THE STORY OF THE TIDES.

WHAT THEY TELL OF THE GROWING LENGTH OF THE DAY AND OF THE BIRTH OF THE MOON.

From a scientific point of view the work done by the tides is of unspeakable importance. Whence is this energy derived with which the tides do their work? If the tides are caused by the moon, the energy they possess must also be derived from the moon. This looks plain enough, but unfortunately it is not true. Would it be true to assert that the finger of the rifleman that pulls the trigger supplies the energy with which the rifle-bullet is animated? Of course it would not. The energy is derived from the explosion of the gunpowder, and the pulling of the trigger is merely the means by which that energy is liberated. In a somewhat similar manner the tidal wave produced by the moon is the means whereby a part of the energy stored in the earth is compelled to expend itself in work. Let me illustrate this by a comparison between the earth rotating on its axis and the fly-wheel of an engine. The fly-wheel is a sort of reservoir, into which the engine pours its power at each stroke of the piston. The various machines in the mill merely draw off the power from the store accumulated in the fly wheel. The earth is like a gigantic fly-wheel detached from the engine, though still connected with the machines in the mill. In that mighty fly-wheel a stupendous quantity of energy is stored up, and a stupendous quantity of energy would be given out before that fly-wheel would come to rest. The earth's rotation as the reservoir from whence the tides draw the energy they require for doing work. Hence it is that though the tides are caused by the moon, yet whenever they require energy they draw on the supply ready to hand in the rotation of the earth. The earth differs from the fly-wheel of the engine in a very important point. As the energy is withdrawn from the fly-wheel by the machines in the mill, so it is restored thereto by the power of the steam-engine, and the fly-wheel runs uniformly. But the earth is the fly-wheel without the engine. When the work done by the tides withdraws energy from the earth, that energy is never restored. It, therefore, follows that the earth's rotation must be decreasing. This leads to a consequence of the most wonderful importance. It tells us that the speed with which the earth rotates on its axis is diminishing. We can state the result in a manner which has the merits of simplicity and brevity. The tides are increasing the length of the day. At present no doubt the effect of the tides in changing the length of the day is very small. A day now is not appreciably longer than a day a hundred years ago. Even in a thousand years the change in the length of the day is only the fraction of a second. But the importance arises from the fact that the change, slow though it is, lies always in one direction. The day is continually increasing. In millions of years the accumulated effect becomes not only appreciable, but even of startling magnitude.

The change in the length of the day must involve a corresponding change in the motion of the moon. If the moon acts on the earth and retards the rotation of the earth, so, conversely, does the earth react upon the moon. The earth is tormented by the moon, so it strives to drive away its persecutor. At present the moon revolves round the earth at a distance of about 240,000 miles. The reaction of the earth tends to increase the distance, and to force the moon to revolve in an orbit which is continually getting larger and larger. As thousands of years roll on, the length of the day increases second by second, and the distance of the moon increases mile by mile. A million years ago the day, probably, contained some minutes less than our present day of twenty-four hours. Our retrospect does not halt here; we at once project our view back to an incredibly remote epoch which was a crisis in the history of our system. It must have been at least 50,000,000 years ago. It may have been very much earlier. This crisis was the interesting occasion when the moon was born. The length of the day was only a very few hours. If we call it three hours we shall not be far from the truth. Perhaps you may think that if we looked back to a still earlier epoch, the day would become still less and finally disappear altogether. This is, however, not the case. The day can never have been much less than three hours in the present order of things. Everybody knows that the earth is not sphere, but there is a protuberance at the equator, so that as our school-books tell us, the earth is shaped like an orange. It is well known that the protuberance is due to the rotation of the earth on its axis, by which the equatorial parts bulge out by centrifugal force. The quicker the earth rotates the greater is the protruberance. If, however, the rate of rotation exceeds a certain limit, the equatorial portions of the earth could no longer cling together. The attraction which unites them would be overcome by centrifugal force, and a general break-up would occur. It can be shown that the rotation of the earth when on the point of rupture corresponds to a length of the day somewhere about the critical value of three hours, which we have already adopted. It is therefore impossible for us to suppose a day much shorter than three hours.

Let us leave the earth for a few minutes and examine the past history of the moon. We have seen the moon revolves around the earth in an ever-widening orbit, and consequently the moon must in ancient times have been nearer the earth than it is now. No doubt the change is slow. There is not much difference between the orbit of the moon a thousand years ago and the orbit in which the moon is now moving. But when we rise to millions of years the difference becomes very appreciable. Thirty or forty millions of years ago the moon was much closer to the earth than it is at present, very possibly the moon was then only half its present distance. We must, however, look still earlier, to a certain epoch not less than fifty millions of years ago. At that epoch the moon must have been so close to the earth that the two bodies were almost touching. Everybody knows that the moon revolves now around the earth in a period of twenty-seven days. The period depends upon the distance between the earth and the moon. In earlier times the month must have been shorter than our present month. Some millions of years ago the moon completed its journey in a week, instead of taking twenty-eight days, as at present. Looking back earlier still, we find the month has dwindled down to a day, then down to a few hours, until at that wonderful epoch, when the moon was almost touching the earth, the moon spun round the earth every three hours.

