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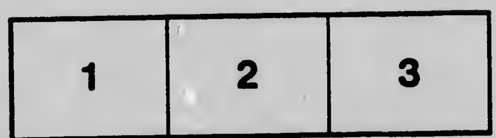
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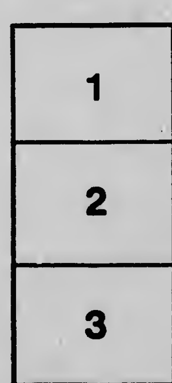
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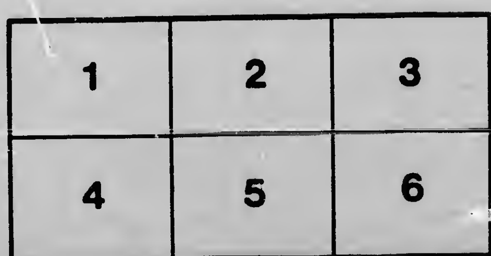
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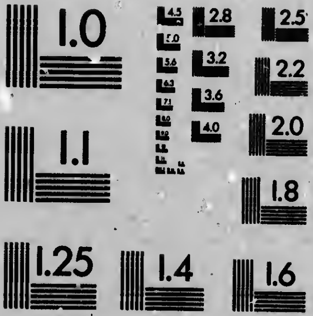

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NEW THEORY

OF

THE TIDES.

BY

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PREFACE.

WHATEVER in science has been sanctioned by sir Isaac Newton should perhaps be privileged from inspection, and taken for true. But it often happens that human genius, weary as well as proud of success, will seek repose in arbitrary explanations of the phenomena it has found difficult to solve. The cause of the tides, seems in this way to have been ascribed chiefly to the moon's attraction; evidently in consequence of an occasional, but very irregular, correspondence between its changes and the variations of the tides. However, the moon and tides have not the pretended coincidence of change; the experience of every month proves their disagreement; that high water sometimes takes place, even three hours after the time when the moon's supposed disturbing force is greatest; and low water within three hours of the same period, and even at the same time. The supposition that the gravity and viscidity of water prevents its promptly obeying the moon's force, would be well founded if the moon's changes were sudden. But the moon's progress is slow; and, consequently, had the moon the disturbing force attributed to her, the changes in the waters which partly cover the globe would necessarily be regular: high water would take place precisely when the moon's force was greatest, and would steadily follow the moon in her progress.

The theory admits and requires, that the attraction of the moon, detached and distant as it is from the earth, is sufficient to controul, and therefore greater than, the various opposing forces of 1st, gravity, whereby the particles of water are drawn and bound to the common centre of the globe of which they form a part; 2dly, the attraction of cohesion, acting mutually on the particles in contact with each other.

It is further assumed, that the waters of the globe are raised in the region immediately beneath the moon and at the antipodes of that region, at the same time; so that the moon attracts one side of the globe, and repels the other.

The sun and moon, in conjunction or opposition, are required to produce the same effect. Thus the sun and moon, acting together on the same radius, on the principle of attraction are supposed to disturb the waters of our globe, in the same way as when the sun is acting in exact opposition to the moon.

The moon's attraction must be a tendency to approach the whole mass of our globe, but not to derange or disunite its parts.

Could the moon's attraction disturb the waters of our globe, one wave or tide only, would perpetually follow the moon; and, instead of two high and two low tides, at each place, in twenty-four hours, there would be but one tide during that time.

Indeed the difficulties met with, in the application of the common theory to the reality, drew from the editors of the Encyclopædia Britannica the following remarks;

" The reader will undoubtedly be making some comparison in his own mind, of the deductions from this theory with the actual state of things. He will find some considerable resemblances; but he will also find such great differences, as will make him very doubtful of its justness. In very few places does the high water happen within three quarters of an hour of the moon's southing, as the theory leads him to expect; and in no place whatever does the spring tide fall on the day of new and full moon, nor neap tide on the day of her quadrature. These always happen two or three days later. By comparing the difference of high water and the moon's southing in different places (and they might have added at the same place at different times) he will hardly find any connecting principle."

But such are the irregularities observable in the tides, that no assignable cause whatever can appear in perfect unison with them; and science will probably have to chuse its solution of their phenomena among plausible probabilities. The theory here suggested is grounded on a principle daily experienced; and, it is humbly presumed, more satisfactorily applied than that on which the common theory is founded.

NEW THEORY OF THE TIDES.

