's, however, is not inconſiſtent with their being the cauſe of conſiderable earthquakes; neither does it contradict the communication of one volcano with another, by means of ſubterraneous paſſages †. But the depth of the furnace is the object of our preſent inveſtigation; and it cannot be very diſtant from the mouth of the volcano. To produce an earthquake in a plain, it is not neceſſary that the bottom of the volcano ſhould be below the level of that plain, nor that there ſhould be ſubterraneous cavities filled with the ſame burning matter under the plain. A violent exploſion, with which eruptions are uniformly accompanied, may, like that of a powder-magazine, give ſuch a concuſſion as to produce, by its re-action, an earthquake of conſiderable extent.

I mean not to ſay that there are no earthquakes which derive their exiſtence from ſubterranean fires ‡; but that there are earthquakes produced ſolely by the exploſion of volcano's. In confirmation of what has been ſaid upon this ſubject, volcano's ſeldom or never appear in plains; on the contrary, their mouths, or craters, are always found on the tops of the higheſt mountains. If the ſubterraneous fire of

* Borelli de incendiis Ætnæ. † Phil. Tranſ. abridged, vol. ii. p. 392. ‡ Proofs, art. XVI.

volcano's

volcano's ſtretched below the plains, would not new paſſages be opened there during violent eruptions, rather than in the tops of the mountains, where the reſiſtance is greater? In the firſt eruption, would it not have been eaſier to pierce a plain, than a mountain of half a league in height?

It is not difficult to diſcover the reaſon why volcano's appear only in mountains. Greater quantities of minerals, ſulphur, and pyrites, exiſt in mountains, and nearer the ſurface, than in plains. The mountains have likewiſe this farther advantage; they are more ſubject to the impreſſions of the air, and receive more rain and moiſture, by which mineral ſubſtances are capable of being fermented to ſuch a degree as to produce actual inflammation.

To conclude, it has often been obſerved, that, after violent eruptions, the mountains have ſunk and diminiſhed, nearly in proportion to the quantity of matter thrown out, which is another proof that volcano's are not ſo deep as the baſe of the mountains, and even that they are not much below the ſummit.

In many places, earthquakes have formed conſiderable hollows, and even ſome large gaps, in mountains. All other inequalities are coeval with the mountains themſelves, and owe their exiſtence to currents in the ocean; for, in every place which has not been diſturbed by accidental convulſions, the ſtrata of mountains are parallel

rallel, and their angles correſpond *. It is not difficult to diſtinguiſh ſubterraneous caverns and excavations formed by volcano's, from thoſe produced by water. The latter conſiſt only of ſolid rocks, the ſand and clay with which they were formerly filled being carried off by the water, which is the origin of caverns in hills; for thoſe found in plains are commonly nothing but old pits and quarries, like the ſalt-quarries of Maeſtricht, the mines of Poland, &c. But natural caverns are proper to the mountains; the ſummit, or higher parts, furniſh them with water, which afterwards iſſues out to the ſurface wherever it can find a paſſage. Theſe caverns are the ſources of ſprings and rivers. When a large cavern of this kind is ſuddenly filled up by the falling of its roof, an inundation is generally the conſequence †.

From theſe facts, it is eaſy to perceive how much ſubterraneous fires have contributed to change both the ſurface and internal part of the globe. This cauſe has power ſufficient to produce very great effects. But it is difficult to conceive how any ſenſible alterations upon the land can be introduced by the winds ‡. Their dominion would appear to be confined to the ſea. Indeed, next to the tides, nothing has ſuch a powerful influence upon the waters; the flux and reflux proceed with an uniform pace; their

* Proofs, art. XVII. † Phil. Tranſ. abridged, vol. ii. p. 322. ‡ Proofs, art. XV.

operations are always the ſame; but the action of the winds is capricious and violent. They ruſh on with irreſiſtible fury, and excite ſuch impetuous commotions, that the ocean, from a ſmooth and tranquil plain, in an inſtant is furrowed with waves which emulate the height of mountains, and daſh themſelves in pieces againſt the ſhores. The ſurface of the ocean is ſubject to conſtant alterations from the winds. But ought not the ſurface of the land, which has ſo ſolid an appearance, ever to remain uninfluenced by a cauſe of this kind? It is conſonant to experience, however, that the winds raiſe mountains of ſand in Arabia and Africa; that they overwhelm large plains with it; and that they frequently carry theſe ſands many leagues into the ſea, where they accumulate in ſuch quantities as to form banks, downs, and even iſlands*. It is alſo well known, that hurricanes are the ſcourge of the Antilles, of Madagaſcar, and of other countries, where their impetuoſity is ſo great, that they ſweep away trees, plants, and animals, together with the ſoil which nouriſhed them. They drive back, they annihilate, rivers, and produce new ones; they overthrow rocks and mountains; they ſcoop out holes and gulfs in the earth, and totally change the face of thoſe unhappy countries which give birth to them. Happily, few climates are expoſed to

* Bellarmin. de aſcen. mentis in Deum. Varen. Geog. p. 282. Voyag. de Pyrard, tom. i. p. 470.

the

the violence of thoſe dreadful agitations of the air.

