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THE TRANSACTIONS  
OF  
The Victoria Institute,  
OR  
Philosophical Society of Great Britain.

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JOURNAL OF THE TRANSACTIONS  
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VICTORIA INSTITUTE,  
OR  
PHILOSOPHICAL SOCIETY OF GREAT BRITAIN.

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ORDINARY MEETING, FEBRUARY 18, 1867.

THE RT. HON. THE EARL OF SHAFTESBURY, K.G., PRESIDENT,  
IN THE CHAIR.

The minutes of the previous meeting were read and confirmed, after which the following Paper was read by the Honorary Secretary in the absence of the Author:—

*ON TERRESTRIAL CHANGES, AND THE PROBABLE  
AGES OF THE CONTINENTS; FOUNDED ON  
GEOLOGICAL OBSERVATIONS AND ASTRO-  
NOMICAL DATA. By EVAN HOPKINS, C.E., F.G.S.,  
Mem. Vict. Inst.*

**N**OTWITHSTANDING the facts explained by geologists with regard to terrestrial mutations, the generality of mankind get so accustomed to and familiar with the configurations of our continents, during the comparatively brief period of their lives, that they look at them as they do at an artificial globe, and imagine that they have been the same since the days of Adam. The changes of the earth are so slow in comparison to the duration of our lives, that they are overlooked and forgotten. From the apparently quiet and regular succession of natural events to which we get accustomed, and the

repugnance we feel to the idea that it is possible for the foundation of our habitation to be always changing, upheaving, depressing, and moving *en masse*, from clime to clime, without our being sensible of such movements, we are apt to attribute all changes to past ages, and deny the possibility of their going on during the period of our existence.

Pythagoras taught, 2,350 years ago, that "the surface of the earth was ever changing; solid land had been converted into sea, and sea changed into dry land. Marine shells were found far distant from the deep, and the anchor had been found on the summit of hills. Peninsulas had been separated from the main land, and had become islands." "The changes of the earth," says Aristotle, "are so slow in comparison to the duration of our lives, that they are overlooked; and the migrations of people after great changes, or their removal to other regions, cause them to be forgotten. The distribution of land and sea does not endure throughout all time, but it becomes sea in those parts where it was land; and there is reason for thinking that these changes take place according to a certain system, and within a certain period. Everything changes in the lapse of ages."

Whatever difference of opinion may exist as to the cause of the upheavals and subsidences of the lands, there can be none as to the fact of their occurrence. These terrestrial changes are now too well established to be controverted; the observed facts must be and are accepted. My object on this occasion is, not merely to confirm them, but to point out the order in which they occur, with the view of forming some idea of the probable ages of the existing continents.

Various attempts have been made to compute the ages of geological formations, or the deposits of drifts with organic remains, by means of the rate of *upheaval* measured on any given coast at a certain time. Simple reference to the changes daily going on would at once show that such a method could only be adopted for a short period, within comparatively narrow limits, as the rate of rising and sinking is extremely variable, not only in countries far apart, but even along the coast of the same island. The western coast of South America, from Terra del Fuego to Panama, is subject to very irregular upheavals and depressions. So are New Zealand and Australia. Besides the slow normal mutations of the earth, there are also periodical actions of increasing intensity occurring during earthquakes, as on the coast of Chili in 1835, when the island of Santa Maria was upheaved ten feet in one day. The coast of Puzzuoli, near Naples, in 1538, was raised twenty feet in a single night. Therefore it is quite clear that no reliable data

for computing the age of any given land or formation can be obtained from *upheavals*.

I need not refer to the slow upheavals along the coast of Greenland, Norway, and Sweden, as they are neither uniform nor continuous in their movements. Lands often rise gradually for a certain time, then remain stationary at the same elevation above the sea, and again subside. No computations can be founded on such irregular and uncertain mutations. I alluded to the *upheavals* in Australia in my former paper, to which I beg reference. I shall next refer to another movement of the earth which has not been duly attended to, although it is the most important of all the changes; viz., the movement *northward*, which produces climatal and *geographical changes*. The evidence of the lands having not only upheaved, but also moved *en masse* from the tropics to the Arctic region, is as strong and conclusive as the proofs of their having been raised from the deep.

Before proceeding to consider in detail the northerly movement of the lands, I shall give a brief description of the currents of the ocean, and endeavour to show that terrestrial matter generally is subject to the same law of movement from pole to pole. The currents of the ocean are well described in Captain Maury's *Physical Geography of the Seas*, to which I beg reference for details. These currents commence in the Antarctic region, and after flowing along the various configurations of the coasts in the Indian, Pacific, and the Atlantic Oceans, terminate in the Arctic Circle, and become absorbed therein. These oceanic streams carry with them the vegetable forms of the southern climes into the Arctic basin, by means of the Gulf-stream in the Atlantic, and the Japanese stream in the Pacific.

The northerly actions of the "Gulf" and the "Japanese" streams are so well known as not to require further comment on this occasion. The actual rate at which the ocean moves, as a whole, from south to north, is not yet ascertained; but there are strong reasons for believing that the entire ocean changes place in less than seven years.

A bottle thrown into the sea off Cape Horn in 1837 was picked up on the coast of Ireland a few years afterwards.

This northerly action of the ocean alone causes very important geological changes, inasmuch as it not only carries the *débris* of the vegetation of different climes to the northern hemisphere, which become deposited in high latitudes, but it also conveys a large amount of fine sand and mud, held in suspension, from the mouths of great rivers (like the Amazon

and the Orinoco) northward, or in the direction of the local bends of the oceanic streams.

Had the vegetable tropical remains, which are found in the formations of the northern hemisphere, consisted simply of broken fragments and mere *débris*, their occurrence at high latitudes might easily be accounted for by the northerly action of the ocean; but as we also find tropical fossil trees standing with their roots still attached to the soil in which they grew, surrounded with their fallen leaves and the remains of reptiles, we cannot come to any other conclusion than that the lands themselves have moved bodily in that direction.

The oceanic streams radiate from the south pole as the fountain-head, and carry with them the sands, gravels, and the icebergs of the Antarctic region to very low latitudes, sometimes approaching the boundary of the southern tropic. Hence this part of the globe is a scene of desolation and barrenness to the parallel of about  $50^{\circ}$  latitude south. A very different appearance is seen in the north. The streams of the ocean flowing through the tropics enter into the Arctic basin comparatively warm, with floating vegetation from all climes, and become absorbed therein. The crust, or the crystalline film of the earth, has a similar action, but at a much slower rate of movement.

In Greenland, Spitzbergen, Iceland, Northern Canada, and Nova Scotia, we have excellent examples of fossil trees, in upright positions, with their roots still attached to the soil in which they grew; thus furnishing most incontestable proofs of their having flourished and died on the very same lands as those in which they are now found. At Atanekrdluk, in lat.  $70^{\circ}$ , trunks of trees are seen standing upright in their native soil. This fossil forest grew on the ground on which the plants are now found fossilized. The fossil plants of North Greenland prove that the land had been favoured with a climate at least  $30^{\circ}$  Fahrenheit warmer than it is at present, as it is quite certain that they never could have borne a low temperature. If we look at those species which we may consider as possessing living representatives, we shall find that, on an average, the highest limit attainable by them, even under artificial culture, lies about  $14^{\circ}$  to the southward. In Spitzbergen, lat.  $78^{\circ}$  N., we find the beech, hazel-nut, and some other species, identical with those from Greenland. The extreme northern limit of the growth of such plants as the fossil trees of Greenland is lat.  $53^{\circ}$  N. The conclusions drawn from the general appearance of the fossil forests of Greenland, are, that the country was, some years ago, truly a *green* land, on which vegetation flourished as abundantly as we now see in California. According to the Ice-

landic histories, Greenland had a large population in the year 982, with whom Hamburg as well as Norway merchants had a commercial intercourse. The communication continued till the year 1418, when, from the increased severity of the climate, and other causes, such as the black death, &c., the country and its inhabitants became forgotten, and almost disappeared from history.

The contents of all the European deposits indicate that in past ages the lands which are now in the northern hemisphere were once in a much warmer climate, and of so uniform and mild a temperature, that the surface was clothed with coniferous trees, arborescent ferns, and palms. The shores also teemed with turtles and various amphibious reptiles.

The Malay Archipelago is about the size of Europe from the North Cape to the Mediterranean, and from Britain to Russia, and therefore equals all the geological formations which have been examined by geologists with any degree of accuracy. This Archipelago, with its numerous large islands, contains the representatives of nearly all the organic remains found in the formations of Europe. I have seen sharks near Java upwards of twelve feet long, and chambered shells of large dimensions; also elephants of gigantic size in Ceylon and Malacca. The temperature of the sea is high; the nautilus and spirifer Peronii, like the ammonites, and various mollusca, abound on the shores, and the corals grow in luxuriant clusters to great magnitude on the reefs, and the bottom of the shallow channels.

#### THE RATE OF THE TERRESTRIAL CHANGES DETERMINED UPON ASTRONOMICAL DATA.

At the commencement of the last century our geographical maps were extremely imperfect, therefore we have no reliable data on which to make a correct comparison as to the position of any given place now, and that which it occupied a few centuries ago. Humboldt very justly remarked that the latitudes of even the European observatories in the last century were not correct within *twenty minutes of a degree*. If this was the case in scientific stations, where correct astronomical data might have been expected, what must be the errors and the uncertainties of the positions of other places? These facts show that there are no grounds whatever on which it can be maintained that the latitudes of the lands do not change.

The only means by which we are able to ascertain the

latitude of any given place with exactitude is by reference to the fixed stars, as it is impossible to make terrestrial measurements from the poles. Even in taking the stars as the fixed points to determine the latitude at any given period, they must be observed when in the zenith, so as to be free from errors. The laws of refraction, even at the present day, are not sufficiently accurate for taking observations to determine small changes many degrees below the zenith; therefore, all computations requiring great exactness are founded on zenith distances.

Bradley, during his astronomical observations between the years 1726 and 1735, found, by comparing the catalogues of stars made by Hipparchus and Tycho Brahe, that a change had taken place in the position of the fixed stars with reference to any given station on earth, equal to 50 seconds of a degree per annum, in the plane of the ecliptic westward. Bradley made his observations by means of a vertical telescope. The star chiefly made use of to determine this change was that marked  $\gamma$  in the constellation of *Draco*. (See *Phil. Trans.*, 1748.) Besides the direct and continuous change of 50" per annum, he also detected a small undulating movement, which he attributed to a *nutations of the poles*. He was under the impression that the land was fixed to the globe, as the maps are on an artificial globe. Hence all changes were attributed to nutations of the axis, or to the earth bodily, and not to any movements of the surface of the globe. These movements, although well known in the time of Pythagoras and Aristotle, appear to have been forgotten, and therefore were totally neglected by modern astronomers, in speculating on the probable cause of the above changes.

Bradley was appointed Astronomer Royal in 1742; but beyond the fact of determining the annual change referred to, he made no further observation with reference to this question.

