The hundred wonders of the world

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Phenomena of the ocean.

PHENOMENA OF THE OCEAN.

They that go down to the sea in ships, that do business in great waters; these see the works of the Lord, and his wonders in the deep.—PSALMS.

With wonder mark the moving wilderness of waves,
From pole to pole through boundless space diffused,
Magnificently dreadful! where, at large,
Leviathan, with each inferior name
Of sea-born kinds, ten thousand thousand tribes,
Find endless range for pasture and for sport.
Adoring own
The Hand Almighty, who in channelled bed
Immeasurable sunk, and poured abroad,
Fenced with eternal mounds, the fluid sphere;
With every wind to waft large commerce on,
Join pole to pole, consociate severed worlds,
And link in bonds of intercourse and love
Earth's universal family.

MALLET.

THAT huge mass of waters impregnated with salt, which encompasses all parts of the globe, and by the means of which, in the present improved state of navigation, an easy intercourse subsists between the most distant nations, is denominated THE OCEAN, and has three grand divisions assigned to it. First: That vast expanse of water which lies to the westward of the northern and southern continents of America, and by which those continents are divided from Asia. On account of the uniform and temperate gales which sweep its surface within the tropics, it is named "the Pacific Ocean;" and has again been distinguished into the Northern and Southern Pacific, the equator being considered as the boundary of each, and "the Southern Ocean," or South Sea, being, consequently, that part of the general assemblage of waters which roll in the direction from about the fortieth degree of latitude towards the south pole. Its general width is estimated at about ten thousand miles. Secondly: The "Atlantic Ocean," which divides Europe and Africa from the two American continents, and has a general width of about three thousand miles; while the waters which occupy the polar regions are named "The Northern sea." And, lastly: "The Indian Ocean," which extends from the

eastern shores of Africa along the southern coasts of Asia, and has the same general width with the preceding one.

Among the chief of those less expansive sheets of water, properly called seas, may be mentioned the Baltic, the Mediterranean Sea, and the Black and Red Seas. The Caspian Sea, being entirely encompassed by land, might, with more propriety, have been styled a lake; but as its water possesses the quality of saltness, it is ranked among the seas. It is, notwithstanding, certain that Lake Superior, in North America, has a still greater circumference, extending around its shores at least fourteen hundred miles, while the extent of the Caspian Sea does not exceed twelve hundred.

Of the origin of this division into different seas, and seas of different depths, little is known; but it is highly probable that many of the larger excavations and partitions now met with, have existed, without much change as to their extent, from the creation. Others have undoubtedly been the result of that conflict which is perpetually taking place between the elements of land and water, and which has, for the greater part, given rise to islands, isthmuses, and peninsulas; while subterraneous volcanoes, and those truly surprising and indefatigable exertions of corals, madrepores, tubifores, and other restless and multitudinous zoophites, have laid, and are daily laying the foundation of new islands and continents in the middle of the widest and deepest seas.

The *quantity* of water in the ocean not only remains constantly the same; but, notwithstanding its most violent and incessant motion, continues *stable* within certain limits. This, however, is what cannot be inferred from observation; for, although in the almost infinite variety of disturbances to which the ocean is liable, from the action of irregular causes, it may appear to return to its former state of equilibrium, still it may be apprehended that some extraordinary cause may communicate to it a shock, which, though inconsiderable at its origin, may augment continually, and elevate it above the highest mountains. It is, therefore, interesting to investigate the conditions which are necessary for the absolute stability of the ocean. This has been effected by the celebrated Laplace, who has demonstrated that the equilibrium of the ocean *must* be

stable, if its density be *less* than the mean density of the earth, which is known to be the case. He has likewise determined, by means of his refined analysis; that this stability would cease to exist, if the mean density of the sea *were to exceed* that of the earth; so that the stability of the equilibrium of the ocean, and the excess of the density of the terrestrial globe above that of the waters which cover it, are reciprocally connected with each other, and indicate infinite wisdom and contrivance in such an adjustment.

SALTNESS OF THE SEA.

Of the various phenomena of the sea, that of its saltness is one of the most obvious. No questions concerning the natural history of our globe have been discussed with more attention, or decided with less satisfaction, than that concerning its primary cause, which had perplexed the philosophers before the time of Aristotle, and surpassed even the great genius of that profound enquirer into natural causes. Father Kircher, after having consulted not less than thirty-three authors on this subject, could not help remarking, that the fluctuations of the ocean itself were scarcely more various, than the opinions concerning the origin of its saline impregnation.