But the greateſt changes upon the ſurface of the earth are occaſioned by rains, rivers, and torrents from the mountains. Theſe derive their origin from vapours raiſed by the ſun from the ſurface of the ocean, and are tranſported by the winds through every climate. The progreſs of theſe vapours, which are ſupported by the air, and tranſported at the pleaſure of the winds, is interrupted by the tops of the mountains, where they accumulate into clouds, and fall down in the form of rain, dew, or ſnow. At firſt, theſe waters deſcended into the plains without any fixed courſe*; but they gradually hollowed out proper channels for themſelves. By the power of gravity, they ran to the bottom of the mountains, and, penetrating or diſſolving the lower grounds, they carried along with them ſand and gravel, cut deep furrows in the plains, and thus opened paſſages to the ſea, which always receives as much water by rivers as it loſes by evaporation. The windings in the channels of rivers have uniformly correſponding angles on their oppoſite banks; and as mountains and hills, which may be regarded as the banks of the valleys by which they are ſeparated, have likewiſe ſinuoſities with correſponding angles, this circumſtance ſeems to demonſtrate, that the valleys have been gradually formed by currents of the

* See proofs, art. X. and XVIII.

 ocean,

ocean, in the ſame manner as the channels of rivers have been produced.

The waters which run upon the ſurface, and ſupport the verdure and fertility of the ſoil, compoſe not perhaps one half of the quantity that is produced by vapour. Numberleſs veins of water ſink deep into the bowels of the earth. In ſome places, you are certain of obtaining water by digging; in others, none can be found. In almoſt all the valleys and low grounds, at a certain depth, water is uniformly to be met with. But, in all high grounds, it is impoſſible to extract water from the bowels of the earth. It muſt be collected from the heavens. There are extenſive countries where no wells can be obtained: There men, and other animals, are ſupplied with drink from ciſterns and pools. In the eaſt, and eſpecially in Arabia, Egypt, and Perſia, wells and ſprings are great and valuable rarities. To ſupply their place, the inhabitants have been obliged to make large reſervoirs to collect the water that falls from the heavens. Theſe works, projected and executed from public neceſſity, conſtitute the moſt beautiful and magnificent monuments of the eaſt. Some eaſtern reſervoirs have more than two ſquare leagues of ſuperficies, and fertilize whole provinces by numberleſs ducts and canals let out from all ſides. But, in plain countries, furniſhed with large rivers, it is impoſſible to break the ſurface of the earth without finding water. In camps ſituated in the

the neighbourhood of rivers, it often happens that every tent may have its own well, by giving a few ſtrokes with a pick-ax.

Moſt of the water, ſo liberally diffuſed through low grounds, comes from the neighbouring hills and eminences. During great rains, or the ſudden melting of ſnow, part of the water runs upon the ſurface; but moſt of it penetrates the earth and rocks, by means of ſmall chinks and fiſſures. This water riſes again to the ſurface, whenever it can find an iſſue; but it often drills through ſands, and creeps along till it finds a bottom of clay, or hard earth, and there forms ſubterraneous lakes, brooks, and perhaps rivers, of which the channels are for ever buried in oblivion. Subterraneous rivers, however, muſt follow the general law of nature, and uniformly run from the higher to the lower ground. Their waters muſt of courſe either fall at laſt into the ſea, or be collected in ſome low place, whether at the ſurface or in the bowels of the earth: For there are ſeveral lakes which neither receive nor give riſe to any river. A ſtill greater number receive no conſiderable river, but are the ſources of the largeſt rivers on earth; as the lakes from which the river St. Lawrence iſſues; the lake Chiamè, from which two large rivers ariſe, that water the kingdoms of Aſem and Pegu; the lakes of Aſſiniboil in America; thoſe of Ozera in Muſcovy; thoſe that give riſe to

the Bog and the Irtis, and many others*. It is plain, that theſe lakes muſt derive their exiſtence from the waters of ſuperior grounds, running through ſubterraneous paſſages. Some, indeed, have affirmed, that lakes are to be met with on the tops of the higheſt mountains. But this is incredible; for the lakes found on the Alps, and other elevated ſituations, are all overtopped by higher mountains, and derive their origin from the waters which run down the ſides, or are filtered through the bowels of theſe ſuperior eminences, in the ſame manner as the lakes in valleys are ſupplied.

From this reaſoning, the exiſtence of ſubterraneous collections of water, eſpecially under large plains, is apparent†: For mountains, hills, and heights of every kind, are expoſed on all ſides to the weather. The waters which fall upon their ſummits, and upon elevated plains, after penetrating the earth, muſt, from the declivity of the ground, break out at many places in the form of ſprings and fountains: Of courſe, little water will be found in the bowels of mountains. But, in plains, as the water filtrated through the earth can find no iſſue, it muſt be collected in ſubterraneous caverns, or diſperſed in ſmall veins, among ſand and gravel. This is the origin of the water ſo univerſally diffuſed through low grounds. The bottom of a pit, or well, is only a ſmall artificial baſon, into which

* Proofs, art. XI. † Proofs, art. XVIII.

the

the water inſinuates itſelf from the higher grounds. At firſt it generally falls in by drops; but afterwards, when the paſſages become more open, it receives freſh ſupplies from greater diſtances, and runs in ſmall continued veins or rills. To this circumſtance it is owing, that although water may be found in any part of a plain, only a certain number of wells can be ſupplied. This number is in proportion to the quantity of water diffuſed, or rather to the extent of the higher grounds from which it comes.