HEAT, or, as called by chemists, caloric, whether a substance or quality, expands whatever it pervades; and this effect is the same, whether caused by the sun's presence, by friction, or otherwise.*

Besides a variety of particular experiments, daily experience demonstrates the expanding force of heat. In proportion to the degree of heat present, the mercury

* Although few things are more generally known, than that heat expands whatever it pervades, the following account of this effect is cited in explanation:

" The principal effect of heat is to augment the volume of all bodies, without adding to their weight. In general, every body in nature is dilated by heat, and all mineral substances, without exception, experience a dilation which is greater the more intense the heat. Philosophers have made an experiment with a cylinder of metal fitted to an orifice in a metallic plate, so as just to pass through it when cold, and they find that the same cylinder, when heated, could not pass. It is therefore established that bodies expand by heat, and that their dimensions are enlarged in all directions." Elements of Chemistry, by M. de Fourcroy, article Heat.

in the thermometer swells and rises in the tube; and shrinks and retires in proportion to the diminution of heat. Water in a kettle, placed over a fire, is seen to boil up to double the original volume, and, on being removed, to return to its first dimensions.

As fluids are composed of particles without continuity, and whose adhesion is feeble, they are more sensibly affected by the presence of heat than solid substances. The same degree of heat that would produce a scarcely perceptible expansion of a bar of iron, would cause a quantity of water, which but half filled a kettle, to boil over, and would raise the mercury of a thermometer several hundred degrees, if sufficiently long to admit of such a range; also, that degree of heat which will raise mercury 10° will raise spirits of wine 12° or 13°. The latter fluid recedes farther from a state of solidity than the former.

EVAPORATION.

It cannot fail to be objected, that, notwithstanding the sun's heat generally dilates all matters within its reach, yet, in regard to fluids, the presence of heat tends chiefly to raise portions of them into vapour. The objection is well founded in regard to small quantities of fluid: for instance, a bason of water. In this case, the rays of the sun are reverberated from the sides of the bason, and the diffusive motion of the heat being only upwards, the particles of the water are soon dispersed.

Not so with the vast oceans that cover the globe.

The sun's rays penetrate to, and spread unconfined throughout, their deepest regions, and the diffusive motion is perpetually downwards, but, as it proceeds, becomes more and more feeble, and too faint to admit of reverberation from the bottom.

Evaporation is slower, in proportion to the greater bulk of a fluid. To prove this, two tin vessels, whose forms were similar, and capacities to each other as 5 to 1, were placed on the top of a stove equably heated. During the time the water evaporated from the vessel which was as 5, the vessel which was as 1 was filled up 6 times, and was 6 times emptied by evaporation. One sixth part more water than the larger vessel contained was dispersed from the smaller vessel, in the same time, and by exactly the same agent.

Evaporation is slower, also, in proportion as the volume of fluid is more collected. The water shed by a cloud, when scattered over a plain, is dissipated in a period of time incalculably shorter than an equal quantity would be if collected in a pond. In the latter condition, the heat has liberty to range; in the former, the heat, arrested by the earth, and reflected therefrom, suddenly carries off the particles of water. Indeed, if each drop of the water which composes an ocean could be carried off by the sun with as much speed as a single drop cast on a solid body, it probably would require but a few days to empty the Atlantic Ocean, were the atmosphere capable of receiving it; and the land sections of the globe would have to sustain an uninterrupted deluge from above.

Two tin vessels of cylindrical form, whose diameters were equal, but whose heights, and therefore capacities, were to each other as 10 to 1, the height of the former being equal to its diameter, were placed on a stove equably heated. During the time the water evaporated from the vessel which was as 10, the vessel 1, was emptied 18 times; so that, in the same time, about half the quantity of water only was carried off from the deeper vessel, that was carried off from the other.

Two tin vessels of equal capacities, but whose depths were to each other as 2 to 1, were placed as above. The vessel which was but half the depth of the other, but which nevertheless contained an equal quantity of water, was emptied in a decidedly less time.

Since, then, by these simple experiments it appears, the degree of heat being the same, evaporation diminishes with the increase of the volume of a liquid, and the more collected its form; it is concluded that, in such enormously extensive bodies of water as the oceans are, evaporation must almost cease.

This conclusion is farther supported by facts. It may be generally stated, the more remote from land, the more serene the sky. Mariners going to sea, look for good weather; approaching land, they expect foul. The Pacific Ocean, the longest uninterrupted body of water, is unobscured by a cloud for months together, and from this circumstance derives its name. The atmosphere is generally clear over the Atlantic Ocean, even during seasons when the neighbouring countries are enveloped with fogs or clouds. The sun's heat, confined and checked by the solid surfaces which land presents, is spent in dissipating and diffusing the small bodies of water, which, in the form of swamps, lakes, and rivers, may be lodged or running on the face of a country; and the more frequent such bodies of water occur, the more is the ambient sky loaded with vapour.

