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will be variable on different portions of the surface. The amount of solar heat received on any given portion of the surface will depend first on the obliquity of his rays as they fall on that surface, and secondly, on the length of time in which the surface is exposed to the solar rays.

When the solar rays fall vertically upon a body, a greater quantity of those rays are received in a given space than when his rays are received obliquely. For instance, let this tabernacle be so enclosed, as to exclude all heat and light from the sun, except through a circular apperture one inch in diameter, and let a piece of pasteboard be held perpendicularly to the beam of solar light entering the apperture: a bright circular image will be seen on the paste-board; let the surface of this image be measured. Now hold the paste board obliquely to the beam of light, and it will be seen that the surface of the bright spot is increased. The more inclined the pasteboard is the longer will be the bright spot, until the surface is doubled, thribled, quadrupled, &c. Hence, the amount of heat and light which falls on the vertical surface, is divided and subdivided and spread out over an increased area; therefore, the temperature is diminished, as the surface increases; or in other words, the temperature decreases as the obliquity of the solar rays increases. Apply this to the earth and it will be perceived that the surface of the torrid zone receives the solar rays in nearly a vertical manner, while the two temperate zones receive the calorific and luminous rays more obliquely. The heating power of these rays being distributed over an increased surface, are proportionally weakened, and consequently the temperature is decreased. In the frigid zones the obliquity of the rays is the greatest, and therefore, the cold attains its maximum value.

In the north temperate zone, the meridian altitude of the sun on the 21st of December is less by 46° 55′ than his altitude on the 21st of June. This is the principal cause of the cold of winter and of the heat of summer.

Another cause of the great variations of temperature, in the different zones, is the length of time in a day or night. The longer the sun remains above the horizon the greater the temperature imparted to any given surface exposed to his rays. During the absence of the sun, or in the night, the earth is continually losing its heat by radiation. Sometimes certain zones lose by night less than they gain by day, then the temperature increases: at other times, the dissipation of the heat by night exceeds the quantity received by day and the temperature decreases.

The same cause which diminishes the obliquity of the solar rays, increases the length of the day compared with that of the night; hence, both these causes combined increase the temperature of the zones where they operate to its maximum value.

By the combination of the causes just referred to, it might, without sufficient reflection, be supposed to produce the highest temperature of summer about the 21st of June, when the days are the longest and the altitude of the sun the highest; but such is not the case; our hottest days usually occur about one month later, near the last of July. The reason of this is that the daily augmentations of temperature are the differences between the amonnt of heat received, and the amount lost by radiation in the period of 24 hours. It is true that these daily accessions of heat will gradually increase from the 21st of December until the 21st of June, but the sum of all these daily augmentations do not attain their maximum value until towards the last of July, when the hottest days of summer occur. So likewise the daily diminutions of temperature take place gradually from the 21st of June until the 21st of December, but the sum of all these daily diminutions does not attain to its greatest value until towards the last of January, when the coldest days of winter occur.

If the hourly loss of temperature during the night were equal to the hourly gain of temperature during the day, the hottest day would take place at the autumnal equinox, and the coldest day at the vernal equinox. But as the hourly loss of temperature in the night is far more rapid than the hourly temperature gained during the day, the maximum and minimum temperatures must transpire several weeks before the equinoxes.

These general laws of temperature depending on the sun are often interfered with by continents, oceans, islands, mountains, valleys, deserts and other geographical and local causes, producing fluctuations or small deviations from the general laws, which often appear very irregular in their character.

Another cause of the variation of temperature upon our globe is the elliptic form of its orbit. About the first of January the earth is in the perihelion point of its orbit, when it is about 3,000,000 of miles nearer the sun than it is on the first of July. Now the intensity of heat and light diminishes as we recede from a heated or luminous body. The diminution is not in proportion to the increased distance, but in a far greater ratio, varying, like gravity, inversely as the square of the distance. Therefore the quantity of solar heat daily received by the whole earth, when in and near its perihelion, is considerably greater than what is daily received when in and near its aphelion. The daily temperature of the whole earth decreases from the perihelion to the aphelion, and increases from the aphelion to the perihelion. But as the earth requires nearly eight days longer to describe the 180° of longitude in the aphelion part of its orbit, than it does to describe the remaining 180° in the perihelion part, the amount of heat received during the former or longer period, will be exactly equal to the amount received during the latter or shorter period.

The longer period includes our summer, beginning about the 31st of March, and ending about the 3rd of October. By this means, the intensity of heat during our summer is slightly modified, by being extended over a longer period of time. Though the summer in the southern hemisphere receives the same amount of temperature as the northern summer, yet it receives this equal amount in about eight days less time, and therefore the heat is intensified more than in the northern.