This question does not seem capable of admitting an illustration from experiment; at least, not any experiments have been hitherto made for that purpose: it is, therefore, not surprising that it remains nearly as problematical in the present age, as it has been in any of the preceding. Had observations been made three or four centuries ago, to ascertain the then saltness of the sea, at any particular time and place, we might now, by making similar observations at the same place, in the same season, have been able to know, whether the saltness, at that particular place, was an increasing, or a decreasing, or an invariable quantity. This kind and degree of knowledge would have served as a clue to direct us to a full investigation of this matter in general. It is to be regretted, however, that observations of this nature have not, until very lately, been made with any degree of precision.

One of the principal opinions maintained on this subject by modern philosophers, and more particularly supported by Doctor Halley, is, that since river water, in almost

every part of the globe, is impregnated, in a greater or less degree, by sea-salt, the sea must have gradually acquired its present quantity of salt from the long-continued influx of rivers. The water which is carried into the sea by these rivers, is again separated from it by evaporation, and being dispersed over the atmosphere by winds, soon descends in rain or vapour upon the surface of the earth, whence it hastens to pour into the bosom of the ocean the fresh tribute of salt it has collected in its inland progress. Thus the salt conveyed into the sea not being a volatile substance, nor performing an incessant circulation, must be a perpetually increasing quantity; and sufficient time, it is contended, has elapsed, since the creation, for the sea to acquire from this source its present quantity of salt.

This opinion has been successfully combated; and it is denied that fresh water rivers can, in the course of many thousand years, have produced saltness in the sea. If this were the case, every sea, or great body of water, which receives rivers, must have been salt, and have possessed a degree of saltness in proportion to the quantity of water which these rivers discharge. But so far is this from being true, that the Palus Mæotis, and the great American lakes, do not contain salt water but fresh. It may indeed be objected, that the quantity of salt which rivers carry along with them, and deposit in the sea, must depend on the nature of the soil through which they flow, which may in some places not contain any salt; and that this is the reason why the great lakes in America, and the Palus Mæotis are fresh. But to this opinion, which is merely hypothetical, there are insurmountable objections. It is a curious fact, that the saltness of the sea is greatest under the line, and diminishes gradually towards the poles; but it cannot therefore be assumed that the earth contains more salt in the tropical regions than in the temperate zones, and more in these again than in the frigid zones. On the other hand, if it be allowed that the sea receives its saltness from the rivers, it must be equally salt, or nearly so, in every part of the earth; since, according to a simple and well known principle in chemistry, *when any substance is dissolved in water with the assistance of agitation, at whatever part of the water it is introduced, it will be equally diffused through the whole liquid.* Now, though

it were true that a greater quantity of salt should have been introduced into the sea under the line, than towards the poles, from the constant agitation occasioned by the wind and tide, the salt must have soon pervaded the whole mass of water. Neither is this greater proportion of saltness owing to a superior degree of heat, since it is an established principle in chemistry, that cold water and hot water dissolve nearly the same proportion of salt.

The saltness of the sea has also been ascribed to the solution of subterraneous mines of salt, which is supposed to abound in the bottom of the sea, and along its shores. But this hypothesis cannot be supported. If the sea were constantly dissolving salt, it would soon become saturated; for it cannot be said that it is deprived of any portion of its salt by evaporation, since rain water is fresh. If the sea were to become saturated, neither fishes nor vegetables could live in it. It may hence be inferred that the saltness of the sea cannot be accounted for by secondary causes, and that it has been salt since the beginning of time. It is, indeed, impossible to suppose that the waters of the sea were at any time fresh since the formation of fishes and sea-plants; for, as these will not live in water saturated with salt, neither will they live in water which is fresh. It may hence be concluded that the saltness of the sea has, with some few exceptions, perhaps, arising from mines of rock-salt dispersed near its shores, been nearly the same in all ages. This hypothesis, which is the simplest, and is involved in the fewest difficulties, best explains the various phenomena dependent on the saltness of the sea.

Although this saline property may be one of the causes by which the waters of the sea are preserved from putredity, still it cannot be considered as the principal cause. The ocean has, like rivers, its currents, by which its contents are circulated round the globe; and these may be said to be the great agents which keep it sweet and wholesome. A very enlightened navigator, Sir John Hawkins, speaks of a calm in which the sea, having continued for some time without motion, assumed a very formidable aspect. "Were it not," he observes, "for the moving of the sea, by the "force of winds, tides, and currents, it would corrupt all the world. The experiment of this I saw in the year 1590, "lying with a fleet about the islands of Azores, almost six

" months, the greater part of which time we were be-
" calmed. Upon which all the sea became so replenished
" with various sorts of gellies, and forms of serpents,
" adders, and snakes, as seemed wonderful; some green,
" some black, some yellow, some white, some of divers
" colours, and many of them had life; and some there
" were a yard and a half, and two yards long; which, had
" I not seen, I could hardly have believed. And hereof
" are witnesses all the companies of the ships which were
" then present; so that hardly a man could draw a bucket
" of water clear of some corruption. In which voyage,
" toward the end thereof, many of every ship fell sick, and
" began to die apace. But the speedy passage into our
" country, was a remedy to the crazed, and a preservative
" to those who were not touched."