Had this movement only affected the fixed stars, it might have been urged that it originated from the starry heavens moving slowly towards the south-east, and not the lands towards the north-west. But since it also affects the sun, moon, and planets, such an idea could not have been maintained; therefore astronomers have necessarily concluded that it proceeds from a *real motion of the earth*. The correctness of Bradley's observations was subsequently verified. This change—which causes the appearance of a recession in the equinoxes, is so well established now as not to require further confirmation. The annual amount of this spiral movement of the surface westward at an angle of about  $23^{\circ} 30'$  from

the plane of the equator, is but an extremely minute quantity, viz., 50" in longitude and 20" in latitude; yet its continual action from year to year makes itself very conspicuous, and that in a way highly inconvenient to practical astronomers. It destroys, in the lapse of a moderate number of years, the arrangement of their catalogues of stars, with reference to the stations on earth, and renders it necessary to reconstruct them from time to time.

Since the earliest catalogue on record—that made by Hipparchus 2,140 years ago—the stations of reference have moved towards the north-west  $30^\circ$ , and have, in round numbers shifted northward during the same time  $12^\circ$  in latitude. That is equal to the cosine of the angle of the spiral plane (of  $23^\circ 30'$ ) the direction of the superficial movement. The effect of this change in the aspect of the heavens is to make the southerly stars appear to recede southward, and those situated in the north to approach at the rate of 20" per annum in the meridian. Hence it appears that the superficial film of our globe has been made free to move, like the ocean, from south to north, but in a spiral path: this movement has been determined to a fraction of a second of a degree, and is seven and a half furlongs in longitude W. and three furlongs in latitude N. per annum.

As a further illustration of this terrestrial change, let us, by way of an example, take  $\gamma$  Ursæ Majoris as a convenient fixed star to determine annually our geographical position. The situation of this star is very favourable for making observations in this latitude, inasmuch as it passes within  $3^\circ$  of the zenith, and therefore is, when in that position, unaffected by refraction on its transit.

In January, 1853, Greenwich was  $3^\circ 2' 5''$  to the south of the transit of  $\gamma$  Ursæ Majoris. In January, 1864, the Observatory was  $2^\circ 58' 24''$  S. of this star. In 435 years hence the Observatory will have arrived at the same parallel as  $\gamma$  Ursæ Majoris, when the star's transit will be seen in the zenith. It might be urged that such a small movement, which is only detected after the lapse of ages, would not be sufficient to account for the geological changes referred to; but I shall endeavour to show that, small as it is, it is quite sufficient to produce them, and in the exact order in which they are seen. I shall take the Isle of Portland as an example. In the deposits of this island is a petrified tropical forest, proving that that part of England has not only been upheaved, but also exposed to a tropical, or at least, a semi-tropical sun. Many of the fossil trees are still standing erect, with the roots in the very ground in which they grew. The plants are similar to

the palms and other varieties of vegetation now flourishing luxuriantly in Africa in latitude  $35^{\circ}$  N. Dr. Hook, in 1705, remarked that "the fossils found in Portland seemed to him to have been the productions of hotter countries; and it is necessary to suppose that *England once lay under the sea within the torrid zone.*"

Let us compute backwards how long ago it is since the south of England was in latitude  $35^{\circ}$  N., where the animals and vegetables found entombed in the Portland deposits still flourish. As we are now in possession of the exact amount of the rate of the terrestrial change, which has been determined to a fraction of a second, we can safely proceed with our computations, and thus ascertain, with some degree of exactitude, the probable age of any given land. About 3,150 years ago, the site on which Greenwich Observatory stands was about  $20^{\circ} 28' 30''$  S. of the parallel of  $\gamma$  Ursæ Majoris, and therefore in latitude  $35^{\circ}$  N., when the Portland organic remains might have flourished, and the deposits have been formed. The southern part of England, according to the slow rate of change of  $20''$  per annum, must have been within the tropics about 5,500 years ago. Hence England might have risen from the deep within the tropics, and produced all the geological deposits found on it during the last 6,000 years, without allowing for any increased movement, which it is highly probable occurred during the Noachian deluge.

Amongst the animals entombed in the deposits of Siberia are the elephant, rhinoceros, hippopotamus, bear, hyæna, lion, tiger, and others, which can only live and flourish in or near the tropics. The fossil ivory is found in deposits like quarries of bones, and forms a lucrative article of commerce. Tobolsk, the capital of Siberia, is now situated in the parallel of  $58^{\circ}$  latitude N.

In Cabool, Lahore, and Delhi, say in  $50^{\circ}$  latitude N., elephants and tigers still abound. How long is it since Tobolsk (site) was in the parallel of  $30^{\circ}$  N. latitude? The difference between the two parallels being  $28^{\circ}$ , the time required to produce this change is 5,040 years.

The flesh of the Siberian mammoth has been found in the ice and gravel in so fresh a state as to serve as food for dogs, bears, and wolves. Yet it is contended that the deposit *must* be tens of thousands of years old!

There are species of tigers and other tropical animals roving occasionally as far north as  $45^{\circ}$ . A tiger was killed in 1828 on the Lena, in latitude  $52\frac{1}{2}^{\circ}$  N. Bears, with long hair, and black tigers, are seen within the tropics, as high as the inferior limits of perpetual snow; therefore these animals are not

necessarily confined to the tropical parallels. The long-hair mammoth found in Siberia might have lived far beyond the tropics, and the carcass might have been carried by the floods of the rivers towards the Arctic region two or three thousand years ago. Had Africa been connected with the south of Spain, as it was in former ages, Spain would even now be infested by tropical animals. It is necessary to bear this in mind when we discuss questions connected with terrestrial changes. The African rhinoceros is found as far south as the Cape of Good Hope, latitude  $34^{\circ}30' S.$ , and lions as far north as Algiers, about  $36^{\circ}$  lat. N.

The fossil forest of Atanekerdluk, in latitude  $70^{\circ}$  N. (Greenland), is still standing erect on its native soil. When those trees flourished, they required a temperature of at least  $30^{\circ}$  Fah. higher than is now found in that parallel. This land 4,000 years ago was within the parallel of  $48^{\circ}$  N., in which similar vegetation now flourishes in France.

The Nova Scotia coal-beds contain calamites, fern-trees *rooted* in the arenaceous beds, surrounded by their fallen leaves, and the remains of tropical reptiles. This formation is now in latitude  $45^{\circ}$  N. About 4,000 years ago it was in latitude  $23^{\circ}$  N., and might have then received its sedimentary deposits, in the same manner as they are now seen forming in the lagoons of St. Martha, near the mouth of the river Magdalena.

The south-east part of England, when the Wealden deposits were formed, was in a very warm climate. It had then its lagoons, with palms, arborescent ferns, &c. Crocodiles, iguanoes, turtles, and various reptiles, infested its fens and rivers, and have left their remains as memorials of their former existence. All this might have occurred about 4,000 years ago, when the south of England was in latitude  $30^{\circ}$  N.

How much more satisfactory it is to the inquiring mind to learn that these great geological changes are not the result of chance or disturbed elements, but are occurring as regularly, and are as uniform and exact in the rate of their movements, as the rotation of the earth; and that they do not proceed from a series of igneous catastrophes, regulated by no laws, and reducible to no fixed principles, as assumed by geologists.

I shall not refer to the theory which was propounded at the commencement of the last century, and attempted to be improved by D'Alembert, to account for the change referred to by an assumed conical motion of the terrestrial axis. This inconsistent hypothesis has been lately exposed and demolished by M. Poinset, an eminent member of the French Insti-

tute. Astronomers will continue to be perplexed with the results of their observations until they have corrected their tables of refraction, and adopted the now well established superficial movement, instead of the *reeling* or *conical motion of the terrestrial axis*, which has not a single physical fact to support it. The Astronomer Royal, in his report for 1861, remarked that "the transit circle and collimators still present those appearances of agreement between themselves, and of change with respect to the stars, which seem explicable only on one of two suppositions—that *the ground itself shifts with respect to the general Earth*; or that the axis of rotation changes its position."

We have innumerable proofs of the land's upheaving, subsiding, and shifting, but none whatever as regards any changes in the position of the axis.

I shall next refer to the lands of the southern hemisphere. The conditions of that part of the globe are very different to those in the northern hemisphere. With the exception of a small part of the south of New Zealand and Patagonia, there are no lands in the Antarctic Sea, but mere patches of sands, gravel, and icebergs—scenes of barrenness and desolation—to the latitude of  $45^{\circ}$  S. In the north, between the parallel of  $45^{\circ}$  latitude N. and the Arctic basin, are situated all Europe as far as Spain and Italy. Also Siberia, Tartary, and the northern part of China. Likewise nearly all the British possessions of North America. We have to advance from the south as far as the tropics—say to the latitude of  $20^{\circ}$  S.—before we can obtain sufficient area of habitable lands in that part of the globe to investigate their geological formations, so as to form a correct opinion of their general character and probable ages. The parallel of  $20^{\circ}$  lat. S. will embrace New Zealand, Tasmania, about two-thirds of Australia, the Cape of Good Hope, and the southern part of South America. A general description of the deposits of these countries has been already given, therefore need not be repeated on this occasion. In the sedimentary deposits of the northern hemisphere are the remains of the flora and fauna of the semi-tropical and tropical climates, and not those flourishing in the northerly zones in which the deposits are now seen. The relics of the past entombed below are totally uncongenial to the climates of high northern latitudes.

In the south, on the contrary, *the organic remains found in the deposits correspond with those now living in the same regions.* In Australia, New Zealand, and the southern part of South America, are growing most luxuriantly arborescent ferns, Cycadææ, Araucariæ, and various coniferæ. The coasts abound

in corals and sponges even to Tasmania; also Terebratula, Trigonia, and a variety of mollusca, unknown in Europe excepting as fossils. Hence the entombed organic remains of that part of the world present no indications whatever of the lands having shifted from other climes, as we see in the northern hemisphere. We have many unequivocal proofs of the comparatively modern origin of the lands of the southern hemisphere, and that they gradually emerged from the sea, but they are occasionally subject here and there to somewhat rapid upheavals, as seen in New Zealand and on the coast of Chili, as described in my former paper.

To determine the probable age of the lands of the south temperate zone, we can have no assistance from the organic remains; we can only be guided by astronomical observations and the space traversed from the parallel of emersion in the south to the parallel now occupied. However, this is quite sufficient for my object, and as the fact of the 20" per annum movement has been well proved in all parts of the world, and, indeed, is recorded in the *Nautical Almanac* as an essential element to be taken into account in all our astronomical observations to insure accuracy, the ages of the lands referred to can be determined within a few centuries.

I shall take the southern part of Australia to the latitude of 30° S. as an example; and as this parallel will embrace also the whole of New Zealand, Tasmania, Cape of Good Hope, Patagonia, La Plata, and Chili, the computation will serve for all. The result of the various explorations which have been made in the Antarctic Sea shows that *no permanent land on which animals and plants can exist* emerges and remains above the level of the sea until it reaches the parallel of about 50° lat. S. All the so-called lands, with the exception of Terra del Fuego and its neighbourhood (which is a hard mass of primary rock), are mere shifting sands and gravels, constantly subject to be washed away by the streams and icebergs flowing from the south polar region towards the north.

