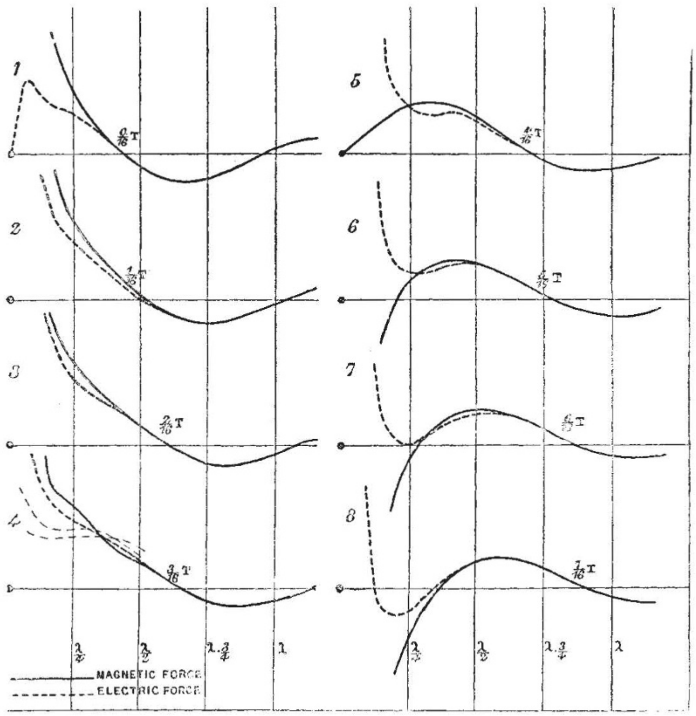
tion of light, which are, apparently at least, secondary actions due to a reaction of the matter set in motion by the radiation on this radiation.

Some further diagrams were exhibited, plotted from Hertz's theory by Mr. Trouton, to whom much of the matter in this paper is due. They are here reproduced, and show eight simultaneous positions of the electric and magnetic waves during a semi-oscillation of an electric oscillator. The dotted line shows the electric force at various points, and the continuous line the magnetic force. In the first diagram the magnetic force is at its maximum near the origin, while the electric force there is zero. In the second the magnetic energy near the origin has partly turned into electric energy, and consequently electric force begins. The succeeding figures show how the magnetic force decreases near the origin, while the electric force grows, and the waves already thrown off spread away. The change of magnetic force between Figs. 4 and 5 is so rapid, that a few dashed lines, showing interpolated positions, are introduced to show how it proceeds. It will be observed how a hollow comes in the line showing electric force, which gradually increases, and, crossing the line of zero force at about a quarter of a wave-length from the origin, is the source of the electric wave, which, starting with this odds, picks up and remains thenceforward coincident with the magnetic wave. From this origin of electric waves they spread out along with the magnetic waves and in towards the origin, to be reproduced again from this point on the next vibration. These electric and magnetic forces here shown as coincident are, of course, in space in directions at right angles to one another, as already explained. The corresponding diagrams for a magnetic oscillator are got by interchanging the electric and magnetic forces.

A further experiment was shown to illustrate how waves of transverse vibration can be propagated along a straight hollow vortex in water. It was stated that what seemed a possible theory of ether and matter was that space was full of such infinite vortices in every direction, and that among them closed vortex rings represented matter threading its way through the ether. This hypothesis explains the differences in Nature as differences of motion. If it be true, ether, matter, gold, air, wood, brains, are but different motions. Where alone we can know what motion in itself is—that is, in our own brains—we *know* nothing but thought. Can we resist the conclusion that all motion is thought? Not that contradiction in terms, unconscious thought, but living thought; that all Nature is the language of One in whom we live, and move, and have our being.



THE CLIMATES OF PAST AGES.[1]

II.

WE need not enter on a detailed description of the other vegetable types of the Coal-measure formation; we can only note the abundant occurrence of tree-ferns, and the existence of not very numerous conifers, which amid this strange vegetation are the forms most nearly related to those of our present world.