For this same reason, our winter is slightly modified by the decreased distance of the sun; while the winter in the Southern hemisphere is rendered slightly colder by his increased distance. The fluctuations of temperature, arising from the elliptical form of the earth's orbit, are but small compared with those resulting from the sun's altitude and the variations between the lengths of days and night, as already explained.

From what has been said concerning the present temperature to which different portions of the earth have been subjected, the question naturally arises, Is this temperature permanent? Or, are there causes in operation which will greatly derange this permanency sufficient to endanger the existence of the animal and vegetable organism of our globe? These questions resolve themselves into the following: Does the whole earth annually receive more heat from the solar rays than it loses by radiation? Or does the loss exceed the gain? Or are the quantities received and lost equal?

So far as experiments and the limited observations of man have extended, the mean annual temperature of numerous points on the earth's surface is found to be permanent. Apparently the temperature is very irregular and subject to perpetual change; but a little attention, with the aid of the thermometer, will soon convince us that the irregularities observed are merely slight deviations from permanent laws. Observation, if continued a sufficient number of years, will inform us that the differences of the mean annual tempe ature, at any given place, is scarcely appreciable; some years arising a little higher—in others, falling a little under its mean state. And the longer the period during which the observations extend, the more unchangeable is the result.

If the earth, therefore, ever was in a state of higher temperature, or, as some have supposed, in a state of fusion, it is very evident that it has cooled down to a state of equilibrium, in which the amount of heat annually lost by radiation just balances the amount annually received from the sun.

This equilibrium, however, could not be maintained should the period of the diurnal rotation, or the annual revolution of the earth, be considerably changed. It may be asked, Have we any assurance that these periods will not change? May not the earth gradually slacken its rotation, so that the period of day and night will be lengthened out two, three, four or more times greater than at present? May not our seasons be totally subverted by a retardation of the velocity of the earth, and the consequent diminution of its annual period in a smaller orbit? Either of these causes alone, or both combined, would overthrow and entirely destroy the nice adaptations and wise adjustments which now exist between organized nature and climate. For the seasons being made two or three times shorter would prevent the fruits of the temperate climates from ripening; grains of all kinds, vegetables, berries, etc., etc., could not come to maturity, but would speedily perish by the sudden alterations of heat and cold, arising from the shortness of the seasons. The intensity of heat, arising from the diminished distance from the sun, would render the globe uninhabitable, unless new adjustments were made to correspond with the new circumstances.

But observation demonstrates that our diurnal period is invariable: for the last 2,000 years it has not changed the one-hundredth part of a second; neither has the year varied its length only within very small limits, which are known to be periodical—the mean year remaining absolutely unchangeable.

The invariability of these periods depends upon the stability of the laws of motion, one of which may be stated thus: A body at rest continues at rest, unless acted upon by some impulse causing motion: a body in motion continues in motion, in one direction, and with a uniform velocity, unless its course or velocity is changed by force. We see the stability of this law verified in the exact constancy of the period of the earth's rotation during some 800,000 revolutions on its axis. During that lengthy period its velocity has not in the least been retarded. The same is true in relation to the uniformity of its annual period. Its mean orbitual velocity is neither accelerated nor retarded. This proves either that the medium in which these movements take place contains no substances offering any appreciable resistance, or that the resistance, if any, is counteracted by some unknown propelling force equivolent to such resistance, and capable of maintaining the uniformity which now prevails

We have, as yet, only spoken of the surface temperature of the earth and its variations in different zones. We may now inquire in what manner the interior is affected by the solar heat? It is evident that the whole amount of heat falling on the earth is not immediately reflected or radiated from its surface into surrounding spaces; but a portion is absorbed by, and slowly conveyed through, the solid materials of the interior, penetrating to depths below and commingling with the internal heat originated from the action of the terrestrial elements within. As the earth rolls upon its axis, this daily wave of heat will roll in the opposite direction, following the sun from east to west, and flowing over the whole earth every twenty-four hours. Thus this powerful ethereal wave moves onward and inward, having its apex, or maximum intensity, underneath the path of the vertical sun, and lagging some two or three hours behind him. This incessant wave has, since the creation, made some 2,000,000 of revolutions. Each succeeding day imparting a vast quantity of heat, not only to the surface strata, but to the whole interior.