If, then, we take the parallel of 50° as the starting-point from which Australia and the other lands mentioned emerged from the deep, it follows that, according to the rate of movement of 20" per annum in the meridian, the lands bounded by the parallel of 30° lat. S. can only be 3,600 years old at most. They might have first risen from the deep in the parallel of 45°, which, indeed, is highly probable, as they contain but a small amount of terrestrial deposits, and predominate in loose sands and gravel with marine shells, indicating comparatively recent origin; this would reduce the age to about 2,700 years. According to the present rate of rising in Australia, four-

fifths of that country were below the level of the sea 1,000 years ago. In making these computations on the probable ages of the existing lands, it must be borne in mind that the computations refer strictly to the dry lands or continents, and not to the earth as a body. The globe, with all its elements, might have existed from eternity. The ocean and the lands emerging from the Antarctic Pole, merge again into the Arctic Pole, and thus circulate from pole to pole through the medium of the earth's axis. This question is beyond the reach of demonstrable science; but as regards the existing dry lands, we are able to determine the extreme limits of their probable ages almost to a mathematical certainty.

A new land emerging from the deep in latitude 50° S., moving at the present slow rate of 20" per annum northward, would arrive at the Arctic Circle in less than 22,000 years. Hence, had Greenland been emerged in that parallel, and had since been slowly shifted from thence, it could only be 22,000 years old. But as far as the fossil contents of that country are concerned, Greenland might have emerged from the sea, like many other northern lands, in latitudes corresponding to Spain and Portugal, and if so, it might not be above 5,000 years old. Again, we must not forget the miracle of the Flood. It is highly probable that the Flood was brought about by means of the established terrestrial physical operations. The movement of the ocean northward must have been greatly *intensified*, and thereby, from the same natural causes, the action of the lands in the same direction, must have increased, and thus, during their immersion by the ocean, have been carried *en masse* many degrees northward, with the carcasses of the animals then destroyed, leaving a new land for Noah and his live stock free from the remains of the former animals, to replenish the world with organic life for future generations.

Besides this possible extra movement northward during the Flood, we have to reflect also on the great intensity of the action of terrestrial operations in the days of the Creation. When everything was created and made to appear perfect and in a state of maturity, as quick as the word of command, "Let it be; and it was so" — *time* was not required. Although the Creation was spread and divided over six days as a type of certain ordinances which were to be established for the guidance of man, so many days could not have been required by our Maker. The great *intensity of action* which of necessity must have been going on during the days and nights of the Creation, has not been sufficiently considered by those who have attempted to compare geological formations with the Mosaic records. Greater results must have then been pro-

duced in an hour than were effected, subsequently to the sixth day, by the normal action of the polar forces in many centuries. Why then demand a greater time than is recorded in Genesis, and declared in the fourth commandment? The lands must have risen above the level of the sea on the second day within the tropical zone, to provide the necessary vegetable nourishment for the animals which were to appear on the fifth and sixth days. The oceanic movement and the electro-magnetic currents of the globe from the first day to the fifth, before man and the large terrestrial animals appeared on the scene, were doubtless circulating from pole to pole at a rapid rate, preparing and forming the entire surface of the earth in every zone from south to north.

Taking all these terrestrial operations into account in connection with the established fact of there being a constant movement on the surface of the earth equal to 20" per annum in latitude northward, I have long come to the conclusion that there is no necessity whatever to alter the literal meaning of the first chapter of Genesis, or the description of the Deluge, nor yet to alter the Jewish chronology, in order to account most satisfactorily for all geological phenomena hitherto discovered.

The great electro-magnetic power which envelops our globe circulates from pole to pole, and completes its circuit of action through the medium of the axis. It propels the currents of the ocean from the Antarctic to the Arctic focus of convergence, and by its directive property and action on magnetic needles guides the mariner on the seas in the darkest nights. The existence of this great universal power was scarcely known a few centuries ago; yet its everlasting action in the subterranean base imperceptibly changes the aspects of man's habitation, remodels again and again the superficies of the globe, and makes all pass away in succession like a scroll. Thus all things terrestrial are ever changing, decaying, and renewing; the lands, like generations, are passing through different stages, and finally merge into eternity, according to the will and ordinance of our Maker.

The CHAIRMAN.—It is my duty, as President of the evening, to propose a vote of thanks to the able and accomplished author of this paper. You will hardly expect from me anything in the shape of scientific criticism; but I may say this—(and I have no doubt that many of you would say the same)—that I have been intensely interested by what we have heard. I think it is an admirable paper, and one that must be productive of benefit to us all. Without entering into discussion, I will mention one fact that may be regarded as interesting. I could not help being struck by the frequent allusions in this paper to periods of 4,000, 5,000, and 6,000

years ; and when Cuvier was in England, I saw him frequently, and one Sunday evening I was with him, and whilst we were talking of the Bible and modern science, he said this :—" All my researches have brought me to this conclusion, that the geological changes on the earth do not require a longer period for their accomplishment than 6,000 years"—the period which we think is the duration of the world from the beginning, as we gather from the first chapter of Genesis. I will now invite discussion on the paper, and any gentleman who has anything to say will please address the meeting.

Mr. WARINGTON.—Before I commence my remarks on this paper I wish to ask one question. I was in hopes that the author would have been here to answer it, but I dare say, though he is not here, some other gentleman better acquainted with astronomy than myself may be able to solve my difficulty. It is this. Mr. Hopkins states that the direction in which the crust of the earth is moving, is at the angle of  $23\frac{1}{2}$  degrees to the Equator, that is to say, in the same angle as the line of the ecliptic ; and he says that this is equivalent to an annual motion in latitude of 20 seconds, and in longitude of 50 seconds ; in other words, the proportion is as two to five. Now, upon looking at the globe, and seeing what relation there is between the changes of latitude and longitude involved in the motion of the ecliptic, I find instead of these changes being in the proportion of two to five, they are in the proportion (nearly) of two to eight. How is this to be explained ? Which is right ? Is the motion really a motion in the plane of the ecliptic at an angle of  $23\frac{1}{2}$  degrees, or is it a motion in the proportion of two of latitude to five of longitude—that is, at an angle of 36 degrees ? I want to use these figures in testing Mr. Hopkins's conclusions, and until I know which method of reckoning is right I am altogether at sea. Is there any one present who can help me ? If so, I should be glad if they would do so before I say another word.

Rev. WALTER MITCHELL.—I think, perhaps, Mr. Warington may be labouring under a misconception. There is some degree of vagueness on that point in the paper ; but I think that astronomers admit there are two motions, or one motion, in reality, which is resolved into two. One of these motions is accounted for by a gradual change of the point at which the ecliptic cuts the Equator. That is the motion by which the plane of the earth's motion round the sun is slowly changing ; but that is not sufficient to account for all the changes. Besides that, which is called the precession of the equinoxes, there is another change, and that is accounted for by what is called " nutation," consisting of a wriggling motion of the earth's axis, as it were, in space. While the plane of the motion is changing, you have a change like the motion of a teetotum ; and the whole change that takes place is compounded of these two motions. It was the popular theory a little while since—the generally received theory of all the text-books on astronomy—that there was no real motion of the earth's crust, but that the only motion was a change in the earth's axis occasioned by the disturbing forces of the moon and planets upon the earth. There is now a growing belief on the part of astronomers, including the Astronomer Royal, that the

above causes are not sufficient to give the explanation of the whole motion ; and now there is a tendency—(and it is so far admitted as to be discussed by the Royal Society, and it has been entered into by other authors than Mr. Evan Hopkins)—to assert that there is in all probability an actual motion of the earth's surface ; but as to matters of detail or calculation as to this movement, I am not at present prepared to enter into.

Mr. WARINGTON.—My course must be, then, to take Mr. Hopkins's figures, rather than his angle, since it is the figures, not the angle, which he uses for his calculations. Now, let us realize the motion which this theory assumes. In the first place, it is a motion of the *whole crust* of the earth, of course only visibly apparent in the continents, but really extending over the whole surface of the globe. If, for example, England is moving in a certain direction, it is very plain that the bed of the sea on all sides must be moving also, or there would be a continual wrenching of the earth's crust going on where sea and land meet, such as we know does not, in fact, occur.

Mr. REDDIE.—Mr. Hopkins considers the sea as included in the crust of the earth.

Mr. WARINGTON.—Then, in the next place, it is a motion of the earth's crust to a considerable *depth* ; we do not know what depth, but it is certain, whatever the motion is, it is a motion which affects the earth to a considerable depth, not merely a surface of a few hundred yards, but a crust some miles (at least) thick of solid rock. What, then, is Mr. Hopkins's notion ? It is that of a spiral motion by which every portion of the earth's surface is perpetually, as long as the motion goes on, getting nearer and nearer to the North Pole. Bear that in mind. He supposes the land to start from the South Pole, to pass the whole way up northward to the Equator, and then on again to the North Pole. This is the theory as I understand it, and it is a motion strictly spiral, by which the whole crust of the earth is constantly tending northward. I ask, then, what mechanical alteration in the surface of the earth does such motion occasion ? You will observe that the earth being a sphere, the parts nearest to the poles are far smaller in circumference than those near the Equator. What, then, does this theory require us to believe ? Why, that this same identical thick crust of earth, which occupies now a certain space, is being perpetually crushed up together and put in a smaller space. For example, it requires us to believe that the land which stood in our latitude 6,000 years ago has passed on into a latitude 30 or 40 degrees further north, where it now occupies only one-half the surface it formerly occupied, since this motion is not only said to be taking place in England, but the whole surface of the globe is supposed to be thus tending northward. The theory involves, therefore, of necessity an enormous crushing together of the crust of the earth. (Hear, hear.) Is that a fact ? Let us take the change involved in our own latitude within a single year by way of example. I have made a rough calculation of what this would amount to, and find that the mere motion of a single year (if this theory be correct) involves a crushing of one mile and three quarters of the earth's surface into nothing—that is to say, in one year hence this solid crust of earth is to be