CONGELATION OF SEA WATER.

ALTHOUGH the assertion that salt water never freezes has been contradicted by repeated experience, it is still certain that it requires a much greater degree of cold to produce its congelations than fresh water. It is, therefore, one of the greatest blessings which we derive from this element, that when we find all the stores of nature locked up to us on the land, the sea is, with a few exceptions, ever open to our necessities. It is well known that at particular seasons, the mouth of the river St. Lawrence, the entrance into the Baltic Sea, &c. are so much frozen over as to be impassable by ships; while the vast mountains and fields of ice in the polar regions have, for ages past, been insurmountable obstructions to the daring researches of modern navigators. These exceptions, however, will appear of comparatively trifling importance to navigation, when the number of ports which are, in almost every region, open at all seasons of the year, are considered; and this facility of intercourse would certainly not have been afforded, if sea water had admitted of as easy a congelation as that of water not impregnated with salt.

On the origin of ice in the frozen seas different opinions have been entertained. The authority of Captain Cook and Lord Mulgrave has been cited by Bishop Watson, to show that good fresh water may be procured from ice found in those seas; but he observes that, notwithstanding the

testimonies of these very able navigators, it may still be doubted whether the ice from which the water was obtained, had been formed in the sea, and, consequently, whether sea water itself would, when frozen, yield fresh water. He thinks it probable that the ice had either been formed at the mouths of large fresh water rivers, and had thence, by tides or torrents, been drifted into the sea, or that it had been broken by its own weight, from the immense cliffs of ice and frozen snow, which, in countries where there are few rivers, are found in high latitudes to project a great way into the sea. An early navigator, Fotherbye, in the relation of his voyage toward the South Pole, in 1614, considers snow to be the original cause of the ice found at sea, he himself having observed it to lie an inch thick on the surface; and Captain Cook, from his own observations in the South Sea, was disposed to think, that the vast floats of ice he met with in the spring, were formed from the congelation of snow. It is certain that the snow which falls upon the surface of the sea, being in a solid state, and, bulk for bulk, lighter than sea water, will not readily combine with it, but may, by a due degree of cold in the atmosphere, be speedily converted into a layer of ice. The upper layer of this first surface of ice being elevated above the surface of the sea, will receive all the fresh water which falls from the atmosphere in the form of snow, sleet, rain, or dew, by the successive congelation of which the largest fields of ice may at length be formed.

It is a matter of little consequence to a navigator, whence the ice which supplies him with fresh water is produced. Leaving, therefore, these hypotheses relative to the formation of ice in the Frozen Seas, it should be observed that the question, whether congealed sea water will, when thawed, yield fresh water, has been satisfactorily decided by experiments made with every suitable attention. A quantity of sea water having been taken up off the North Foreland, was exposed to a freezing atmosphere, and afforded an ice perfectly free from any taste of salt; and it has likewise been found, that not only sea water, but water containing double the proportion of salt commonly found in our sea water, and more than is contained in the sea water of any climate, may be frozen by the cold prevailing in our atmosphere.

ICE ISLANDS.

This name is bestowed by seamen on the huge solid masses of ice which float on the seas near or within the Polar circles. Many of these fluctuating islands are met with on the coasts of Spitzbergen, to the great danger of the vessels employed in the Greenland fishery. In the midst of these tremendous masses, navigators have been arrested and frozen to death. In this manner the brave Sir Hugh Willoughby perished with all his crew in 1553; and in the year 1773, Lord Mulgrave, after every effort which the most accomplished seaman could make, to reach the termination of his voyage, was caught in the ice, and nearly experienced the same unhappy fate. The scene he describes, divested of the horrors attendant on the eventful expectation of change, was most beautiful and picturesque. Two large ships becalmed in a vast bason, surrounded on all sides by ice islands of various forms; the weather clear; the sun gilding the circumambient ice, which was low, smooth, even, and covered with snow, except where pools of water, on a portion of the surface, shot forth new icy crystals; and the smooth surface of the comparatively small space of sea in which they were hemmed. Such is the picture drawn by our navigator, amid the perils by which he was surrounded.

