

tide on that side—the ocean rising toward the moon; and there will be an equal tide on the other side—the antipodes—the ocean rising away from the solid earth and the moon attracts the water under it, which, being mobile, yields and swells up, and thus forms the tidal undulation. On the face of it, this explanation seems satisfactory so far as relates to the tide on the side of the earth proximate to the moon; but, whether the statement be correct or incorrect, it does not account for the reverse tide on the opposite side. Now, the moon does not attract the earth as a unit, and *vice versa*, but every particle of matter in the moon attracts every particle of matter in the earth, and *vice versa*. Moreover, attraction diminishes with the increase of the distance of the object attracted according to the square of the distance, by a well-established rule. These principles governing the nature and measure of attraction being, as we suppose, undeniable, it follows that the attractive force exerted by the moon—which, of course, is diminished by the amount of the counter-attraction of the earth upon the moon—upon the surface of the earth next to her is greater than it is at the centre of the earth in a right line, and greater at the centre than it is at the opposite side of the earth, extending the radius. In fact, it diminishes with the increase of the square of the distance, so that there ought to be a much less tide upon the opposite side of the earth, or, rather, there ought to be no tide at all, if it be true that the tide proceeds from the drawing of the water by the moon; yet there is an equal tide corresponding exactly with the one directly under the moon.

Some writers, to escape the dilemma, have assumed that the moon not only draws the mobile water under her, but the solid kernel of the earth also, and that the water on the opposite side does not follow the kernel, but remains behind, and thus forms the reverse tide. Now, the reverse tide averages about four feet a day; consequently, by that amount the earth must have been nearing the moon for ages, as no counter-motion to countervail the assumed one can be demonstrated. As the earth and the moon have not approached each other in such wise, the proposition is untenable. But, were it true that the kernel of the earth is deflected in the way and to the degree asserted, what reason can be given for the water remaining behind on the opposite side? By the law of gravity it would follow, and there would not only be no tide, but possibly very low water. The whole hypothesis is contrary to physical laws, and reminds one that kind of exegesis of a difficult passage of Scripture, which either begs the question, or is no exegesis at all.

Notwithstanding, the phenomenon of the reverse tide exists, and must be susceptible of explanation. We think it can be elucidated in accordance with known physical laws.

In considering it, we will neglect centrifugal force, as that force, being only about one sixteenth of the force of the attraction of gravitation at the equator, is inappreciable.

Every particle of matter in the earth by the law of gravity, attracts every other particle in the direction of the centre. In obedience to the law of gravity, every particle seeks the centre. The ocean, though it constitutes a part of the terraqueous globe, is a free fluid on the surface of the solid part of the earth. The superficies of water is vastly greater than that of land. Yet it is equally subordinate to the law of gravity. The density or weight of water is not always the same. It varies according to circumstances. When we say that the density or weight of a given part of the ocean is increased beyond the average at any time by any influence, we mean that, at that time, and at that part the attraction of gravitation, and consequently the tendency of the water to press toward the centre of the earth, is enlarged. The measure

of density or weight is the measure of gravity.

Suppose, for example, the moon to be on the east side of the earth. There will be a tide on the east and west sides of the earth, and low water on the north and south sides. The moon evidently exerts an influence which causes this undulation in the ocean. But how does she do it? We answer: her influence is not to draw the mobile water on the east side of the earth toward her, as some fondly imagine, but her influence to increase the weight or density of the water on the north and south sides. Hence the water on the north and south sides, succumbing to the law of gravity, presses toward the centre of the earth, and, in so doing, causes the water on the east and west sides to swell up; it is squeezed in on the north and south sides, and squeezed out on the east and west sides. Thus there is, necessarily, for mechanical reasons, an equal tide on the east side of the earth, next the moon, and on the west side opposite, the whole ocean taking the form of a slight ellipse. It is an undulation, and changes its position as the earth revolves and presents different faces to the moon, and also in accordance with the relation the waxing and waning moon may bear to the earth.

Such is the action of the moon, and similarly of the sun, to produce their respective tidal waves. To examine into a nice calculation of the relative influence of each is aside from our purpose. We only wish to set forth the general principle, which is very simple, and explains the mystery equally of the super and infra tides.

But some one may ask: "How do you know that the moon increases the action of gravity, as above stated, on the north and south sides of the earth?" We answer: Just as we know the truth of any other problem susceptible of demonstration, viz., by working it out mathematically. If the astronomer says Venus is so many miles distant, and possesses such a density, presuming his calculation to be correct, we accept his dictum. When, therefore, the scientist, who, we are satisfied, understands the laws of the attraction of heavenly bodies, of gravity, and of all other forces which constitutes elements in the case, having made a complete mathematical demonstration, avers that the moon, when it is on the east side of the earth, increases the weight or density of the water on the north and south sides of the earth, and that, in consequence thereof, the water on the north and south sides presses in, and so squeezes out the water on the east and west sides of the earth, we accept the truth of the proposition, though we may not be sufficiently accomplished in mathematics to work out his profound calculations, any more than we can those touching the distance and density of the heavenly bodies, which indeed only exact, scientific astronomers can verify. Moreover, accepting the accuracy of the calculation, we comprehend very readily why there must be an equal tide at the same time on both sides of the earth, why high water will always occur at right angles to low water, and *vice versa*.

What we have said is no novelty, no fancied discovery. The proposition, as we have popularly set it forth, has been mathematically demonstrated by Professor Barlett, late of West Point, in his work, which has long been in use at our Military Academy. Our purpose has been merely to draw away the veil from the tidal mystery—one which we have seen hopelessly perplex teachers and pupils.

We will add that the fluid atmosphere is subject to the same law as the water, exhibits similar tidal undulation, and takes a similar slight elliptical form. Yet we believe the atmospheric tide is so insignificant that it is not appreciable by the barometer.

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