crushed together to such an extent that it shall occupy  $1\frac{3}{4}$  miles less surface than now ; and this is to be continued year by year at a continually accelerated rate, since the further north the land proceeds, the faster will be the crushing. I ask, then, what change do we see going on, or can we trace historically, which can, in the smallest degree, answer to this crushing of the earth's surface, which is such an essential element in Mr. Hopkins' theory ? Is there such a phenomenon ? Now, you will observe there are only two ways in which this action can take place. It must be either by a crumpling and crumbling of the earth's crust, throwing it up and down, or it must be by a bending of the surface, as to cause it to occupy a smaller horizontal area. The first method may be rejected at once as incredible. Concerning the second it is to be asked, What amount of bending would be required ? Suppose an extreme case, that by this bending the surface formerly horizontal was thrown into an angle of  $45^\circ$  ; this would only cause a diminution of about one-third in the original area occupied, and so, instead of  $1\frac{3}{4}$  miles, we should require 5 miles of the earth's surface in our latitude to be yearly thrown from a horizontal position into an angle of  $45^\circ$ , to account for the change. Now we are certain, from what we know of the amount of rising and sinking actually in progress, that there is no such oscillation of the earth's surface—no such bending and doubling of the surface going on at the present time, as will account for this perpetual diminution of the surface. This is not all, however. In the northern hemisphere, you have this crushing of the surface together, but in the southern hemisphere you must have just the reverse—a perpetual extension and spreading out. The land in the southern hemisphere is supposed to be constantly getting nearer to the Equator, and so covering a larger surface than before, which involves, of necessity, a cracking and pulling of itself out. Now, solid rock, of the depth of several miles, is not easily pulled or stretched out, any more than it is not easily bent about or crushed. But even if this could be done—if the land was so peculiarly ductile as, in fact, it is not, still you have only got through half the difficulty ; for I ask next, When the land has got to the North Pole, what becomes of it ? Here has been the whole crust of the earth, for the last 6,000 years, going to the North Pole. Where is it ? It has not formed itself into a great mountain at the North Pole. Where is it ? Observe this—it is not merely a crumpling up, or pulling out, year by year, of so many miles of the surface, but a pushing away of all the land that was there before. Mr. Hopkins refers, indeed, for analogy to the ocean ; but what do we find there ? True, there are enormous currents of water passing from south to north, but, then, there are also equally enormous return currents, and without these return currents the motion could not take place. There is no great store of water in the south from whence a supply may be sent to the north, neither is there any gigantic vessel or receptacle at the north for the water to run into ; the water, to circulate thus, must get back again, and it does so. The question is, then, can the land, in like manner, get back again ? Mr. Hopkins's theory plainly requires us to believe that it does. He says nothing of any accumulation of land at the North Pole, or

of any unfailling store of land at the South Pole to supply the place of the land moving northward. Yet, how is such a return current of land to be conceived? In the face of such difficulties; such a crumpling together of the land in the north; such a pulling out of the land in the south; such an utter lack of information as to where the land goes to, and from whence it comes: how, I ask, can we receive this theory of a spiral motion of the earth's crust? It is simply incredible, because of the mechanical difficulties necessarily involved, which mechanical difficulties would seem to have been altogether overlooked. Whoever, then, maintains this theory to be the true one, is bound to tell us how it is that the land coming from the south first occupies an immensely larger surface as it approaches the Equator, and then an immensely smaller one as it proceeds further north; what becomes of it when it reaches the North Pole, and whence it came from at the South; and, further, to give proof that such changes as these are, in fact, now taking place. It seems, then, that this idea of a spiral motion must be given up. Must we say, in consequence, that there is no motion in the surface of the earth to account for the observed astronomical changes? In making a hypothesis, we are bound to account for the facts of the case. Some motion there must be somewhere which accounts for these astronomical changes. What motion, we may ask, would account for this? If the whole surface of the earth were simply revolving round, not spirally towards the North Pole, but in a plane inclined to the Equator—that is, half towards the north-west and half towards the south-east—these changes of latitude and longitude would at once be accounted for, and this without any crushing together or pulling out of the land, or getting land from no one knows where; but to do this the motion must not be, as I say, a spiral one from south to north, but one of simple revolution in an inclined plane to the Equator. Such a motion will account for the facts of the case. Now observe, if we take this view, what follows. We have no longer a motion of the *whole* earth's surface to the north-west, but we have *half* the surface moving to the north-west, and *half* to the south-east; since, if the motion going on the whole way round, is of the nature of a revolution, each joint of the surface must eventually come back again to where it at first stood. It seems, therefore, that the only motion of the earth's crust which will account for this astronomical phenomenon (if in this way it can be accounted for) is a revolution of the entire crust, as of a hollow sphere, without crushing together and breaking, and that such motion must of necessity return upon itself. It is impossible to twist a revolving sphere in such a way that at last every point shall not return to its original place, that is always supposing you do not disturb the substance of the sphere itself. But if this is the case, how will it tally with the facts alleged as to changes of climates? Mr. Hopkins gives England as an example; and we can well suppose that England, moving in this way, was once in a much hotter climate than now—a tropical latitude, if you will. Then he takes another case, Greenland, and another, Australia. But it is simply impossible, on this view of the motion of the earth's crust, for all these three parts of the globe to have

been at the same time moving in a north-westerly direction. One or the other must have been moving in a south-easterly direction, since you cannot, by any art, make all three come within a single hemisphere ; and they cannot, therefore, on this view, have all been moving to the north-west. In one or other case, then, I do not in the least care which of the three, so far from these astronomical changes involving a change of climate which would account for the geological phenomena, they involve a change quite the other way. The theory does not then, even at its best, account for the facts of the case. Now to apply another and very different test. Hitherto I have been dealing with this subject on purely theoretical grounds ; now I want to come to the test of positive historical fact. I propose to test the worth of the theory by what we know of the ancient climate of Palestine, the land of which we have at once the earliest and the most authentic historical account. We know from the Scripture to a certain extent what the climate of Palestine was 3,400 years ago. Now, if Mr. Hopkins's theory is correct, if the land of Palestine has been moving at the regular rate of twenty seconds North Latitude, and fifty seconds West Longitude every year, then it follows that 3,400 years ago Palestine was not where it now is, but where Madras now is ;—that is, in the very heart of the tropics. If you look carefully to the evidence of the Pentateuch, you can prove to a certainty that there has been no alteration in elevation or general geographical situation in Palestine during the last 3,400 years ; you can prove that the sea-coast lay in the same place, that the mountains were of the same height, since the views seen from their summits then are the same as those to be seen now ; that the whole state of things, in fact, exactly corresponded with what we now see ; and we thus are not at liberty to assume any change of this kind to account for variation in climate. I ask, then, does Biblical evidence show us, that in the days of Moses Palestine was in the tropics ? Was the climate, then, such as it must have been if Mr. Hopkins's theory is true ? Let us look at the subject carefully. In the first place, we notice that the vegetation now observable in Palestine is identical with the vegetation mentioned in the Pentateuch. You have oak, the terebinth, &c., as the characteristic trees then just as now ; the palm, mentioned but seldom, and as found only in certain places, as in the Valley of Jordan, just as at present. In the same way, also, with regard to the zoology of Palestine, we know perfectly well—for it is one of the things we advance as proof that the Bible is authentic, that the plants and animals, the zoology and botany of the country at the present day are exactly those which the Bible describes. Is this credible, if a change of climate has taken place during the interval from the tropical climate of Madras ? But now, to bring this home to particular instances. It might be said, Ah, but these plants will grow also quite as well in the tropics. This is not the case ; some of them will not grow in the tropics ; and we have instances of such mentioned by Moses as growing in his days in Palestine. First of all, I will mention the olive. Humboldt says that the olive will not grow in the tropics. I suppose few men have studied more deeply the subject of the distribution of plants than Alexander Von Humboldt ; we may

well, therefore, take him as an authority. And he has laid this down, as the result of his researches, that the olive will not grow in the tropics. The land of Palestine and Egypt seems, indeed, to be the extreme southern limit in which the olive will grow. Now there is no doubt that the olive was one of the characteristic productions of Palestine. Moses describes it as "a land of figs, of pomegranates, and of oil-olives." There is thus no doubt that it was a characteristic production of Palestine in his days; yet this it could not have been, if Palestine was situated then where Madras is now. Then I take the case of wheat and barley. In the tropics, wheat and barley cannot be cultivated, because of the intense heat which dries them up before they have time to ripen. Look, for instance, at Johnston's "Physical Atlas," where he describes the different regions in which different cereals are grown, and you will find wheat and barley as the productions of the coast of the Mediterranean, Palestine, Greece, Italy, Spain, and the north of Africa. But the instant you get into the tropics you have not wheat, but rice. Now there is no mention of rice in Palestine, but there is of wheat and barley. Moses says it is "a land of wheat and barley," but of rice he says nothing. Wheat and barley, however, could not have been productions of the land if it experienced the same climate as Madras. Then again, we are told the wheat and barley will especially not flourish in hot climates if the land is flat and near the sea. Now, what were the characteristics of the grain districts of Palestine? Why, flat plains, and especially the flat plains of Philistia. Look at the history of Samson, and you find an allusion to this, where he tied firebrands to the tails of the jackals, and sent them into the standing *corn* of the Philistines. You see there the character of the place, standing corn growing on the land—land where it would be impossible for it to grow if Palestine had the same climate as Madras. But, further still, those persons who have been to Palestine, and examined most carefully its climate and productions, who are also most deeply conversant with the evidence of the Old Testament, tell us that so far from the evidence pointing to the climate of Palestine at the present day being colder than it was before, it tends the other way, that rather it was *colder* in the days of David and Moses than at the present time. And why? Why, because you find more mention of *snow* in the Old Testament than we should expect to have found from the present experience of the inhabitants. For instance, you have such an incident as that recorded in the days of David, where one of his mighty men went and slew a lion—on a snowy day. That is the very thing, the snow is referred to as a natural, common occurrence, and so is frequently introduced into the Psalms as an emblem of glory and purity. Now in the present day, snow is extremely scarce in Palestine, and therefore the probability is, that instead of a hotter, it had formerly a colder climate than at present. Let us take another step yet. Upon the ravines of the Lebanon there are plain marks of glaciers having once swept down them, and yet we are told that the climate formerly must have been enormously hotter than it is at the present day. Now when we test in this way, not by theory, but by taking a plain case

of real historical evidence, to show what the climate of a particular land really was three or four thousand years ago, it seems to me impossible to accept Mr. Hopkins's theory as true. I am not denying his facts, that the latitude and longitude, astronomically considered, have altered to the extent he says. I am looking at the matter from a purely practical point of view. Does that alteration of latitude involve a change of climate? and taking account of this instance of Palestine, I am compelled to conclude that it does not; for though the latitude may have altered astronomically, it has *not* caused a corresponding alteration of climate. What follows then? Granted that the latitude of Greenland, of England, of Australia have varied to the extent that he says they have, and I am quite prepared to admit it, still this does not involve what Mr. Hopkins would have us think it does,—the change of climate. The latitude has moved, but the climate we have no ground for thinking has thereby altered in the least. I am afraid I am taking up a great deal of your time (No, no), but I was interested in the matter, and have gone into it somewhat fully. Now just a few remarks on the subject of the time involved in Geological changes generally. What does history show us as to the period which has elapsed without any change in the surface of the globe having taken place? I take again the land of Palestine, or rather one remarkable portion of it, the Dead Sea. We can trace back the history of the Dead Sea to the days of Abraham. In what respect was the condition of the Dead Sea then different from what it is now? There were two differences and two only; First, the sea, we have strong reason to believe, did not extend to the same extent as at present, its southern part being probably dry land, on which stood the cities of Sodom, Gomorrha, &c. Then, second, the land was not then impregnated with salt, but was fruitful, well watered, and exceedingly fertile, like the land of Egypt, which could not be if it was impregnated with salt. Two changes have taken place, then; the water has risen slightly, and it has become salt. Both of these can be accounted for by one geological mutation, viz., the lifting up of the great salt mountain. There is no doubt that the great salt mountain has been lifted up, since you find surrounding it on all sides a deposit of marl, containing also a large quantity of gypsum, from twenty to sixty feet thick, which deposit is found also at the *top* of the salt mountain. The mountain is from 300 to 400 feet high, and the inference hence is, that its top stood originally at the same level with the surrounding marl, but that the mountain has been pushed up with the deposit on its top. The same thing is stated by Mr. Tristram to be observable in the salt mountains of the Sahara. This elevation of the salt will account for the rise of the water, because when salt is dissolved in water it swells its bulk; and here I do not hesitate to say, that if you could take the salt out of the Dead Sea, you would not only leave the southern lagoon entirely dry, but would also sink the water level of the northern basin several yards deeper. The elevation of the salt mountain is thus quite sufficient to account for all the changes in the Dead Sea district since the days of Abraham. Now what was the state of this ravine before the days of Abraham? What traces are