What becomes of all this solar heat, conveyed into the interior principally through the surface of the torrid zones? Is it accumulated in some vast reservoir, deep in the bowels of the earth, to break forth some day in a mighty terrible conflagration, consuming this creation and converting it into its original chaos? Or does it follow the universal law of all fluids seeking an equilibrium? It is evident that the great law of equilibrium is the one which governs this vast ocean of fluid, in obedience to which it seeks out and permeates through myriads of channels and makes its way to the colder regions of the globe, where it finds an outlet and escapes by way of radiation into the polar spaces of the heavens.

About three-quarters of the surface of our globe is covered with water; the remaining quarter is dry land. The dry land is mostly found in the Northern hemisphere, while the Southern hemisphere exhibits one vast ocean of water, interrupted here and there by comparatively small patches of land.

While the solar heat is transmitted through solids by *conduction*, it is conveyed through water by *currents*. As the upper surface of the ocean in the torrid zone becomes heated by the sun's vertical ray, it is rendered specifically lighter than the cooler stratum beneath. But in the frigid zones, the surface stratum is continually being cooled to a lower temperature than the waters underneath, and hence, becoming specifically heavier, they sink. To supply the place of the constantly sinking upper surface, the adjacent surface waters are drawn in from warmer regions nearer the torrid zones, producing an upper current from those heated zones towards each pole. As the upper surface of the ocean in the equatorial regions is thus being continually drawn off, the equilibrium is restored by an under current of cooler water from the two poles.

If the whole earth were covered with water, and had no rotation, but was heated by a diurnal revolution of the sun, the upper currents would be directly north in the Northern hemisphere, and directly south in the Southern hemisphere; but by the rotation of the earth these ocean currents in the torrid zone have a velocity eastward equal to twice that of a cannon ball, and as they proceed slowly to the north in our hemisphere, the equatorial rotatory velocity is not diminished in proportion to the diminished distance of the different parallels over which they pass from the axis of motion; hence, these northern currents have a constant tendency to move eastward or out-run the surface over which they move. By the combination of these two causes, a current is produced from the south-west to the north-east. In the Southern hemisphere, for like reasons, an upper ocean current must exist from the north-west to the south-east. For similar reasons, the under ocean currents in both hemispheres will run in the opposite directions to their respective upper ones.

But these great ocean currents are greatly interfered with by continents, islands, shoals and other irregularities over the bottom of the ocean, being modified also by the fluctuations of temperature caused by the seasons.

By the constant circulation of the oceanic and atmospheric currents of our globe, the extremes of temperature, which would otherwise exist in the five zones, are greatly modified. The heat of the torrid zones is conveyed by these currents into the temperate and frigid zones, warming them up and ameliorating the severities of the climate; while on the other hand, the lower temperature of these latter zones is conveyed by the under currents of both atmosphere and ocean to modify the otherwise excessive heat of the former.

As a proof of this theory, the audience is cited to the well-known phenomena of the Gulf Stream, which takes its rise in the north torrid zone in the excessively hot regions of the West India Islands. At first, the course of the current is nearly north, inclined slightly to the east, as it should be according to theory. As it progresses, it deviates still more from the north, crosses the Atlantic towards the western shores of Europe. On its passage this great current is subdivided; one part continuing on its legitimate course towards the Arctic regions; the other, encountering the return current from the polar seas, is overpowered and deflected to the south, proceeding along the western shores of Europe, until it re-enters the torrid zone, where, gradually sinking by its increased specific gravity, it flows westward whence it originated; or more philosophically, the earth's greater equatorial velocity out-runs it to the eastward, giving an appearance of the great stream flowing westward.

Though the theory which the lecturer has just proposed, to account for the most wonderful circulation of the ocean fluid, has undoubtedly been advanced in part by others, yet, with him, the particulars as now given are original, and may need some revision.

Besides the solids and ocean fluid, which constitute the most of the globe, it has a gaseous substance enveloping it, called the Atmosphere. This ærial ocean is supposed to be about 45 miles in height above the general level of the sea. It exerts a pressure or weight upon the whole surface of the globe of about 15 pounds, on an average, to every square inch. This pressure diminishes as we ascend above the general sea level. For equal heights, the pressure diminishes in a geometrical progression. Thus, at three miles height, the pressure is only one-half, or 7½ pounds on a square inch. At six miles, the pressure is one fourth, or 3¾ pounds. At nine miles, the pressure is only one-eighth equal to 1⅞ pounds. At the elevation of twelve miles, the pressure would be diminished to one-sixteenth, which would be less than one pound to every square inch of surface.

By the earth's rotation, this ærial ocean is gathered up from the two poles into the equatorial regions, where it is maintained at an elevation above the centre of the earth nearly fourteen miles more distant than the polar elevation.