But, *notwithstanding it be admitted evaporation constantly takes place from the oceans which cover the globe*, a small part only of the sun's heat is engaged therein, because,

1st. The progress of the sun's heat is so rapid and constant, that the employment of it by evaporation is too slow to prevent the farther action of the sun throughout the whole extent of the water. Thus the heat of a fire acts so powerfully on water placed in a kettle, as to swell the water considerably at the same moment that it is losing much by evaporation. This experiment is made every day in every kitchen, and is a correct though violent representation of the periodical swells of the oceans caused by the action of the sun.

2d. Because the capacity of the atmosphere is limited, and can receive but a limited quantity of vapour, and because the sun's heat is infinite when compared to the capacity of the atmosphere. The infinite remainder of the sun's heat unengaged in evaporation, necessarily pervades and mingles with the waters of the oceans, and thereby augments their volume.

The atmosphere has a limited capacity. It can admit, in the form of vapour, only a certain finite quantity of water. When charged to its utmost capacity, evaporation must cease. It is probable the atmosphere is at all times nearly charged to its utmost capacity, because the extent of water, which is the material, and the sun the agent, are constantly the same, and constantly employed in maintaining that utmost charge. The continual changes in the atmosphere, only prove, that an infinitely various distribution of nearly an equal quantity of vapour is taking place, every where and at all times. Some regions of the atmosphere are receiving water, while from other regions it is returning. This is not made less probable by the long continuance of clear weather, since the atmosphere often acquires a condition which refuses evaporation. The long duration of clear, dry weather, at times, when the same causes of evaporation are in force that loaded the atmosphere with vapour, furnishes a sufficient proof. For two, three, or more weeks, the sky often continues calm and clear, and free from dew, beneath a vertical sun. It follows, that at those periods the atmosphere refuses the vapour conconstantly offered by the action of the sun; or, what seems more probable from the above-recited experiments, the sun, in regard to very large bodies of water, is little employed in evaporation, but chiefly in dilating their volume.

The gentle evaporation that may take place from the oceans does not affect their height. They being co-extensive with the atmosphere, whatever quantities of water the atmosphere may acquire in the form of vapour, by the action of the sun, in some places, are in other places returned into the oceans, directly in the form of rain, or indirectly by the channels of rivers and rivulets. And this routine of evaporation and rain, it is certain, keeps up a steady balance of accounts, since the high and low water marks, through successive centuries, remain the same in all places: so that, from the natural tendency of liquids to gain a state of equilibrium, and the various oceans communicating one with the other, it follows, the waters which cover the globe would remain in a state of undeviating height, were they not otherwise influenced by the expanding power of heat.

It is not to be supposed, the action of the sun on the waters in high latitudes produces the changes there, *e. g.* the English Channel. The sun's heat may be said to act as a percussive force, and to give a periodical stroke to the great bosom of the ocean over which the sun passes vertically. The changes of the water along the shores are the effects of the impulsion given to the central regions of the oceans; and the farther the shore, to a certain extent, the greater the change. Impulsion is adopted instead of swell, to render the idea more distinct. Each swell moves off in a wave; and, the greater range it takes, the higher the undulation. This will appear by dipping the hand in an oblong tub, full of water, nearer to one end than the other: the rise of the water will be considerably greater at the end most distant from the stroke. And this may account for the greater height of the tides in middle latitudes than near the line. The undulation is exhausted in its progress towards the poles.

EXPLANATION OF THE PHENOMENA OF THE TIDES.

The sun emits a perpetual flood of heat in all directions, and mingles with and swells the waters which cover the globe.

The sun's heat pervades one half of the surface of the globe at all times; and by the periodical visitation of the various oceans by the sun, in consequence of the diurnal rotation of the globe, periodical swellings are produced in those oceans, which exhibit all the phenomena of the tides.

The waters contained in any given tract of the globe, for instance, the Atlantic Ocean, are exposed to, and receive the sun's heat once in twenty-four hours, in consequence of the diurnal motion of the earth. Let the sun be on the line: the nights and days will be equal, and the sun will rise at six o'clock. The moment the sun rises, its heat begins to sink into the ocean; as the sun ascends, the heat becomes greater, its intrusive, pervading, and expansive force greater, until it reaches the zenith, and the gradual augmentation of the water by the immersion of heat during this time, will exhibit a flood tide along the edges of the shores in contact with the ocean. It will be noon, and six hours will have elapsed. As the sun gradually declines westward, there will be also a gradual secession and escape of the heat from the ocean. The ocean, thus insensibly abandoned by the heat, will consequently shrink, and exhibit along the shores an ebb tide. At six o'clock in the evening, the sun having set, and the heat altogether vanished, low water will take place. During this first solar day of twelve hours, there will be one flood tide and high water, and one ebb tide and low water: one rise and one fall of the water.

This rise and fall, having disturbed the edges of the ocean, or where the ocean is in contact with land, a *re-action* will ensue; but, in consequence of the gravity and viscidity of water, it will be performed in rather a longer time than the first swell, which is the cause.