there of changes still earlier in date? changes, that is, which occurred more than 4,000 years ago. The next point of evidence is, that the whole ravine to a height of some 300 to 400 feet was filled with fresh water. How is that proved? Because you find remains of ancient beaches traceable the whole way round at uniform levels, varying in height from 30 to 200, 300, or even 400 feet. But how can we tell that the water then was fresh water? Because there are shells found in these beaches, and the shells are invariably fresh-water shells, shells of exactly the same species as are found to this day in the Jordan. I was doubtful on this point when reading Mr. Tristram's book, and being then working at the subject of the Dead Sea, I wrote and asked him if he had found any marine shells in these beaches, and he said in reply that there was not a trace of one, they were all recent fresh-water ones. Our next step back is then to show that the Dead Sea was neither a salt sea, nor a small sea, but an enormous fresh-water lake. The fresh-water lake was gradually dried up, not quickly nor uniformly, for it left marked beaches only at intervals, whereas had it dried up quickly, it would have left *débris* all over the shore. Allowing, then, time enough for the formation and slow drying up of the fresh-water lake, what comes before that? We have yet to account for the salt. The only way we can imagine such an enormous mass of rock salt to have been formed—the mountain is about eight miles long, half a mile wide, 300 to 400 feet high, and how deep no one knows—the only reasonable way is to suppose that an arm of the sea was shut in here, dried up, and left the salt. Now, when you have accounted for the rock salt, where are you? Still in the post-tertiary period; not a single geological formation proper has been touched. We started, then, in the days of Abraham, nearly 4,000 years ago, with a small, probably brackish sea, before which was a fresh-water lake, before that an arm of the sea, and still nothing but post-tertiary remains. How much time have we to dispose of for these changes? From Abraham to the Deluge is about 360 years. I ask, then, is it credible, when 4,000 years have done next to nothing, we should suppose that the previous 360 did so much? More than this 360 years we cannot allow, if the current view of the Deluge be true, since if the sea swept across this district at the time of the Deluge, all traces of a preceding fresh-water lake must have been destroyed, and we are thus obliged to suppose that the lake, at all events, was formed and dried up within 360 years of the Deluge. But I am not sure even of all that 360 years, for I have started from the point when I *know* the cities of Sodom, &c., were standing; how long they had been so, I do not know; they may have stood for a considerable part of the 360 years. I say, again, is it credible that such enormous changes should have taken place in so short an interval, when the last 4,000 years have done so little? Beyond the Deluge we have but 1,600 years to the Creation; to which period, therefore, must the whole of the geological formations be referred, if such views as Mr. Hopkins's are to be maintained. I think that is a strong case of what history can tell us as to geological changes, and I cannot but wish simple facts like these were more looked to, before

theories are propounded as to the time probably consumed in such changes taking place.

REV. WALTER MITCHELL.—It is, perhaps, a pity that some notes for discussion which Mr. Hopkins has sent us were not read previously to Mr. Warington's remarks. I think they contain some facts bearing upon the paper which will meet some of the objections of Mr. Warington. I shall now read them:—

"TERRESTRIAL SUPERFICIAL CHANGES.—The late M. Arago, the French astronomer, in a very elaborate paper brought forward innumerable proofs that the *northern limits* of the growth of the best wine-grapes in France and other places on the Continent were gradually retrograding southward. Many places where, a few centuries ago, grapes of superior quality grew in abundance, are no longer capable of producing ripe grapes."

"Since the discovery of America, and the cultivation of the sugar-cane and tobacco by the Europeans, the northern limits of the growth of these products have very considerably retrograded southward, according to observations made in the United States."

"THE ARCTIC REGION.—*Extracts from the Journals of Arctic Explorers.*—The Gulf Stream renders the sea between Spitzbergen and Nova Zembla comparatively warm and free from ice. The coasts of Spitzbergen contain large quantities of drift-wood from all climates."

"*Bottle-records* conveyed by the Gulf Stream to the Arctic Sea have proved that they never return, but are generally thrown on some of the islands or coasts of the Polar Sea."

"SURVEYS OF LANDS, COASTS, &c., &c.—The configuration of coasts is subject to such changes as to necessitate the employment of a staff of naval officers more or less constantly, to ensure the safety of navigation. The coast of Australia is different from what it was in the time of Cook and Flinders. Even our local trigonometrical surveys are not completed before the first maps require some correction and revision."

I may say here, partially in defence of Mr. Hopkins, that whatever we may have to say with regard to the theory he has brought forward, we cannot but thank him for the immense mass of facts he has adduced—facts of the greatest possible importance in coming to any decision upon such an important question. His theory may be faulty in many respects, but as these motions have been observed for so few years comparatively, (that is, the smaller motions, some of the most important,) we do not know whether they do occur at any regular rate or not, and it would require many years probably of careful observation before that rate is fully determined. I should not altogether, perhaps, myself be inclined to agree with Mr. Hopkins in one portion of his theory, namely, the gradual spiral movement of the earth from the South Pole up to the North Pole, and then the dipping down of the earth through the earth's axis. That is the way in which he accounts for his theory, and I think that escaped Mr. Warington—

MR. WARINGTON.—I looked for it, and could not see it.

REV. W. MITCHELL.—He says, "The globe, with all its elements, might have existed from eternity. The ocean and the lands emerging from the Antarctic Pole merge again into the Arctic Pole, and thus circulate from Pole to Pole through the medium of the earth's axis." This he gives as a

purely hypothetical thing, he does not quote his previous facts in proof of this movement, because he says, "This question," that is, such an hypothesis as this, "I conceive to be beyond the reach of demonstrable science," but he pledges himself to the spiral movement of the earth. But a great deal of the crushing Mr. Warrington has described, we do find demonstrated wherever we go in northern latitudes. If, for instance, we observe the contorted rock strata of slate, no one can look at such twisted and contorted strata—which at one time have necessarily, from the formation of the strata, been horizontal—and see them crumpled up as you would crumple layers of paper, without being aware there is some terrific force in existence, and doing this somewhere in the earth. None of the popular geological theories give us the slightest theory to account for such crumpling as this, nor the manner in which successive masses of earth are broken and laid one over the other. If I assume the present phase of Geology, and take the popular theory of Sir Charles Lyell that the earth has always been going on as it is now, and that we have merely certain subsidences and upheavals; how are we to account for the great distinction that there is in the successive fauna which present themselves when we take the strata of one layer, and find it covered by another layer and other strata? The other popular theory, scarcely yet gone out of the text-books, was this,—that these fauna belonged to one creation and then they were covered by the fauna belonging to another creation, and that followed by a third creation. And what stopped that hypothesis? Why, the discovery that there was a certain percentage of the fauna of these lower creations intruding upon the upper, and a certain percentage of the fauna of each creation intruding itself upon the other fauna. Now, according to all these old hypotheses, without some power bringing the fauna of one zone over the top of another and a third over that, we want some such theory as Mr. Hopkins supplies, if we are now to believe that all these three fauna were not fauna of distinct creations, but might have been co-existent on the earth at the same time. To take an example from known facts, we find that owing to the course of the Gulf Stream upon one portion of our coast, or of the coast of Europe, we may have an African fauna, and within a few miles of that a northern fauna, brought by the return of the Gulf Stream. I say that according to all our present modes of reading the Palæontological records of the earth, that as regards these places within a few miles of one another, if the mass of earth from one part could be carried and deposited on the earth a few miles north of it, we should have all these phenomena of certain percentages of fauna intruding as it were from certain strata into others, and we should have very much in point of fact what we do find displayed in the various superincumbent strata of the earth. It may be said that this could not have been done within the limits of the time assumed, and that Mr. Hopkins has made a great mistake in his calculations. A want in Mr. Hopkins's paper has been supplied by Mr. Warrington's objection. The crumpling up, as it were, of one stratum on another is just what is found to be a fact. It must also be remembered that you could have a motion of the globe moving freely over itself; and that the theory (I think it is Sir Henry James's) of the present solid crust of the

earth, as it were, moving slowly over an envelope, would account for almost all the motions in question. If you put one globe over another, you could, without having this dipping down of the actual earth through the medium of the axis, and circulation from pole to pole, account in a great measure for the changes which are mentioned by Mr. Hopkins, without that great crushing and crumpling which Mr. Warington has pointed out must take place if 10 or 12 miles are squeezed into nothing, owing to the difference of area and surface at the Polar regions. But there would be crushing owing to another cause. There would be no crushing if the earth was a sphere; but if a prolate or oblate spheroid you would have a great deal of crushing. Now, with regard to what Mr. Warington has stated respecting the Holy Land, I do not think he has made out so strong a case against Mr. Hopkins's hypotheses, as at first sight may seem. The temperature of any place on the earth's surface, I believe, depends upon two things; it depends upon the height above the level of the sea, as well as the latitude and longitude. It also depends on such causes as the Gulf Stream and proximity to the coast, so that there are many things which modify the effect of latitude. Isothermal lines are very different lines even for places at the same height on the earth's surface; they are irregular in their character and very different from the lines of latitude, so that we cannot always calculate the heat of a country by merely knowing the latitude and longitude. (Hear, hear.) Again, height has a very considerable influence. We know that in the Himalayas you may, within an hour or two's journey, pass from all the tropical plants up to those almost of Siberian character. The same can be done in the Andes. You may in the morning breakfast amid sugar-canes, in a tropical climate, and in the region of rice. A few hours may transfer you into the region of the grape and wheat, and you may go on until you actually come into the frozen regions. Now I think Mr. Warington has pointed out that there has been not altogether a fixed climate in the Holy Land, but that a considerable change has taken place. Unfortunately the change is not what Mr. Hopkins would have, because it has been a change rather from cold to heat. But there is another thing which might account for that. Has there been any very great depression of this country? Well, I do not think that in the Biblical times there were any accurate trigonometrical surveys, or astronomical data, but I think Mr. Warington differs slightly from Mr. Tristram in one particular. I think he considers that the greater portion of the Dead Sea has been formed since the days of Abraham, or since the destruction of the cities of the plain—

Mr. WARINGTON.—About one-third. But I do not think Mr. Tristram holds that opinion.