After fruitless attempts to force their way through the fields of ice, the limits of these became at length so contracted, that the ships were immoveably fixed. The smooth extent of surface was soon lost: the pressure of the pieces of ice, by the violence of the swell, caused them to pack; and fragment rose upon fragment, until they were in many places higher than the main-yard. The movements of the ships were tremendous and involuntary, in conjunction with the surrounding ice, actuated by the currents. The water having shoaled to fourteen fathoms, great apprehensions were entertained, as the grounding of the ice, or of the ships, would have been equally fatal: the force of the ice might have crushed them to atoms, or have lifted them out of the water, and have overset them; or, again, have left them suspended on the summits of the pieces of ice at a tremendous height, exposed to the fury of the winds, or to the risk of being dashed to pieces by the failure of their

frozen dock. An attempt was made to cut a passage through the ice; but after a perseverance truly worthy of Britons, it proved ineffectual. The commander, who was at all times master of himself, directed the boats to be made ready to be hauled over the ice, till they should reach navigable water, proposing in them to make the voyage to England; but after they had thus been drawn over the ice, for three progressive days, a wind having sprung up, the ice separated sufficiently to yield to the pressure of the ships in full sail. After having laboured against the resisting fields of ice, they at length reached the harbour of Smeeringberg, at the west end of Spitzbergen.

The vast islands of floating ice which abound in the high southern latitudes, are a proof that they are visited by a much severer degree of cold than equal latitudes towards the north pole. Captain Cook, in his second voyage, fell in with one of these islands in latitude 50° 40′ south. It was about fifty feet high, and half a mile in circuit, being flat on the top, while its sides, against which the sea broke exceedingly high, rose in a perpendicular direction. In the afternoon of the same day, the 10th of December, 1773, he fell in with another large cubical mass of ice, about two thousand feet in length, four hundred feet in breadth, and in height two hundred feet. Mr. Foster, the naturalist of the voyage, remarks that, according to the experiments of Boyle and Marian, the volume of ice is to that of sea water nearly as 10 to 9: consequently by the known rules of hydrostatics, the volume of ice which rises above the surface of the water, is to that which sinks below it as 1 to 9. Supposing, therefore, this mass of ice to have been of a regular figure, its depth under water must have been 1800 feet, and its whole height 2000 feet: estimating its length, as above, at 2000 feet, and its breadth at 400 feet, the entire mass must have contained 1600 millions of cubic feet of ice.

Two days after, several other ice-islands were seen, some of them nearly two miles in circuit, and 600 feet high; and yet such was the force of the waves, that the sea broke quite over them. They exhibited for a few moments a view very pleasing to the eye; but a sense of danger soon filled the mind with horror: for had the ship struck against the weather side of one of these islands, when the sea ran high, she must in an instant have been dashed to pieces. The

route to the southward was afterwards impeded by an immense field of low ice, the termination of which could not be seen, either to the east, west, or south. In different parts of this field were islands, or hills of ice, like those which had before been found floating in the sea.

At length these ice-islands became as familiar to those on board as the clouds and the sea. Whenever a strong reflection of white was seen on the skirts of the sky, near the horizon, then ice was sure to be encountered; notwithstanding which, that substance itself was not entirely white, but often tinged, especially near the surface of the sea, with a most beautiful sapphirine, or rather berryllne blue, evidently reflected from the water. This blue colour sometimes appeared twenty or thirty feet above the surface, and was probably produced by particles of sea water which had been dashed against the mass in tempestuous weather, and had penetrated into its interstices. In the evening, the sun setting just behind one of these masses, tinged its edges with gold, and reflected on the entire mass a beautiful suffusion of purple. In the larger masses were frequently observed shades or casts of white, lying above each other in strata, sometimes of six inches, and at other times of a foot in neight. This appearance scemed to confirm the opinion entertained relative to the increase and accumulation of such huge masses of ice, by heavy falls of snow at different intervals: for snow being of various kinds, small-grained, large-grained, in light feathery locks, &c.; the various degrees of its compactness may account for the different colours of the strata.

In his third attempt to proceed southward, in January, 1774, Captain Cook was led, by the mildest sun-shine which was, perhaps, ever experienced in the frigid zone, to entertain hopes of penetrating as far toward the south pole as other navigators had done toward the north pole; but on the 26th of that month, at four in the morning, his officers discovered a solid ice-field of immense extent before them, bearing from east to west. A bed of fragments floated around this field, which was raised several feet above the surface of the water. While in this situation, the southern part of the horizon was illuminated by the rays of light reflected from the ice, to a considerable height. Ninety-seven ice-islands were distinctly seen within the

field, beside those on the outside; many of them very large, and looking like a ridge of mountains, rising one above the other until they were lost in the clouds. The most elevated and most rugged of these ice-islands were surmounted by peaks, and were from two to three hundred feet in height, with perpendicular cliffs or sides astonishing to behold. The largest of them terminated in a peak not unlike the cupola of St. Paul's.