The geographical extent of this typical flora was extraordinarily great; we trace it from the shores of the Atlantic through the northern half of the Old World to China, and it is also greatly developed in the eastern half of the United States. There, and in China, are the greatest developments of beds of coal. Besides these, we find similar deposits with nearly the same vegetation in the far north, in the American polar archipelago, in Spitzbergen, and Nova Zembla. It is these facts that have led to the conclusion, already mentioned, that in the Carboniferous period a uniform climate prevailed from the equator to the pole, together with a dense atmosphere rich in carbon-dioxide, and impenetrable to the solar rays. And yet a simple examination of the facts assures us that all these suppositions are groundless. In so far as regards the character of the flora, we really know nothing of the temperature requisite to the Calamites, Lepidodendra,

[1] Translation of a Lecture delivered by the late Dr. M. Neumayr before the Society for the Dissemination of Natural Science, at Vienna, on January 2, 1889. Continued from p. 151.

Sigillariæ, and other extinct types. Conifers grow now in very severe climates, and only the tree-ferns really indicate warm climatic conditions. At the present day their chief development is in the tropics, and they require, not indeed great heat, but the absence of frost. We do not, however, know that this was equally the case in former ages; in the Carboniferous period, the highest division of the vegetable kingdom, now so dominant, the flowering plants, were either non-existent, or were sparsely represented only by a few early forms, and it is by no means improbable that these types in their gradual extension have exterminated the tree-ferns in the colder regions to which they formerly extended, and that these latter have lost the power which they once possessed of withstanding frost.

Another fact that has been adduced to prove the former prevalence of a warm climate, is the great thickness of the beds of coal, which, it was assumed, could only have been formed by a luxuriant vegetation stimulated by a high temperature. But this also is incorrect; remarkably rich plant-growths are to be met with also in countries with very severe climates, and indeed few countries surpass, in this respect, the inhospitable Terra del Fuego, with its impenetrable beech forests. Moreover, there is no good ground for the assumption that a luxuriant growth of plants is necessary for the formation of thick beds of fossil fuel. At this present time we know of but one mode in which vegetable remains accumulate in thick beds, and thus exhibit to us the first step of the process of coal formation: this is the formation of peat, which, as is well known, is effected by the most inconspicuous and poorest of plants, viz. certain kinds of mosses. It is not in the towering primæval forests of India and Brazil, nor the mangrove swamps of tropical coasts, but in the moors of the sub-arctic zone, that plant-remains are now being stored up in a form that, in the course of geological ages, may become converted into beds of coal.

A closer examination of these conditions apprises us of certain important facts. The reason why great masses of vegetable remains do not accumulate in warm countries is that, in the presence of a high temperature the decaying plants decompose too rapidly, and speedily disappear; it is only in a cold climate that they are preserved; and we may therefore regard the existence of coal-beds as a proof that at the time of their formation a high temperature did *not* prevail.

Out of the mass of baseless assumptions, then, this tolerably well-founded fact remains, that an arborescent vegetation of the Carboniferous period presents itself in 76° of northern latitude, whereas, at the present day the northern limit of tree-growth nowhere exceeds 72°; and if we assume that there has been no displacement of the earth's axis of rotation, we must conclude that in these high latitudes the mean temperature of the year was formerly some degrees warmer than at this present time; in the temperate zone we may infer, with some probability, a cool climate with moderate heat in the summer and cold in the winter, and with but little frost: in fact, an insular climate, such as our knowledge of the distribution of land and sea in that age presupposes.

So far we have regarded only the conditions obtaining in the north temperate zone and the polar regions. These, however, show certain peculiarities of distribution. The greatest coal deposits are all in the temperate zone, and chiefly concentrated in its middle and northern regions. The most northerly of the great deposits of the productive Coal-measures are those of Scotland, the most southerly those on the border of the central plateau of France; such as lie further north or south are of little importance. In North America, it is true, they extend considerably further south, but none reach to the 30th parallel of latitude; while, in the north, they extend into British North America. The coal of China occurs in the northern provinces, in Shansi, Shensi, and Honan.