Rev. W. MITCHELL.—Now, there is something remarkable about the position of the Dead Sea. I suppose it is about the most depressed part of the earth's surface. I think the rapid trigonometrical observations were made and taken under extreme difficulty by Lieutenant Lynch and the American surveying party (but I think their conclusions have been verified and carried out by the survey of our own engineers); and what have they

taught us? What fact have they brought to light? The fact that the Valley of the Jordan, at least the greater part of it, and certainly the Dead Sea, is very considerably below the level of the Mediterranean. How many feet is it, Mr. Warington?

Mr. WARINGTON.—1,300 feet.

Rev. W. MITCHELL.—The level of the Dead Sea is 1,300 feet, as Mr. Warington admits, below the level of the Mediterranean. Now, I do not think that we have any positive record of the existence of this Dead Sea before the time of Abraham. I know some would maintain that the Bible gives no exact statement that the Dead Sea occupies the position of the cities of the plain; but there is a generally received tradition that the Dead Sea owes its formation to the destruction of those cities, and I believe that universal traditions are generally founded upon fact. (Hear, hear.) Now, if the Dead Sea does owe its formation to the overthrow of the cities of the plain, who can tell us at what rate that enormous depression, of 1,300 feet below the level of the Mediterranean, was taking place? It may have been a slow, or it may have been a rapid rate, and it may have been slow enough to account for all these beaches of marl and fresh-water shells, all the products of the Jordan—

Mr. WARINGTON.—They are all above the level of the old cities to the extent of 200 feet.

Rev. W. MITCHELL.—There I join issue with Mr. Warington, and I say no one knows the site of the old cities—

Mr. WARINGTON.—They were in the plain, and not on the mountains.

Rev. W. MITCHELL.—What plain? The plain described by Mr. Warington just now as a fertile plain; not a salt or barren plain, but a well-watered plain; a country to be envied; one that Lot chose when he went and resided in the cities of the plain, because it was a fertile country, a goodly country, a country that Abraham allowed his nephew, Lot, to take, as it appeared to be the better portion. But what changes have taken place there since! Whence this withered country—this awful sea, for it is an awful sea? If any one would acquire an idea of the awful character of this sea, let him read Lynch's account of it, who measured its depth—who plumbed it—who was, day by day, exposed to the fierce, burning sun, and to the smarting sensation of the salt vapours, and the sulphurous fumes, and all the other deadly emanations of this sea—who felt that he was in a "cursed land"—who tells you that no one could stay as he stayed there, without feeling that this was the kind of land that you would say, as it were, God's breath had blasted for some fearful crime! I think these are the words of Lynch, or something like them (I do not profess to quote his words accurately), but I know he does say that that is the place to which he would bring the infidel and the scoffer who would doubt the truths of Scripture. But what I want to point out is, that we must have had great changes going on, if these cities of the plain are to be sought underneath the Dead Sea. If that depression is still going on, is there no corresponding depression of the other parts of the country, and might not that be sufficient to account for the change of the climate from cold to heat—viz., being depressed and

coming down to a lower level? I only mention these things to show that we are not, on this ground, at liberty altogether to reject the facts, and many of the deductions that Mr. Hopkins has made from them. There are some other points:—for instance, Mr. Warrington has asked, with some degree of triumph, how we are to account for a still greater degree of heat in the Holy Land, if glaciers have cut their way through the ravines of the Lebanon, and marked their course in these ravines? In the first place, I might say that considerable doubt has been felt as to these glacial markings in many places; but, even supposing we admit them, we have one portion of Mr. Hopkins's paper bearing the test of history, for Mr. Warrington very properly says we should have history to test these things. Well, history has given us the change of the climate of Greenland. (Hear, hear.) Is it *Green-land* now? Has it any pretension to the name of Greenland? Would any voyager now call it Greenland, or would he not call it White-land, an ice-bound land? But there are other matters to be taken into consideration with regard to this. I am one of those who do believe in a universal deluge; and a universal deluge could not have taken place without a very considerable change of the whole earth's surface, and without leaving very considerable marks on the surface. And the reason, I think, why the popular theorists in geology of the present day do not find the same marks of the deluge that a Cuvier could find, is because they look only for superficial marks, instead of looking for great and gigantic marks. (Hear, hear.) I have heard of another theory of deluges. There is the theory of *Adhammer*; and, though I am not going so far as Adhammer does—namely, to a succession of deluges, one after another—certain I am of this, that Adhammer, both with the acumen of a good geologist, and of a sound physical and mathematical observer, has shown the manner in which a deluge could have taken place—a deluge which would have swept the whole of the newly-formed earth with gigantic masses of ice. I know no other theory which will account, in the slightest degree, for “the glacial period” hypothesis. (Hear, hear.) I know no theory which has ever been propounded to account for the glacial period, which can at all compete with Adhammer's theory—I won't say of deluges, but of one deluge; and, perhaps, the time may come, when science advances far enough, when we shall have patiently accumulated a sufficient number of facts to account for all the paradoxes which we do meet with in the phenomena which geology has given us. We have not only to account for the palm flourishing in this country, and for its having once enjoyed a tropical climate, but we have to account for mountains of ice floating over the country from one end to the other, and I believe that, without extended periods of millions upon millions of years, Mr. Hopkins has, at any rate, sketched out for us a sufficient number of facts to cause us to suspend our judgment before we accept these very great and lengthened periods of time to account for things which may, perchance, (we will only say “may, perchance,”) be included within the limit of some six or seven thousand years, instead of millions and billions of ages.

Mr. WARRINGTON.—Might I add two words in support of my view, that the Dead Sea stands in the same place as in the days of Abraham? I should

have mentioned it at starting. It is this. We are told in two places in the book of Genesis of Abraham going to look at the Valley of the Jordan: once at Bethel, and again he goes out of Mamre to some other place on the road towards the cities of Sodom, and obtains a view of the cities. These two identical places remain at the present day; the two places from which the Valley of the Jordan and the site of Sodom can be seen. A man residing in Hebron would have to go to identically the same spot to get the first sight of the Valley of the Cities of the Plain. It seems that is a forcible ground for believing that the level was the same as in the days of Abraham.

Rev. WALTER MITCHELL.—I do not see that at all. I admit the fact Mr. Warrington states, but I do not draw his conclusions. He does not show that the sea existed before the time of Abraham, nor meet the question I have supposed, of a change of the whole mass of the country, because there might have been a total depression of the country; but you might have all that depression of the Dead Sea, and yet still Abraham might have looked over the mountains in the same direction, and towards the direction of where the plain sunk. I believe there has been a gradual sinking there, and that alone would account for the change.

Captain FISHBOURNE.—I observe that Mr. Hopkins does not dwell upon the question of alterations of climate, except as to facts. He merely gives them, as far as they go, to prove other facts, to substantiate other facts. He is equally aware, as Mr. Mitchell, that various circumstances will alter the climate. Mr. Warrington admits the fact that there has been an alteration of latitude—the facts he cannot deny. Now, going to Egypt, there is a very distinct alteration with respect to the Pyramids. They have been moved in their position, and astronomical observations distinctly mark a change. But for a still more recent instance, let us go to the other side of the world. In Philadelphia the streets were laid out north, south, east, and west, but they are now changed, though it is only a very short period since the city of Philadelphia was founded. Again, with respect to the sites of churches, the sites of old churches were generally laid east and west, but now they are found to have changed; and how are these things accounted for? It is evident there is some cause, some power, which has produced these changes. What is the cause? It may not be magnetism, as suggested by Mr. Hopkins; there may be something more. It has been suggested, just as the tides are acted on by the sun and moon, and because the water is mobile and the earth is not, that the tides oscillate backwards and forwards, whereas only portions of the earth oscillate. The whole earth moves, but in proportion and degree as it is mobile, and not all at the same rate. There may be chains of mountains not subject to the same forces, but which do not move until considerable pressure has taken place, and then move by convulsion—for instance, the Cordilleras were moved by one action. Geologists say this is a volcanic operation, but mechanical philosophers say, “No, it is a mechanical operation of the attraction of the sun and moon.” We know the formation of the earth, the diameter at the Equator is twenty-six miles greater than the polar axis. Well, the supposition is, that this mass is in motion, and that may be produced by the

magnetism which Mr. Hopkins supposes is the cause. But magnetism may not be the cause, but the result, of the operation. It is tolerably clear that there has been a motion in the crust of the earth—that is undeniable; and what Mr. Warington has said with respect to Syria is rather the exception to the rule, and may be accounted for just as Mr. Mitchell has been explaining.

MR. REDDIE.—It is somewhat unfortunate, my lord, that Mr. Hopkins, the author of the paper read this evening, has not been able to be present himself to defend it. But I may venture to say this, that I am sure he will be extremely obliged to Mr. Warington for his valuable criticisms. It was never intended that this paper should be accepted here, as absolutely solving the great difficulties that there unquestionably are as regards what is called “the precession of the equinoxes,” whether we endeavour to account for them by the motion of the earth’s axis, or the motion of the whole crust of the earth. I am afraid Captain Fishbourne was assuming the point at issue in taking for granted that the apparent alteration in the position of the streets of Philadelphia, and in the orientation of churches, must be caused solely by the motion of the crust of the earth. It would be equally explained by what astronomers have given as the cause—(at least, if I cannot say *equally* explained, I may say that it would be approximately so explained); but then what Mr. Hopkins rests upon, in favour of his view as against the astronomical one, is the existence of those other facts which do appear to afford the proofs of a change of climate having taken place in different parts of the earth, and which Mr. Warington has entirely passed over. Of course it was no part of Mr. Warington’s duty to meet the other side of the case, so to speak; but at the same time, we must not forget that he did only meet one side of it. He did not account for the remains of tropical plants and animals found in Portland and Sheppey, and in the present latitude of London; and he took no notice of the change of climate in Greenland, as Mr. Mitchell has pointed out. Mr. Hopkins, however, will no doubt himself reply to the most important parts of Mr. Warington’s criticisms, especially as regards the exact degree of obliquity of this supposed motion. I believe there has been a slight misunderstanding about it, but nothing that Mr. Hopkins will not either satisfactorily explain, or admit to be unaccounted for. We now come to consider those parts of Mr. Warington’s observations which, as it were, lie within themselves, or the supposed mechanical difficulties of the theory. I scarcely think he has quite established that these difficulties which were to him so great, as to this necessary crumpling and crushing, are any objection to the hypothesis now advanced. Because the obvious result of such crushing would be the raising up of the earth’s crust at one place and its depression at another, and these Mr. Warington will not deny to be geological facts; for even when we go to Palestine he tells us of an upheaval there. Now, Mr. Warington is quite right, that if the earth is being twisted round, and a larger quantity of its solid crust is compressed into a smaller space, there will be this crushing; but what, on the other hand, will there be if the mountains are upheaved by expanding the surface of the globe? Would there not then be a riving asunder, an opening of the earth’s crust, which is not the fact? It appears to

me, these upheavals and depressions *without* forming gaps in the earth's crust are just the very difficulties in geology that Mr. Hopkins's paper tends to solve. Geological authorities now admit that mere upheaval and depression do not account for the phenomena. In Professor Ramsay's inaugural address to the Geological Section of the British Association he says :—

“In the Alps we find areas half as large as an English county, in which a whole series of formations has been turned upside down. But by what means were *masses of strata many thousands of feet thick bent and contorted, and raised into the air*, so as to produce such results, and thus affording matter for the elements to work upon? Not by igneous or other pressure and upheaval from below, for that would *stretch* instead of *crumpling* the strata in the manner in which we find them, in great mountain-chains like the Alps, or in less disturbed groups like those of the Highlands, Wales, and Cumberland, which are only fragments of older mountain-ranges.”