The outer, or northern edge, of this immense field of ice, was composed of loose or broken ice closely packed together, so that it was not possible to find any entrance. Such mountains of ice, Captain Cook was persuaded, were never seen in the Greenland seas, so that not any comparison could be drawn; and it was the opinion of most of the persons on board, that this ice extended quite to the pole, to which they were then within less than nineteen degrees; or, perhaps, joined to some land to which it had been fixed from the earliest time. Our navigator was of opinion that it is to the south of this parallel that all the ice is formed, which is found scattered up and down to the northward, and afterward broken off by gales of wind, or other causes, and brought forward by the currents which are always found to set in that direction in high latitudes. "Should there," he observes, "be land to the south behind this ice, it can "afford no better retreat for birds, or any other animals, "than the ice itself, with which it must be wholly covered. "I, who was ambitious, not only to go farther than any "one had been before, but as far as it was possible for man "to go, was not sorry at meeting with this interruption; "as it in some measure relieved us, or at least shortened "the dangers and hardships inseparable from the navigation "of the southern polar regions."

The approximation of several fields of ice of different magnitudes produces a very singular phenomenon. The smaller of these masses are forced out of the water, and thrown on the larger ones, until at length an aggregate is formed of a tremendous height. These accumulated bodies of ice float in the sea like so many rugged mountains, and are continually increased in height by the freezing of the spray of the sea, and the melting of the snow which falls on them. While their growth is thus augmented, the smaller fields, of a less elevation, are the meadows of

the seals, on which these animals at times frolic by hundreds.

The collision of great fields of ice, in high latitudes, is often attended by a noise, which, for a time, takes away the sense of hearing any thing beside; and that of the smaller fields with a grinding of unspeakable horror. The water which dashes against the mountainous ice, freezes into an infinite variety of forms, and presents to tne admiring view of the voyager ideal towns, streets, churches, steeples, and almost every form which imagination can picture to itself.

ICEBERGS.

Analogous to the ice-fields described above, are those large bodies of ice, named Icebergs, which fill the vallies between the high mountains in northern latitudes. Among the most remarkable are those of the east coast of Spitzbergen. They are seven in number, and lie at considerable distances from each other, extending through tracts unknown, in a region totally inaccessible in the internal parts. The most distant of them exhibits over the sea a front three hundred feet in height, emulating the colour of the emerald: cataracts of melted snow fall down in various parts; and black spiral mountains, streaked with white, bound the sides, rising crag above crag, as far as the eye can reach in the back-ground. At times immense fragments break off, and precipitate themselves into the water with a most alarming dashing. A portion of this vivid green substance was seen by Lord Mulgrave, in the voyage above referred to, to fall into the sea; and, notwithstanding it grounded in twenty-four fathoms water, it spired above the surface fifty feet. Similar icebergs are frequent in all the arctic regions; and to their lapse is owing the solid mountainous ice which infests those seas.

The frost sports wonderfully with these icebergs, and gives them majestic, as well as other most singular forms. Masses have been seen to assume the shape of a gothic church, with arched windows and doors, and all the rich drapery of that style of architecture, composed of what the writer of an Arabian tale would scarcely have ventured to introduce among the marvellous suggestions of his fancy—*crystals of the richest sapphirine blue.* Tables with one or

more feet; and often immense flat-roofed temples, like those of Luxor on the bank of the Nile, supported by round transparent columns of cerulean hue, float by the astonished spectator. These icebergs are the creation of ages, and acquire annually additional height by falls of snow and rain, which latter often freezes instantly, and more than repairs the loss occasioned by the influence of the sun's heat.

LUMINOUS POINTS IN THE SEA.