Thus we find that the greater deposits are restricted to a zone of variable width, the southern limits of which are between 30° and 45°, the northern between 50° and 60° N. lat.; beds of true coal of the same age are not indeed entirely wanting outside these limits, but they are rare; as a rule we meet with only the characteristic plants, and these gradually disappear as we proceed further south. In a few instances they may be traced as far as Northern Africa and the peninsula of Sinai; but between the tropics the typical flora of the coal formation seems to fail entirely; not a single instance of their occurrence can be cited; and their first reappearance seems to be in the southern temperate zone in the coal-fields of Southern Brazil.

For a long time it was very doubtful what explanation should be given of this phenomenon, whether plant-bearing deposits of this age were altogether wanting in the tropical zone, or whether their development was of so different a character that we had failed to identify them, or finally whether it were due to some other cause. We cannot notice at length the gradual development of our knowledge on this head; we can only sketch out the final results which have been yielded in the last few years. We know now, that in Southern Africa, in India, and Australia, there are extensive deposits of the same age as our productive Coal-measures, with abundant plant-remains, but that these differ very greatly from the contemporaneous growths of our own region. No trace is found of the forms characteristic of our Coal-measures, no Sigillariæ, no Lepidodendrons, no Calamites. Ferns and true Equisetaceæ furnish by far the greater part of the flora; and with these are associated a small number of conifers and Cycads. The commonest and most characteristic form of this flora is the fern genus *Glossopteris*, and accordingly the whole assemblage of associated plants has been termed the *Glossopteris* flora. When put in comparison with our European coal flora, so strange does this seem, that no one would venture to think of it as contemporary until it had been established, by evidence admitting of no question, that such is actually the case.

From this, however, the important result follows that the doctrine of a universal coal flora is altogether false. On the contrary, we find that we have to deal with two very different floral regions, which stand strongly contrasted. And what makes this contrast especially remarkable, and for a long time hindered its true interpretation, is that the *Glossopteris* flora of India, Australia, and South Africa is nearly related to the European flora of a much later period, viz. the Trias.

But the most striking fact connected with this flora is that its first appearance, whether in South Africa, India, or Australia, is associated with deposits of fine argillaceous sand, with numerous stony fragments varying in size from small pebbles to gigantic blocks of many hundredweight, irregularly embedded; they consist for the most part of rocks that do not occur anywhere in the neighbourhood, and must therefore have been transported from a distance, and moreover some among them are scored and scratched. These phenomena, which manifest themselves in three far-distant localities, and according to the latest intelligence seem to recur also in Brazil, bear such striking evidence of the agency of ice in the formation of these deposits, that any doubt on this head seems scarcely any longer admissible, however much it may startle us to find great ice-masses and floating icebergs at the time of the coal formation in regions so far from the poles.

From the facts we have recounted, bearing on the climate of the Coal-measure period, it is abundantly manifest that everything runs counter to the assumption of a uniform and warm terrestrial climate from the equator to the poles. Geographically we have sharply contrasted floras, and we have moreover widely distributed deposits, in the formation of which great masses of ice must have played a part, and thus the old views are utterly overthrown. But when we go further, and seek to learn from the facts before us what the conditions really were, we are quickly admonished that our knowledge is as yet far too small to admit of any definite representation of these conditions. We may say with much probability that the differences of the floral regions must be ascribed to differences of climate, and that, locally, the temperature was so low as to allow of the formation of great masses of ice; but anything beyond this is quite uncertain, and no one of the assumptions that have been made to explain the conditions of that epoch has any claim to validity. Those early ages present us with so much that is strange to us, the unknown is so vast in comparison with what we know, that we dare not as yet attempt any generalization of our knowledge.

We pass over the formations which succeed the Coal-measures, viz. the Permian, the Trias, the Jura, and the Chalk, and after this enormous interval we turn our attention to Tertiary times. Here begin those modern developments that have resulted in our present world; the chief types of animals and plants are the same as those of our own day; and it is only since the beginning of Tertiary times that mammals predominate among the fauna of the land, whereas in the previous formations this leading part had been played by reptiles.