Now, if we regard the earth's crust as a whole, comprising its hills and vales,—and in these vales I especially include the great beds of the ocean,—it does not form one rigid smooth plain; and even supposing it to be crushed together or compressed into smaller space, if we consider that it is not level, but formed of materials unequal both in their constitution as regards stiffness and pliability, and also in elevation and depression, the result would be that mountains would be raised higher, while at other places there would be depressions, by means of that very compression. I do not say that this would be the result universally, for we must further consider the slowness of this motion, and the waste of solid material that also takes place in various ways; as, for instance, from the very atmosphere crumbling down even the hardest granite rocks, and from igneous action below; for although we do not hold, I suppose, now, with the igneous theory that we were taught to believe for a long time, still we know there is burning going on below some parts of the earth, and a certain amount of solid material is thus disposed of. And even this internal heat, it seems, might be the result of this crushing and jamming together that Mr. Warrington finds so difficult to understand. At all events, this subterranean combustion, and the throwing out of materials from below, will make room for the fresh material, to be jammed and crushed together. Of course we know that this paper now puts before a scientific meeting, I think for the first time, a series of views perfectly heretical in geology, and perfectly new, though the facts on which they are based are pretty well known to all; and in my opinion Mr. Hopkins has put forward his hypothesis to account for them very fairly. He has worked at it for many years, and has endeavoured to gain the ear of the public by means of his very valuable work on *Terrestrial Magnetism and Geology*; and we know that Professor Kirk, when at our request he was kind enough to give us a review of the whole theories of geology, was driven, to a certain extent, to the acceptance of Mr. Hopkins's views, as affording the best explanation of those facts, which neither the igneous nor the aqueous theories, nor the upheavals and subsidences of other theorists, could properly account for. Now, that being the case, at least it is of great consequence that this theory

should be fully discussed, and certainly of the greatest advantage to it that it should be as severely criticised as possible. No one can have any interest in accepting what will not stand criticism; and I have no doubt whatever, that as regards anything requiring a reply in what Mr. Warington has advanced, Mr. Hopkins will be prepared with that reply, or if not, he will acknowledge that Mr. Warington has so far refuted his propositions.

The Meeting was then adjourned.

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### REPLY BY MR. HOPKINS.

I much regret that a severe illness prevented me from attending the meeting to enable me to reply personally to Mr. Warington's remarks on my paper. I trust, however, that the following observations will suffice to clear up some of the obscurities referred to, and also to remove the misapprehensions under which Mr. Warington appears to be labouring. I was somewhat surprised at Mr. Warington's difficulty in commencing his observations. He could not see how a right-angled triangle having an angle of  $23\frac{1}{2}^{\circ}$  between the hypotenuse and base, would give a ratio of 50 for the hypotenuse to 20 for the perpendicular. I hope he has since seen that this is correct, as it can be easily proved to be so, and I consider it therefore unnecessary to take further notice of it. In discussing the arguments brought forward in the paper, to prove that the surface of the globe has a motion which shifts the lands from south to north, it is necessary that we should keep our minds entirely free from all preconceived ideas, and restrict our thoughts to the observed conditions or ascertained facts. Now, in examining the lands, we have discovered two primary facts:— 1stly, that the lands are subject to constant changes; and 2ndly, astronomical observations have proved that there is an annual change in a given direction equal to  $50'$ . During the last 2,140 years Alexandria has moved  $30^{\circ}$  towards the N.W., and has advanced in the same time  $12^{\circ}$  in latitude north. This is the total amount of the movement founded on actual observations. As this movement is found to be constantly going on at the same rate and the same direction, we may naturally conclude that it has been going on since the days of the creation. Such a superficial movement cannot take place without changing the latitudes and the climates of the shifting lands. Mr. Warington admits the fact "that the latitude had altered to the extent stated;" but he endeavours to maintain "that the alteration of latitude does not involve a change of climate." Mr. Warington remarks, "Granted that the latitudes of Greenland, of England, of Australia, have varied to the extent that he (Mr. Hopkins) says they have, and I am quite prepared to admit it; still this does not involve the change of climate. The latitude has moved, but the climate, we have no ground for

thinking, was thereby altered in the least." Such an opinion is certainly extraordinary, as it is well known that the climate of countries depends more or less at corresponding elevations on the latitudes, and we have most incontrovertible evidence of the changes which have taken place in Greenland and England as well as in other places. The Icelandic chronicles not only refer to former productions of that island, to forests of birch and fir, and the cultivation of barley and other grain, but also to the forests and the inhabitants of Greenland prior to the Norwegian emigration, and mention the name of a warm and fertile valley (Kirkinbui) near the southern coast. About 1,400 years ago there was a country called Vinland, within a few days' sail of Greenland, watered with rivers yielding abundance of fine salmon, on the banks of which were trees loaded with agreeable fruits, the temperature pleasant, and the soil fertile. Large stumps of the trees of the forests are still seen in Greenland.

The monasteries in the south of Denmark, in the thirteenth century, were confirmed by the papal rescripts in their possession of vineyards. Various documents of the 12th and 13th centuries testify that the wine-grape was grown at that time in the south of England, as was also the case in the north-west part of France (Brittany and Normandy), where it is not cultivated now any more than in England. The climate has become colder, and in this way the vineyards of north-western France and England have vanished, the limit of the vine being driven further south. In the east of Germany the vine-limit was further north formerly, beyond the districts which are now in the parallel of 53°. Mr. Warrington does not appear to be aware of these changes, and he ignores the geological facts altogether. He refers to Palestine, and attempts to sustain his views by reference to the botany and zoology of that country, which he positively maintains are now the same as they were of yore. Let us test the correctness of his arguments by the records :—

Mr. Warrington asks, "Does Biblical evidence show us, that in the days of Moses Palestine was in the tropics?" "The vegetation now observable in Palestine is identical with the vegetation mentioned in the Pentateuch. You have the oak, the terebinth, &c., as the characteristic trees then, just as now; the palm mentioned but seldom, and as found only in certain places, as in the valley of the Jordan, just as at present. In the same way, also, with regard to the zoology of Palestine, we know perfectly well that the plants and animals, the zoology, and botany of the country at the present day are exactly those which the Bible describes." I shall now endeavour to satisfy Mr. Warrington on these points, and would draw his attention to the accounts of former tropical productions in Palestine, such as groves of palm-trees and cedar-trees, as well as the balsam; also to the lions, leopards, &c., referred to in the Scriptures. Before, however, I enter into the question connected with the botany and the zoology of the country, I think it necessary to give a general idea of the configuration of the surface. The physical character of Palestine, like that of Ceylon, renders it capable of producing and nourishing all the organic productions of the world. In no other districts of similar

size, with the exception of Ceylon and some parts of the Andes, could the typical flora and fauna of so many distinct regions and zones be brought into such close juxta-position as in Palestine. It contains four regions distinguished by difference of climate, and necessarily different productions. 1st. In the lowest depression along the valley of the Jordan the temperature is from  $70^{\circ}$  to  $80^{\circ}$ . 2ndly. On the plains 500 feet high the temperature varies from  $65^{\circ}$  to  $70^{\circ}$ . 3rdly. On the table-lands, from 2,000 to 3,000 feet high, the temperature is from  $55^{\circ}$  to  $63^{\circ}$ . 4thly. On the mountains of the Lebanon, from 4,000 to 10,000 feet high, the average temperature is about  $35^{\circ}$ . Hence it will be observed the country must have been capable of producing all the productions of the world, from the tropics to the Alpine regions. The Lebanon ranges are never free from snow. These mountains were over-shadowed with fir and oak trees, and in the valleys below grew magnificent cedars, the latter being tropical trees. The ostrich approached the southern borders. Animals of different climes met in Palestine; but the lions, leopards and panthers have long since disappeared. The lion is a tropical animal. Formerly lions infested Samaria, and frequently attacked the inhabitants. Mr. Warrington refers to the killing of a lion in the snow, but seems to forget that the lion was a tropical animal. The palm-tree is a very characteristic tropical plant, and is much esteemed for its various productions. Now, the palm-tree and the balsam-tree were two peculiar trees of Judea. The groves of palms were tall and beautiful, and abounded in Judea. Jericho was also celebrated for its palm groves, so that it was termed "the city of palm-trees." Even Bethany was called "the house of dates." At the time of our Saviour there were palm-trees near Jerusalem, as we are told in the Gospel of St. John: "The people took branches of palms, and went forth to meet him." Such a rich display of palm-trees is only seen under a tropical sun. The palm groves have long disappeared from Palestine. The vineyards of Palestine at the present time are not very remarkable for their products. In the days of Moses the vines in the valleys were very prolific, producing several crops of ripe grapes during the year. These continuous crops can only be obtained under a tropical sun. "Be ye of good courage, and bring of the fruit of the land. Now the time was the time of the *first* ripe grapes. And they came into the brook of Eschol, and cut down from thence a branch with one cluster of grapes, and they bore it between two upon a staff." "As to the ripe fruit, let them carry that which is *ripe first of all* into the temple." In the tropics several crops of ripe grapes are obtained from the same vine within the year. The country bordering the lake of Gennesareth was formerly very remarkable for its varied productions. Josephus states "there are palm-trees also, which grow best in hot air; fig-trees also and olives grow near them. One may call this place the ambition of nature: it is a happy contention of the seasons, as if every one of these plants laid claim to this country. It not only nourishes different sorts of autumnal fruit beyond men's expectation, but preserves them a great while; it supplies men with the principal fruits, with grapes and figs *continually during ten months of the year*, and