Among the phenomena which have long exercised the sagacity of philosophers, that of the luminous appearance of the surface of the sea, during the obscurity of the night, is highly curious. A variety of experiments were made by a French naturalist at Cayenne, at different seasons, to ascertain its true cause; and to him it appeared that these luminous points were produced by motion and friction alone, as he could not, with the help of the best glasses, perceive any insects floating in the water. But it would seem, from the experiments and observations of many learned men, that this phenomenon is produced by various causes, both jointly and separately. It has been proved by one set of experiments, that the putrefaction of animal substances produces light and scintillation in the sea. A little white fish placed in sea-water rendered it luminous in the space of twenty-eight hours. On another hand, it is certain that there is in the sea a prodigious quantity of shining insects or animalcules, which contribute to this phenomenon. A French astronomer, M. Dangelet, who returned from Terra Australis in 1774, brought with him several kinds of worms which shine in water, when it is set in motion; and M. Rigaud affirms, that the luminous surface of the sea, from Brest to the Antilles, contains an immense quantity of little, round, shining polypi, of about a quarter of a line in diameter. Other learned men, who acknowledge the existence of these luminous animals, cannot, however, be persuaded to consider them as the cause of all that light and scintillation which appear on the surface of the ocean. They imagine that some substance of a phosphoric nature, arising from putrefaction, must be admitted as one of the causes of this phenomenon. By other naturalists it has been ascribed to the oily and greasy substances with which the sea is impregnated; in proof

of which a kind of fish, resembling the tunny, is cited, as being provided with an oil which shines with considerable lustre.

The Abbé Nollet wasconvinced, by a series of experiments, that this phenomenon is caused by small animals, either by their luminous aspect, or by some liquor or effluvium which they emit. He did not, however, exclude other causes; and among these, the spawn or fry of fishes is deserving of attention. M. Dangelet, in sailing into the bay of Antongil, in the island of Madagascar, observed a prodigious quantity of fry, which covered the surface of the sea for the extent of more than a mile, and which he, at first, on account of its colour, mistook for a bank of sand. This immense accumulation of spawn or fry exhaled a disagreeable odour; and it should be remarked that the sea had, for some days before, appeared with uncommon splendour. The same accurate observer, perceiving the sea remarkably luminous in the road of the Cape of Good Hope, during a perfect calm, remarked that the oars of the canoes produced a whitish and pearly kind of lustre: when he took in his hand the water, which contained phosphorus, he discerned in it, for some minutes, globules of light as large as the heads of pins. On pressing these globules, they appeared to his touch like a soft and thin pulp; and some days after the sea was covered with entire banks of small fishes, in innumerable multitudes.

From all these facts it may be deduced, that various causes contribute to the light and scintillation of the sea; and that the light which the Cayenne naturalist attributed to agitation and friction, differs from that which is extended far and near, seeming to cover the whole surface of the ocean, and producing a very beautiful and striking appearance, particularly in the torrid zone, and in the summer season.

TIDES AND CURRENTS.

Alternate tides in sacred order run.
BLACKMORE.

AMONG the most wonderful phenomena of nature may be reckoned the tides of the sea. They were but little understood by the ancients, although Pliny, Ptolemy, and Macrobius were of opinion that they were influenced by the sun and moon. The former expressly says, that the

cause of the ebb and flow is in the sun, which attracts the waters of the ocean; and he adds, that the waters rise in proportion to the proximity of the moon to the earth.

The phenomena of the tides have been ascribed to the principle of *innate* gravitation; but Sir Richard Phillips, in his Theory of the System of the Universe, refers them to that general law of motion which he considers as the primary and proximate cause of all phenomena, operating, in a descending series, from the rotation of the sun round the fulcrum of the solar system, to the fall of an apple to the earth. This motion being transferred through all nature from its source, serves as the efficient cause of every species of vitality, of every organic arrangement, and of all those accidents of body heretofore ascribed to attraction.

The waters of the ocean are observed to flow and rise twice a day, in which motion, or flux, which in the same direction lasts nearly six hours, the sea gradually swells, and, entering the mouths of rivers, drives back the river waters towards their head. After a continued flux of six hours, it seems to repose for a quarter of an hour, and then begins to ebb, or retire back, for six hours more; in which time, by the subsidence of the waters, the rivers resume their usual course. After a quarter of an hour, the sea again flows and rises as before.

According to the theory of Newton, these phenomena were supposed to be produced by an imaginary power called ATTRACTION. The moon was supposed to attract the waters by the *hocus-pocus* of an occult power inherent in all matter; just as the earth was supposed to attract the moon, the moon the earth, and the planets one another. This might be very good philosophy as long as *names* were admitted as efficient *causes*; but the more inquisitive spirit of modern philosophy asks how any attraction, or operative force of the nature of attraction, can exist between bodies necessarily separated, according to the same theory, by a *vacuum* in space, and prevented from falling together by the further necessary hypothesis of *a projectile force*. Besides, in the phenomena of the tides, it was unfortunate for this gravitating theory, that the tides rise on the opposite sides of the earth at the same time.