At that time Europe was far more cut up by inland seas than it now is, and formed a dismembered assemblage of islands and peninsulas. In the first division of the Tertiary age, the Eocene, the seas around its coasts were tenanted by animals of a tropical character. In the later subdivisions, this character was gradually lost. In the Oligocene, a marine fauna of a tropical character extends only to a line which about coincides with the northern limit of the Alps. In the Miocene, which next follows, the fauna even of this part of Europe is, at the utmost, sub-tropical; and, by degrees, the forms which give evidence of a warm climate gradually diminish, so that towards the end of the last division, the Pliocene, the conditions were almost the same as to-day.

What we know of the land organisms agrees entirely with these indications afforded us by the marine fauna, at least in their leading characteristics, since we equally find, at the beginning of Tertiary times in Europe, a predominance of sub-tropical and tropical types, which, later on, were replaced by a flora representative of a temperate climate. In detail, indeed, there are many and not unimportant deviations. Thus, for instance, the flora the remains of which are preserved in the calcareous tufa of Sezanne in Champagne, or in the marls of Gelinde, belongs to the Lower Eocene. The forms here represented are such as at the present time are peculiar to the southern part of the temperate or the sub-tropical zone; numerous evergreen oaks, laurels, cinnamon and camphor trees, various Myrtaceæ, Araliaceæ, figs, magnolias, &c.; many forms point decidedly to a tropical climate, but among them we find also, walnut trees, limes, alders, willows, ivy, and vines, which have an opposite character. Palms and cycads, the specially characteristic forms of hot climates, are absent, or at any rate have not been detected. On the whole, botanists are inclined to infer for that epoch in Central Europe such a climate as now obtains in Southern Japan in 33° N. latitude.

We meet first with truly tropical floral characters in somewhat later deposits, viz. in the Middle and Upper Eocene. At that time there flourished on the mainland and islands of Europe great palms and a number of other plants, whose nearest relatives now exist in tropical Africa, India, and Australia. To judge from the land flora, there was then a maximum of warmth in our neighbourhood (Vienna), from which up to the end of Tertiary times a continuous fall took place. In the Oligocene and Lower Miocene the prevailing character is still that of a tropical or sub-tropical region, but the number of forms that now live in temperate regions has considerably increased; such as now live in Australia occur in remarkable quantity. Then in the Upper Miocene of Central Europe we meet with a flora such as at the present day characterizes the warmer parts of the temperate zone, and in which forms allied to the present flora of North America are especially prominent. In the Pliocene, the latest subdivision of the Tertiaries, the change has progressed still further, and at its end we find in our neighbourhood an assemblage of plants nearly recalling that of the present day, with but a slight intermixture of those of warmer regions.

We may grant generally that these facts prove the existence in Tertiary times of a warmer climate than now prevails in Europe, even though there may be great differences of opinion as to the amount of the difference. Heer, to whom we are indebted for the most important investigations of this subject, has endeavoured to determine the mean annual temperature at certain definite geological epochs from the characters of their respective floras. He found that on the northern border of the Alps in Switzerland, at the epoch of the Upper Oligocene, there was a mean temperature of between 20° and 22° C. (68°–72° F.), such as at the present day is that of Cairo, Tunis, Canton, or New Orleans; at the time of the Upper Miocene, one of 18° or 19° C. (64°–66° F.), corresponding to that of Messina, Malaga, Madeira, and Nagasaki; whereas at the present time the mean annual temperature of Zurich is 8°·73 (47°·7 F.), that of Geneva 9°·67 C. (49°·4 F.). But whereas Geneva and Zurich now lie high above sea-level, we have proofs that in Tertiary times the sea level was much higher in that neighbourhood than now, therefore that this flora grew at a small height above the sea, which would imply alone an increase of about 3° C. ($5\frac{1}{2}$° F.) of temperature. It follows, then, that at the time of the Upper Oligocene the temperature was about 9° C. (16° F.), in that of the Upper Miocene about 7° C. (12° F.) higher than at present.