The first re-action would be followed by others; and were the sun, the original agent, to disappear altogether, nevertheless a vibratory tide might endure for ages. This will appear extremely probable, by the effect produced by dipping a hand in a bason of water. The first rise and fall will be followed by a similar rise and fall, and a vibration will ensue for some time along the edge of the vessel. A stone thrown into a pond of water, will occasion the shore to be lashed for a considerable time by successive equal re-actions of the water, although the water received originally but a single impulse from the stone. The longest calms are scarce sufficient for the ocean to subside to a state of rest. When it most approaches to, or for a while really acquires, a state of quiescence, a ceaseless rise and retrocession of its waters continue along the shores which confine it, commonly called surf.

In consequence of the re-action which follows the original rise and fall of the waters of the first day, occasioned by the sun, the first night will exhibit a repetition of the tides of the first day. From six o'clock in the evening, being sun-set, the waters will rise till midnight. At midnight (or a little after, in consequence, as above stated, of the gravity and viscidity of water) there will be high water. From midnight until some time past six o'clock in the morning, ebb tide will take place; and at past six o'clock in the morning there will again be low water.

Thus, in a little more than twenty-four hours, there will be two flood tides and two ebb tides, twice high and twice low water; and this corresponds with the reality.

But it appears the tides gradually increase for seven or eight days, at the end of which time the highest flood tide, called spring tide, takes place; and, for the seven or eight days following, the tides decrease, and terminate in what is called a neap tide, that is, the lowest tide.

When the sun rises the second day, it overtakes the *re-acting tide*, which is then begining to perform a new flood tide. The sun, acting in conjunction with this tide, increases its extent and duration; so that instead of being at noon, as on the first day, it is near one o'clock when high water takes place. In consequence of the increase of the second day's flood tide, the re-action will be greater; that is, on the ensuing night the tide will be greater. On the third day, the sun acting in conjunction with the re-acting flood tide, increased by the additional impulse of the second day; the flood tide on the third day will be greater than on the second, and high water will take place still later. The flood tide of the ensuing night, being a re-action of the third day's flood tide, will also be greater, and take place later than the flood tide of the second night; and this increase will continue until the highest or spring tide takes place.

The successive increase of the extent and duration of the tides, will evidently change the periods of their vicissitudes or changes; so that, although the sun acted in conjunction with the re-acting tides on the second, third, and fourth days, on the seventh or eighth, in consequence of the prolongation of the tides, it will come to act in opposition to them, until they are worn down to the lowest measure, or neap tide. As has been stated, after the first day, the sun acts jointly with the re-acting tides occasioned by the first disturbance of the ocean. By thus acting together, the extent and duration of the tides are increased: each successive day, they will turn later and later, until the seventh or eighth morning, when, at sun-rise, the time of change will have so much altered, that the ebb tide, which, on the second morning, terminated shortly after sun-rise, will, on those mornings, be so far delayed, that the sun will resist it. Suppose the ebb tide, at sun-rise on the seventh or eighth morning, to be but half spent, the gradual immersion of heat will check and shorten, though it cannot destroy it.

Something similar to this daily takes place on the surface of the ocean. Any supposed wind, blowing strongly over the water, gradually raises a greater and greater swell of the sea. At first a gentle curl will appear; small waves will follow, which will finally grow into long and extensive swells or mountains of water. Let the wind veer round, and blow from the opposite point: the original swell will continue to roll, although with decreasing dimensions, and several days will elapse before the original swell will be altogether subdued by the adverse wind.

REMARKS.

Deviations from these general movements of the tides are occasioned by local circumstances.

The change of seasons cannot alter the supposed action of the sun on the oceans, as its heat constantly strikes a hemisphere of the globe. Whether the sun is considered to be on one side of the line or the other, it is immaterial; since the oceans, extending on each side of the line to the poles, must continue to receive the sun's heat. Could it be possible that the half of the globe, on which the sun shone at any given time, was masked by clouds, the sun's heat would nevertheless reach the waters thus hidden. Heat is so diffusive, that the most dense bodies check it only for a-while: it therefore cannot be supposed that vapour can materially check its progress. The mercury of a thermometer will rise in the shade However, interventions of this kind may cause some of the caprices of the tides.

It may be objected, that, during the night, the atmosphere often continues warm, and that this heat must prevent any distinct effect from the sun's presence. But the warmth experienced after sun-set, is evidently the heat escaping from the surface of the globe, accumulated during the day; since the warmth *gradually* diminishes, and towards morning the atmosphere becomes cool. The diminution is more rapid over water than land, because of the less resistance given to the escape of the heat, in consequence of the less continuity of the particles of fluids than of solid bodies.