The entire theory of all occult attraction and repulsion is, however, visionary and fabulous, and must yield, before

the light of reason, to the new theory, which ascribes all phenomena of motion to superior motions, or to the transfer of the motions of greater bodies to smaller ones. Thus, all motions which we witness on the earth, as the tides of the waters and atmosphere, the fall of bodies, the principle of weight or centripetal force, the motions of animals, &c. &c. are ascribed, by Sir Richard Phillips, to the combined motions of the earth around its axis in every twenty-four hours, and around the sun in every year.

It is easy to conceive, that even if there were no Moon, the moving waters of the two great oceans, the Atlantic and Pacific, would necessarily oscillate, or vibrate, between the continents, which bound them from north to south, by the combined force of the two-fold motions of the earth. They would be intercepted in their rotation by those continents on the eastern sides, which it is well known are worn away by their action; and a re-action would take place on the western sides of the same continents. But as the motions of the moon, in its lunar orbit, coincide with those of the tides in their terrestrial orbit, there is, evidently, a connection in the cause of both motions, or rather, the causes of both appear to be identically the same; and the effects are, therefore, simultaneous.

This common cause, Sir Richard Phillips asserts, is to be found in the MOTIONS of the earth, which operate alike on the waters of the earth, and on the moon according to their respective quantities of matter, and to the square of their distances from the centre.

The connection between the earth and its waters is palpable, but that between the earth and the moon is, he asserts, maintained by means of the gaseous, or fluid medium, which fills all space, and transfers the motions of the sun, from the sun to the planets, and their secondaries, and from the planets to their several secondaries. The gaseous medium filling universal space, is, he says, in this respect, and in universal nature, as efficient in transferring motion from masses to masses in proportion to their quantity of matter and to their distance, as the continuous fixed matter of a rod, or lever of wood or metal.

The causes and phenomena of the tides, according to this new system of Phillips, may be described in the following paragraphs:

1. It is found that the times of high and low water vary every day about fifty minutes, or the difference of time in which the moon arrives on successive days at the meridian of the place. This connexion has been ascribed to a supposed power called attraction or gravitation, acting in some unknown manner between remote bodies; but it is proved by the new system to be a necessary effect of the reciprocal motions of the earth and moon round the centre or fulcrum of their masses, created by the action of each on the intervening medium of space, which action of each at given distances is directly as their quantities of matter, and inversely as the squares of their distances.

2. The moon appears to perform a monthly revolution about the earth; but in truth the moon does not revolve around the centre of the earth, but round a point, fulcrum, or centre of the two masses of the earth and moon; and around this centre the earth also revolves in the same time, during which it revolves 27 times around its own axis.

3. The earth's motion, then, around the centre of the two masses, while it turns on its own axis, necessarily gives a coincident swing, or centrifugal force to the *moveable* waters; and as this force or swing has constant reference to the position of the moon on the opposite side of the common centre of motions, it will vary its direction on the seas accordingly, or about 50 minutes per day, because the moon and earth perform their common revolutions in 27 days, and therefore advance the 27th part of 24 hours.

4. The action or impulse of the sun on the earth and moon being equal at the quarters, when the centre of the earth and moon and the fulcrum of their masses coincides with the sun in his orbit, the earth's diurnal motion, and its lunar impulse coincides, and the swing from the latter being then the least, the tides become the lowest, or what is called neap; but as the two bodies approach the conjunction or opposition at new or full moon, then the greatest difference in the force or swing takes place, and then, also, the oscillation of the seas is the greatest, and the rise forms what is called a *spring* tide.

On account of the shallowness of some seas, and the narrowness of the straits in others, there arises a great diversity in the phenomena, only to be accounted for by an exact knowledge of the place. For instance in the English channel, and the German ocean, the tide is

found to flow strongest in those places that are narrowest, the same quantity of water being, in this case, driven through a smaller passage. It is often seen, therefore, rushing through a strait with great force, and considerably raised, by its rapidity, above that part of the ocean through which it runs.

The shallowness and narrowness of many parts of the sea, give rise also to a peculiarity in the tides of some parts of the world: for, in many places, in our own seas in particular, the greatest swell of the tide is not while the moon is in its meridian height, and directly over the place, but some time after it has declined thence. The sea, in this case, being obstructed, pursues the moon with what dispatch it can, but does not arrive with all its waters until after the moon has ceased to operate. Lastly, from this shallowness of the sea, and from its being obstructed by shoals and straits, it happens that the Mediterranean, the Baltic, and the Black Sea, have not any sensible tides, to raise or depress them in a considerable degree.