With respect to these figures, we must, however, bear in mind that in such computations no allowance is made for the acclimatization of species and whole genera in the course of long geological periods, and therefore that the assigned variations of temperature are almost certainly oo high. Moreover, we must remember that, at that time, tEurope was far more than now interpenetrated by inland seas and straits, and therefore that its climate was more insular, the summers being cooler and the winters warmer than now. But whatever weight we give to these considerations, they are alone insufficient to account for the whole of the difference between the Eocene and the present floras. We must perforce admit that other and deeper-lying causes have co-operated in producing the observed differences.

The examination of the Tertiary floras of high northern latitudes leads us very decisively to a similar conclusion. The various English, American, Danish, and especially the Swedish expeditions have discovered in numerous localities the Tertiary plant-remains of the polar regions, the floras of which have been worked out by Heer. Places which are now among the coldest known spots of the earth have yielded the remains of a rich forest vegetation; nay, within the polar circle itself are found plants which at the present time find even our own latitudes too cold for them. The most northern point from which we have plant impressions is Grinnell Land in the North American archipelago, in 81°45′ N. lat. Its present mean annual temperature is about −20° C. (4° F.). The flora consists chiefly of conifers, among which are our common pine, two species of fir, and the American swamp cypress (*Taxodium distichum*); with these are associated elms, limes, birches, poplars, hazel, and some others, the temperature requisite for which is estimated at about 8° C. (46° F.).

Much richer is the fossil flora of Spitzbergen, between [illegible] d $78\frac{2}{3}$° N. lat. Here also conifers are dominant; among foliage trees are present several poplars, also willows, alders, beeches, birches, large-leaved oaks, elms, plane trees, walnuts, magnolias, maples, and others; accordingly the climate of Spitzbergen at that time must have been much the same as the present climate of Northern Germany. A still warmer climate is indicated by the fossil flora of Greenland, which may be compared with the present flora of the shores of the Lake of Geneva.

These are by no means the only instances of a similar kind; analogous discoveries have been made at many different points in high northern latitudes; for instance in Siberia on the lower Lena, on the New Siberian Islands, in Kamtschatka, Alaska, Sitka, Banks Land, and some other points. It is not yet certainly determined to what part of the Tertiary period these fossil remains belong. While some regard them as Miocene or Upper Oligocene, others consider them to be Eocene; and good reasons may be assigned for both these opinions. Whatever may be the final decision is for our present purpose a matter of minor importance. The point we have to insist on is that in the polar regions, the mean temperature of which is now below the freezing-point, and in which only some of the lowest plants exist, there was in Tertiary times a rich forest growth. The difference between those times and the present was so great that for Grinnell Land we cannot estimate it as less than 27° C. (49° F.).

Such a change is absolutely inconceivable so long as we continue to regard as unalterable the present position of the places in question with reference to the pole. We cannot imagine any change in the distribution of land and water, in marine currents, or in any other influential factor, which, at a time comparatively so little distant from the present, could have brought about a luxuriant forest growth in Grinnell Land. This has long been recognized, and in many quarters it has been contended that the only explanation possible is a displacement of the earth's axis of rotation. To this the answer has been that the stations that have yielded the Tertiary plant-remains form a circuit around the pole, a chain from which, as an English geologist has expressed it, the pole can no more escape than a rat from a trap in a ring of terriers.

In point of fact there is no need for assuming so considerable a displacement of the pole since the beginning of Tertiary times. There is, however, ample room within the circle of the northern Tertiary plant stations for such a change, and there are valid grounds for such an assumption. For nowhere do the Tertiary plants reach so far north, and yet nevertheless testify so strongly to the existence of a warm climate as in the quadrant in which lie Grinnell Land, Greenland, and Spitzbergen; when we pass over to the opposite quadrant we find precisely the opposite case, for the Tertiary plants of Alaska, in North-Western America have, in north latitude 60°, scarcely more the character of a southern flora than those of Spitzbergen in lat. 78°.