the rest of the fruits as they become ripe together, through the whole of the year." Such perpetual productiveness almost throughout the year is only obtainable under a tropical sun—never in temperate zones. Within the tropics *blossoms* and *ripe fruits* are commonly seen on the same trees, and are very conspicuous on orange and lemon trees. Galilee, Samaria, and Judea had a rich and fruitful soil, full of trees of all sorts—the olive, the vine, and the palm-tree. "They have abundance of fruit trees, and are full of fruit, both that which grows wild, and that which is the effect of cultivation." "Take," said Jacob, "of the best fruits in the land and carry down a present, a little balm, and spices, with myrrh, nuts, and almonds." Where but within the tropics could we see these productions and such a prolific scene in the open air? "For the land, whither thou goest, is not as the land of Egypt, from whence ye came out, where thou sowedst thy seed, and wateredst it with thy foot as a garden of herbs: but the land, whither ye go to possess it, is a land of hills and valleys, and drinketh water of the rain of heaven: a land which the Lord thy God careth for." "I will give you the rain of your land in his due season, the first rain and the latter rain, that thou mayest gather in thy corn, and thy wine, and thine oil. And I will send grass in thy fields for thy cattle, that thou mayest eat and be full." "It is a land that floweth with milk and honey."—Deut. xi. The two wet seasons are peculiarly tropical. In the temperate zones we have summer and winter; in the tropics, wet and dry seasons. The former climate of Palestine must have been somewhat analogous to that of the southern part of Arabia bordering the Red Sea, such as we now find it at Medina, Mecca, and at Aden, where sweet spices, balm, and myrrh still grow. In the days of Alexander the Great, frankincense and myrrh were produced near Gaza. Mr. Warrington asserts that "wheat and olive will *not grow in the tropics*." I beg to state that he has been misled as regards these productions, as well as on various other points. I have grown in the very tropical country which Humboldt visited, and within 5° of the equator, grapes, pomegranates, figs, olives, oranges, coffee, pine-apples, corn, &c. I have seen the same variety of productions in Ceylon, Penang, Singapore, &c. In New Granada, on the plains of Bogota, within 4° of the equator, wheat and barley are cultivated in large quantities. Wheat can be produced at 3,000 feet high. In Egypt it is grown at a low elevation during the winter, though not in the hot weather. I hope Mr. Warrington will excuse me from referring to the arguments founded on what may be gathered from "Johnson's Physical Atlas," as they must have originated from a misconception, in connection with the configuration of the surface of the earth, and the general data intended to explain why certain products are more cultivated for commercial purposes in some places than in others in similar climates. It may be thought strange that not only wheat, but *flax*, should thrive in the hot and tropical part of Egypt at low elevations, as well as in the cold regions of Russia as far as 64° lat. N. In Egypt flax (as well as wheat) is sown in December, in the fields just quitted by the waters of the Nile, and it is harvested in April before the hot weather sets in. In Russia, it is sown in

April, and harvested in September. The mountains of Ararat are now situated in latitude of about  $40^{\circ}$ , and are more or less covered with perpetual snow. At the time of the Flood they were in latitude  $16^{\circ}$ , in a warmer climate and suitable to receive Noah's live stock to replenish the earth—the tropical as well as other animals ; and fit for the subsequent growth of the vineyards which supplied Noah and his family with wine. The country in which Nineveh, as well as Babylon, was situated had formerly its palm-trees, as delineated in the ancient carved marbles. It also had its wild beasts—lions, leopards, &c. ; thus indicating that all that region at the time of the Flood was within the tropics. I was very much struck with the general aspect of the country, from the Nile to Arabia, when I first saw it. The scene presented nothing but an interminable, parched, barren desert, with clouds of sand, from Cairo to Suez. The mountains of Horeb and Sinai appeared as burnt ferruginous rocks without a blade of grass to be seen anywhere—a scene of complete barrenness and desolation. It looked as if it was a land first risen from the deep, as it had but a few patches of marine deposits, from the Nile to Palestine and Arabia, with the exception of some calcareous beds. In almost all other parts of the world in both hemispheres the lands are more or less covered with various sedimentary deposits, and many of these are comparatively recent, as if they had been subject to many undulations, rising and sinking from the level of the sea ; but here, in Egypt, Syria, and Arabia, there are no such indications. This part of the world, after having first risen from the deep to receive and sustain the primeval plants and animals at the creation, remained apparently above water until it was overwhelmed and scoured by the flood. Other parts of the world subsequently rose from the deep preparatory to the dispersion of the human race, and the old primeval antediluvian land reappeared as a rocky, barren waste. The upheaval and subsidence of the level of the Red Sea to Syria do not appear to have been very great during the historical period. The coast from Tyre to Sidon, on the shores of the Mediterranean, has risen several feet. The changes in the South at Suez and the eastern arm of the Red Sea have been principally produced by blown sands and gravel from the desert. At the time of Herodotus the Red Sea extended to Heliopolis. The ruins of that city are now situated inland half way between Suez and the Mediterranean. Suez in 1541 received into its harbour the fleet of Solyman II., but it is now changed into a sandbank, and the passage further north has been filled up with sand blown from the desert. On the opposite Arabian side many of the inland ancient towns (now in ruins) were, since the Christian era, on the sea shore. The blown sand and the rapid growth of the corals have encroached on the sea. The eastern valley, between the Dead Sea and the Red Sea, in like manner, has been gradually filling up with sand.

At the time of Herodotus, the sun in summer—that is, in the month of June—passed over the Mediterranean, and retired in winter to Libya (or Central Africa). “During the winter months,” he says, “the sun, passing over the upper parts of Libya, produces the following effect :—As the air in these regions is always serene, and the soil is always hot, he produces the

same effect as he usually does in the summer, when he passes through the middle of the firmament [that is, the zenith of the historian]; for he attracts the water [the Mediterranean] to himself, and, having attracted it, throws it back again [? as rain] upon the higher regions of Libya." Anciently, when the Delta was within the boundary of the tropics, the hippopotamus was found in the Lower Nile, where he was hunted. Now, this animal is rarely seen, even in Lower Nubia, within the northern limits of the tropics. Large crocodiles were common in the Nile, but now we only see occasionally a few small ones even in Cairo. We have to ascend to the cataracts within the tropics before we meet with large crocodiles.

Hipparchus was the most eminent of the ancient Greek astronomers. After studying at Alexandria, he continued his astronomical observations at Rhodes 34 years. He first discovered the phenomenon called the "precession of the equinoxes;" he catalogued the fixed stars, and laid the foundation for a correct system of astronomical computations. At that period, the northern limit of the tropic extended to Rhodes: hence "the sun in June passed through the middle of the firmament." Ptolemy's physical system of astronomy was introduced by Hipparchus. To show how little the theories of astronomy have to do with the astronomical computations, on which alone the science rests, he was able to calculate the period of the eclipses, the mean period of the planets' revolutions, and, in fact, all the observed celestial phenomena. The same was subsequently done by Tycho Brahe, who also entertained a geocentric theory, as accurately as the instruments then provided could admit. We can have no assistance from the modern theory of physical astronomy to guide us in our discussions, as its very foundation has been completely destroyed, not only by restoring the plenum, or a resisting medium, but also by other new ideas regarding the sun, meteors, &c., &c. It must be borne in mind that the only science of astronomy we can depend on, is that founded upon a *system of computation*, and nothing else. I was desirous to restrict my paper on this occasion to giving a brief description of the observed facts connected with the movements of the surface of the earth from south to north. I thought that, as the operations going on at the poles could not be examined, and therefore would have to be determined from analogy, they might be left for future consideration. But whatever may be the opinions as to the character of the actions going on at the poles, they cannot affect the fact of the great superficial movement of the earth from south to north. If we look at the maps of the southern and northern hemispheres, with their respective poles in the centre, it will be seen that the dry lands radiating from the Antarctic Circle are comparatively very limited, and they are composed principally of gravel and sand; whereas, in the northern hemisphere, they are crowded, jammed, contorted, rising in ridges, and they contract the passage of the currents of the ocean to the north polar basin. A superficial glance will show that the dry lands, after passing the parallel of 40° N. lat., become so crowded as to allow but a small space for the ocean, as compared with the other parts of the globe.

The Pacific passage (Behring's Strait) is becoming very narrow. The northerly action of the lands, and the contraction of the space as they approach the Arctic Circle, have apparently caused a lateral pressure, which has squeezed the sedimentary beds of the United States into a series of narrow troughs, which represent the coal-seams in the transverse section in the form of UUs, thus reducing the space formerly occupied by the beds to about one-fourth the width. The same effect is seen in Europe in the coal-beds of Belgium and Prussia. The beds of the coal-measures are squeezed so much as to represent in the sections very acute angles, and in several places the seams are actually seen in a perpendicular position. The seams of the sections in general appear like very acute WWWWs. The original space, in many cases, has been reduced to from one-sixth to one-eighth. As regards the vertical primary rocks below, they can be well observed in the north coast of Ireland and Scotland; also in Norway. The silicious bands become more compact and contracted, whilst the talcose, micaceous, and argillaceous bands are squeezed out and produce polished striae, which, on exposure, are often mistaken for the effects of the action of glaciers. There is also a rapid disintegration and decomposition of rocks going on as they approach the Arctic Circle, and the margin of the polar basin.

With regard to the character of the terrestrial axis, whose ends are the points of emergence and convergence of all the circulating fluids of the globe, we cannot decide. We can only obtain approximate dimensions of the area of the ends by means of observations founded upon the angle of the dipping-needles and the diameter of the cone of the Aurora. According to such observations, the active polar axis is about  $20^{\circ}$  in diameter. No Arctic explorer has been able yet to reach it, and actually to observe the operations going on there. We may, however, venture to assume that it is acting like a magnetic axis, as the perpetual circulation of the magnetic currents from pole to pole could not have continued without the action of such an axis. As the globe is a semi-aqueous body, and not a mere ferruginous magnetic shell, it is evident that it is not merely a magnetic globe, but subject to a great electro-magnetic action; and, if so, the axis would not only be the mere conductor of the returning magnetic currents, but the core of the terrestrial battery; the ocean and all terrestrial substances would be decomposed at the North Pole, and be reproduced again at the South Pole in the same manner as by means of an electro-magnetic apparatus in a decomposing trough. This seems to be more probable than what has been suggested by some philosophers, namely, that the axis might not only be porous, but tubular, and thus would admit of the passage of all the substances in solution from one end to the other.

Although we cannot approach the south polar basin, we know that the sea comes from that pole in strong and continuous streams, as from a great fountain, acting by impulses, and thus causing tidal waves. Many attempts have been made to account for the return of the Gulf Stream, or the ocean from the Arctic basin back to the south, and until very recently it was sup-

posed that there was an actual returning current detected in the bottom of the ocean. All these ideas have, however, been completely set aside by the careful soundings made in connection with the Atlantic Telegraph. There are no such currents. The bottom of the sea is comparatively quiescent. Therefore it is quite evident that the oceanic streams, as they arrive at the north polar basin, and are absorbed therein, are either decomposed, as in a battery, or are made to pass through the axis and to re-appear again at the opposite end. We know from daily experience in subterranean operations in the primary rocks, that the electro-magnetic currents of the earth are very powerful and active, and are constantly reproducing and decomposing the various minerals of which the earth is composed. Therefore, since this is the fact, we may reasonably conclude that the same kind of action must go on at the poles ; and when we consider that the entire electro-magnetic force of the earth is concentrated and converged at the north polar basin with a saline liquid to act upon, over an area of 20° in diameter, it must have sufficient power to dissolve all the substances of the earth as rapidly as they arrive there, and to reduce them to their primary elements, making them to re-appear at the same rate at the opposite pole, atom for atom, or crystal for crystal.

NOTE.—Owing to the lamented death of Mr. Hopkins at the time when his Reply was in the printer's hands, it has not had the benefit of his own final revision ; and the Editor must therefore be held responsible for any inaccuracies or imperfections which may appear therein.