Among the phenomena of the tides, one of the most singular is the BORE, peculiar to several rivers: it is ascribed to the waters, which were before expansive, being suddenly pent up, and confined within a narrow space. This bore, or impetuous rush of waters, accompanies the first flowing of the tide in the Perret, in Somersetshire, and in the Seine, in France. It is also one of the peculiarities of the Severn, the most rapid river in England.

One of the greatest known tides is that of the Bristol Channel, which sometimes flows upwards of forty feet. At the mouth of the river Indus the water rises thirty feet. The tides are also remarkably high on the coasts of Malay, in the straits of Sunda, in the Red Sea, at the mouth of the river St. Laurence, along the coasts of China and Japan, at Panama, and in the gulf of Bengal. The most remarkable tides, however, are those at Batsha, in the kingdom of Tonquin, in 20° 50′ north latitude. In that port the sea ebbs and flows once only in twenty-four hours, while in all other places there are two tides within that space. What is still more extraordinary, twice in each month, when the moon is near the equinoctial, there is not any tide, the water being for some time quite stagnant. These, with other anomalies of the tides there, Sir Isaac Newton,

with peculiar sagacity, ascertained to arise from the concurrence of two tides, one from the South Sea, and the other from the Indian Ocean. Of each of these two tides there come successively two every day; two at one time greater, and two at another which are less. The time between the arrival of the two greater was considered by him as high tide; that between the two less, as ebb. In short, with these simple facts in his possession, that great mathematician solved every appearance, and so established his theory as to silence every opposer.

Besides the common and periodical tides, a variety of LOCAL CURRENTS are met with in different seas, on different parts of the ocean, and for the greater part at an inconsiderable distance from land They have been usually ascribed to particular winds; but their origin is not easy to trace, as they have been occasionally found beneath the surface of the water, running in a contrary direction to the stratum above, and cannot, therefore, have been owing to winds or monsoons. These particular currents have been ascribed to the immense masses of polar ice, which produce a greater degree of cold in the under than in the upper stratum of waters; and it has been suspected that there is an under current of cold water flowing perpetually from the poles towards the equator, even where the water above flows towards the poles. The great inferiority of temperature which is frequently found in deep and superficial soundings of the same space of water is thus accounted for.

The most extraordinary current is that of the gulf of Florida, usually called the GULF-STREAM, which sets along the coast of North America to the northward and eastward, and flows with an uninterrupted rapidity. It is ascribed to the Trade winds, which, blowing from the eastern quarter into the great Mexican gulf, cause there an accumulation above the common level of the sea. The water, therefore, constantly runs out by the channel where it finds least resistance, that is, through the gulf of Florida, with such force as to continue a distinct stream to a very great distance. A proof of its having thus originated is, that the water in the gulf-stream has been found to have retained a great portion of the heat it had acquired in the torrid zone.

A very singular upper current often prevails to the westward of Scilly, and is highly dangerous to ships which approach the British Channel. Currents of this description,

are, however, more frequently met with about the straits of Gibraltar, and near the West India islands, the coasts of which are so subject to counter-tides, or extraordinary currents, that it is often dangerous for boats to land. They proceed to the westward, along the coasts of Jucatan and Mexico, and, running round into the gulf, return into the great ocean, by the straits of Bahama, along the coasts of Florida, in order to pursue, in the north, the course ordained them by the great author of nature. In this course the waters run with an extraordinary rapidity, passing between the great and small American islands in the great deeps, by an almost even and imperceptible motion. Against the shores and coasts of these islands, which form an archipelago, they are, however, very sensible and dangerous, interrupting the navigation, and rendering it scarcely possible to stem them in proceeding to the eastward.

Besides these regular currents, there are others, called COUNTER-TIDES, which are observable on the sea coasts and shores. In places where these flow, the sea rises in an extraordinary manner, becoming very furious without any apparent cause, and without being moved by any wind. The waves rise and open very high, breaking against the shore with such violence, that it is impossible for vessels to land. These counter-tides are chiefly ascribed to the pressure of the heavy black clouds which are occasionally seen to hang over an island, or over the sea.

PRINCIPAL RIVERS.

Tell by what paths, what subterraneous ways,
Back to the fountain's head the sea conveys
The refluent rivers, and the land repays?
Tell what superior, what controlling cause,
Makes waters, in contempt of nature's laws,
Climb up, and gain th' aspiring mountain height,
Swift and forgetful of their native weight?
What happy works, what engines underground,
What instruments of curious art are found,
Which must with everlasting labour play,
Back to their springs the rivers to convey,
And keep their correspondence with the sea?

BLACKMORE.

NOT to mention the great variety of known benefits a river bestows on the country though which it flows, its