Should the earth cease its rotation, not only the oceans of water, but the ocean of air would flow down from the equator and torrid zones to the two poles, leaving the lands in those regions which are now elevated above the sea, with an atmosphere so rarified as to be totally incapable of maintaining respiration; while none but those lands which are now at the bottom of the equatorial sea would be blessed with air of sufficient density to sustain life.

Everything that we have thus far investigated, pertaining to this creation, exhibits the most profound wisdom and wonderful skill in the adjustments of figure, of magnitude, of proportions, of motions, of antagonistic forces, all combining to sustain the peculiar vegetable and animal economy adapted to these combinations. Who can but acknowledge the footsteps of Divinity in every part and in the whole?

We wonder at the power and wisdom displayed in the working of this grand terrestrial machinery; but how much more wonderful is the origin of the machine and the origin of the stupendous motions imparted to it.

How the orbitual and rotatory motions of our planet were first impressed upon it, is not known. By some it is supposed that these motions were given directly by the Creator, at the time of the creation. By others, it is conjectured that they are the results of some general law not yet discovered. It is very evident that divine wisdom generally manifests its purposes, and exhibits its power, and brings to pass its designs, in accordance with certain general laws. When these laws are unknown, the phenomena resulting often appear arbitrary, and are generally ascribed to a supreme power acting independently of law. Before closing this series, the lecturer may venture to advance a theory of his own, to account for the origin of planetary motion, and many other phenomena hitherto unexplained in the grand machinery of the universe. In the meantime, let us exert every effort of the mind to form a correct idea of those sublime exhibitions of our system which have been sought out, and are well understood by the scientific world. This will prepare us to launch forth into the unknown, in search of laws of a still higher order of generalization, under which may be martialed those apparently isolated and out-standing phenomena, the explanation of which have seemed hitherto to baffle the most powerful and giant intellects which have attempted their solution.

AGRICULTURAL.

At the Seventh Annual Meeting of the Ohio Dairymen's Association, which held its Sessions at Wellington, Mr. Horr, of Lorain, delivered an address in which he told his hearers some very plain truths. In the business of farming, he said, as well as in all others, profit depends more upon intelligent management than upon hard day's work. In all classes and departments of manufacture, it is disciplined mind, educated thought, directing and guiding dextrous hands, that organize and give success. Careless farmers need not envy successful merchants, for if the latter had put no more skill into their business than many of the farmers have into theirs, they would have long since met with failure and bankruptcy. He would have farmers learn to value culture and appreciate knowledge for their own sakes. Their especial attention, he says, should be directed to underdraining, to the chemistry of plant growth and animal nutrition, and the adaptation of different soils and manures. Practical works that treat of hedges, horticulture, the preservation of forests, rotation of crops, and of animal and vegetable physiology, should be carefully studied. The monotony of a farmer's life, even the hardships of his daily toil, would be greatly relieved and lessened by this quickening of his mental powers; for culture takes nothing from one's power to perform manual labor and to endure physical suffering. How is it with the majority of men, he asks, when they begin, and when they end a farmer's life? True, they know how to milk cows, how to stable cattle, how to plant corn and potatoes, how to sow, reap and thrash. But what do they know of agricultural statistics, of the geology of the earth, of the chemical constituents of the soil and its products? What of vegetable and animal physiology? What of underdraining, or the selections of manure best adopted to promote the growth of different kinds of plants? What works have they read on rural architecture, on horticulture or irrigation? Yet a knowledge of all these subjects is required for the thorough understanding and profitable prosecution of their business. He ventures the assertion that, outside of farming there is no business in which even a livelihood can be made by persons who have taken so little pains to qualify themselves for its successful management.

He then adds:

"But this cannot last. Cheap lands, virgin soil and primeval forests make it possible for this quackery to obtain partial and temporary success. Future generations will have to pay dearly for the little thrift derived by the present one from this imperfect husbandry. Examine the impoverished condition of whole tracts of land in Virginia and the cotton-growing States; note the marked diminution in the yield of grass and grain per acre on many of our own farms; observe the increasing scarcity and advancing price of timber; then compare our agricultural statistics with those of England, and you may form a faint conception of the disastrous waste, the ignorance and improvidence that characterizes our American farmer."

He reckons that there are two hundred farmers to every lawyer in Ohio and other parts of the Union, and yet in the Senate of the United States there are forty-nine lawyers and only one farmer. In the lower House of Congress there are one hundred and fifty-nine lawyers and but seven farmers. He can readily call to mind a long list of names of lawyers who went into the volunteer army during the late rebellion and won for themselves the rank of Brigadier