To find water, it is unneceſſary to dig below the level of a river. It is commonly found at ſmaller depths. The water of rivers ſeldom ſpreads far in the earth by filtration. Even what is found in the earth, below the level of rivers, is not derived from them; for, in rivers which have been dried up, or whoſe courſes have been changed, no greater quantity of water is obtained by digging, than in the neighbouring ground at an equal depth. Five or ſix feet of earth is ſufficient to contain water, and to prevent its eſcape: I have often remarked, that the banks of rivulets or pools have no ſenſible moiſture at the diſtance of ſix inches from the water. It is true, the filtration is always in proportion to the penetrability of the ground. But, upon examining the ſtagnating pools with a ſandy bottom, it is remarkable that the moiſture ſpreads but a few inches. Neither is the extent of it great in a vegetable ſoil, which is

much more looſe and porous than ſand or hard earth. A garden-bed, though plentifully watered, communicates little or no moiſture to thoſe adjoining. I have examined level heaps of garden-earth, of ſix or eight feet thick, which had remained undiſturbed for ſome years, and found that the rain-water had never reached above three or four feet deep. I have made the ſame obſervation upon earth which had lain 200 years in ridges: Below the depth of three or four feet, it was as dry as duſt. Hence the ſpreading of water, by filtration alone, is not ſo extenſive as has generally been imagined. Very little can deſcend in this way to the bowels of the earth. But water, by its own gravity, deſcends from the ſurface to the greateſt depths. It ſinks through natural conduits, or forces paſſages for itſelf: It follows the roots of trees, the fiſſures of rocks, or interſtices in the earth. It divides and expands on all hands into an infinite number of ſmall branches or rills; and uniformly deſcends till its progreſs is ſtopped by clay or a ſolid earth, where it accumulates and breaks out to the ſurface in form of a ſpring or fountain.

It would be no eaſy taſk to make an exact calculation of the quantity of ſubterraneous waters which have no apparent iſſue*. Many authors pretend that it greatly ſurpaſſes all the waters on the ſurface: Not to mention thoſe who think that the interior part of the globe is entirely

* Proofs, art. X. XI. and XVIII.

tirely filled with water, it is imagined by ſome, that there is an infinite number of rivers, rills, and lakes, in the bowels of the earth. But this opinion ſeems to have no proper foundation; and it is probable, that the quantity of ſubterraneous waters, which never appear at the ſurface, is very inconſiderable; for, if the number of ſubterraneous rivers were ſo great, Why do we never ſee any of their mouths break out, like ſprings, on the ſurface? Beſides, rivers produce conſiderable changes on the ſurface of the earth; they carry off the ſoil; they wear away the moſt ſolid rocks, and remove every thing that oppoſes their paſſage. The ſame effects would reſult from ſubterraneous rivers. But no ſuch changes have ever been diſcovered; nothing below the ſurface is diſplaced; the different ſtrata every where preſerve their parallel and primitive poſition; and it is only in very few places that ſubterraneous veins of water, of any conſideration, have been diſcovered. Thus, the internal operation of water is not great; but, as it is divided into an infinity of ſmall veins, which are often ſhut up by numberleſs obſtacles, it gives riſe to many ſubſtances, which are totally different, both in form and ſtructure, from thoſe of the primitive matter.

From what has been advanced, we may conclude, that the flux and reflux of the ocean have produced all the mountains, valleys, and other inequalities on the ſurface of the earth; that currents

currents of the ſea have ſcooped out the valleys, elevated the hills, and beſtowed on them their correſponding directions; that the ſame waters of the ocean, by tranſporting and depoſiting earth, &c. have given riſe to the parallel ſtrata; that the waters from the heavens gradually deſtroy the effects of the ſea, by continually diminiſhing the height of the mountains, filling up the valleys, and choaking the mouths of rivers; and, by reducing every thing to its former level, they will, in time, reſtore the earth to the ſea, which, by its natural operations, will again create new continents, interſperſed with mountains and valleys, every way ſimilar to thoſe which we now inhabit.

PROOFS

OF THE

THEORY OF THE EARTH.

ARTICLE I.

Of the Formation of Planets.

AS natural hiſtory is our proper ſubject, we would willingly diſpenſe with aſtronomical obſervations. But, as the earth is ſo nearly related to the heavenly bodies, and, as obſervations of this kind illuſtrate more fully thoſe doctrines we have already advanced, it is neceſſary to give ſome general ideas concerning the formation, motion, and figure, of the earth, and other planets.

The earth is a globe of about 3000 leagues in diameter; it is ſituated 30 million of leagues from the ſun, round which it revolves in 365 days. This annual revolution is the effect of two forces; the one may be conſidered as an impulſe from right to left, or from left to right;