In those ancient times I see our earth to be a noble globe, as it is at present. Yet it is not partly covered with oceans and partly clothed with verdure. The primeval earth seems rather a fiery and half-molten mass, where no organic life can dwell. Instead of the atmosphere which we now have, I see a dense mass of vapors, in which, perhaps, all the oceans of the earth are suspended as clouds. I see that the sun still rises and sets to give the succession of day and of night, but the day and the night together only amount to three hours, instead of twenty-four. Almost touching the chaotic body. Around the earth I see this small body rapidly rotating. The two revolve together, as if they were bound by invisible bands. The smaller body is the moon.—*Am. Paper.*

THEORY OF THUNDER STORMS.

Thunder storms are eminently a summer arrangement. They seldom occur except in intensely warm weather. And they are the result of a combination of forces produced by the sun's heat. By the power of this heat aqueous vapors are elevated from every part of the earth's surface and the waters, and float freely in the atmosphere until they fall in dew or rain.

During the night the upper strata of these vapors are congealed, and becoming lighter by this process than watery vapors, they rise to an elevation of several miles into the atmosphere, thus forming what are called the "cirrus cloud." These clouds ("cirri") are distinguished by their feathery forms and fleecy whiteness; and are to be seen during a bright night, or at an early hour in the morning. On the appearance of the sun these icy crystals are by his early rays reduced to watery vapors again, and gradually descend to an altitude of not more than one two or miles above the earth, when they are met by the ascending vapors, and, uniting with them, form the great piles of clouds of hemispherical shapes, called "cumuli clouds." These will be readily recognized by their grotesque and massive forms, their marginal protruberances often shining with a strong silvery or golden light, and contrasting finely with the darker and denser portions of the cloud. As the heat of the day increases, these piles of clouds increase in height and density; and, as they float eastward, are frequently resolved into the "Nimbus," or rain cloud. This change usually occurs soon after noon, or in the hottest hours of the day.

The process of transformation presents a phenomena as surprising as it is grand, and inspires in the intelligent observer sentiments of profound admiration and awe. Floating majestically onward in their course, and every moment gathering new volume in the immense supplies carried upward on the rising columns of heated air, their progress would be unmarked by any extraordinary phase but for the varying or opposing currents of the atmosphere on which they are borne. These opposing currents have the effect of condensing the vapors or clouds, by which the "nucleus" of a rain-cloud is established. And this condensation produces the two-fold result of surcharging the cloud with both rain and electricity. Now this is the initial movement in the formation of the "thunder cloud."

It must be remembered that clouds float higher or lower according to their specific gravity, and in no event discharge their waters in the form of rain till by rapid condensation their specific gravity exceeds that of the atmosphere by which they are supported.

When the equilibrium is overcome by condensation rain will begin to fall. Now the first drop of rain that vacates itself in the cloud for a descent to the earth makes room for the surrounding vapors to flow in and occupy the place it vacated, precisely as a raging fire on the earth's surface produces a rush of air towards it from every point of the surface to fill the vacuum formed by the rising air and flame, only that with the cloud the action is reversed. And as this motion of the wind renders the flame more intense, so long as there is fuel to feed it, so the influx of the surrounding clouds toward a central point augments the force and magnitude of the storm cloud. This centralizing movement among the clouds, extend at length to all that lie within the sphere of its influence in its progress through the heavens; for when the storm is over, the sky is entirely cleared of this cumuli.

But on the first appearance of the thundercloud, which is usually in the higher or mountainous sections of the country where they commonly have their origin, it happens that a very small portion of the cloud will at first assume a darker aspect, indicating a condensation of the vapors at that point, and the presence there of positive electricity, or lightning. And while the vapors are flowing toward this central point, the varying currents of wind, producing an ever varying density of the cloud, promotes the passage of the electric fluid from one section of the cloud to another. This occasions the rolling thunder so constantly heard during the prevalence of a thunderstorm. And it is from these denser parts of the cloud that the lightning darts in zig-zag lines to the earth, producing the most appalling effects upon the objects that lie in its course.

In this connection it is worthy of note that the earth is the great reservoir of electricity; that every particle of water is highly impregnated with this fluid, that it rises into the air with the ascent of the vapors, and that it strikes objects on the earth only in its descent from the cloud; hence, when the cloud is in a positively electrified condition in respect to the earth the electricity will pass from the cloud to the earth. It passes silently in the vapor upward into the atmosphere. It returns to the earth often in sensible volumes and with crushing power,—igniting by friction in its rapid flight the gases of the atmosphere with which it comes in contact, and thus for the instant leaping from its native obscurity into a most luminous and brilliant existence, rivaling even the brightness of the sun.

A. B. C.

Ice Out-Look.

Ice in insufficient supply looks not unlikely next summer, unless a cold snap fills the houses in the remaining half of this month, or in March, as has sometimes happened. The ice houses on the Hudson are not more than half filled, and the river has already began to break up. In Maine, the ice harvest has been smaller than usual, and of poor quality. Higher prices for ice next summer appear extremely probable.—*Philadelphia Press.*

—In Canada the story is about the same.