From these considerations, it seems not improbable that, at the time when these Tertiary plants lived, the pole really had not the same position as now, but was displaced from 10° to 20° in the direction of North-Eastern Asia. The circumstances of the Tertiary deposits in other places outside the polar regions agree very well with this view. In Europe, as we have seen, a very warm climate prevailed universally, but when we turn to other countries we meet with a different result. The flora of the Tertiary formations of the United States give no indication of any essential increase of temperature, and the fossil plants of the probably Miocene and Pliocene formations of Japan, according to the admirable investigations of Nathorst, point to a colder climate than that which now prevails. These facts are obviously eminently favourable to the idea of a displacement of the pole. Curiously enough, we find in the yet but little known Tertiary deposits of the southern hemisphere a somewhat striking confirmation of this view, inasmuch as the marine Tertiary Mollusca which occur in several parts of the Chili coast, do not contain a single species indicative of a warmer climate than that of the present day.

Thus, then, it seems very probable that the position of the pole in Tertiary times was different from that of to-day, and only became as at present at the close of that era. But on this assumption the extreme contrasts are only somewhat palliated, the greater divergences somewhat reduced: no complete explanation is afforded of the phenomena. Whatever position we may assign to the pole, those places in which Tertiary forest trees are found were in any case far nearer to it than is the present northern limit of tree-growth; and when we compare the fossil floras of Europe and Japan, we find that the first shows a much greater departure from the present state of things in the direction of a warmer climate than does the latter in the opposite direction. Thus we are led to the conclusion that the climate of Tertiary times in general was somewhat warmer than that of our own day, but by no means to such an extent as that of the lands specially favoured through the displacement of the pole, viz. Grinnell Land, Greenland, Spitzbergen, and Western and Central Europe.

When from the Tertiary age we take another step forward in time, and reach the Pleistocene, the immediate forerunner of our present age, we meet with quite another picture. The remarkable characteristics of this period have been set forth by a skilled hand in this place, and I need only refer to them in a few words and in so far as is specially important in connection with our present subject.

At the setting in of the Pleistocene, the climate seems to have been somewhat warmer than at present: figs, laurels, and vines grew wild in Central Europe, and among animals, we meet with certain fresh-water Mollusca (*Cyrena fluminalis*) which afford a similar indication. Then followed through the greater part of the Pleistocene that extension of enormous ice masses, which, issuing from Scandinavia, Finland, and the Russian Baltic provinces, covered a great part of Europe and advanced to England, Holland, the base of the mountains of Central Germany, the Carpathians, and in Russia as far as Kiew, Woronesch, and Nishni Novgorod. England, Scotland, and Ireland were almost completely glaciated, the ice-sheet covered nearly the whole Alpine region, a broad ice-girdle lay in front of its northern base, and even the small hill-ranges of Central Europe and some of the greater ranges of Southern Europe developed independent glaciers. On a still greater scale, similar phenomena present themselves to us in North America, and in Northern Asia the greater mountains were then glaciated. Also further south, in the Himalaya and the Karakorum were enormous glaciers, and the same in the neighbourhood of the equator in the Sierra di Santa Martha in the northern part of South America. In the southern hemisphere, traces of glaciers occur very extensively in the southern part of the same continent, and according to many accounts also in South Africa.

It was long doubtful whether the glaciation of the northern and southern hemisphere took place simultaneously; but there is now no longer any doubt that such was really the case. Attempts have been made to explain the formation of great ice-accumulations without any depression of temperature, nay even in warm climates, solely as the result of an excessive precipitation of rain and snow, and in consequence of the prevalence of warm winters and cool summers; but these views are wholly untenable; a depression of temperature is testified to, not only by the extension of the glaciers, but also by the vegetable and animal denizens of the land and the sea. When in Pleistocene deposits of the Mediterranean basin we find Mollusca suddenly appear which now live only in the German Ocean, no other explanation is possible than that the temperature at that time was low.

We need not indeed conclude that an excessive degree of cold was necessary to produce the phenomena of the Glacial period; the height of the snow-line at that time has been computed for many of the mountains of Europe, and from this it has been deduced that the extreme reduction of temperature was at the utmost 6° C. (11° F.), and possibly considerably less. Much has been said and written of the causes which brought about the cold of the Glacial period. Very thoughtful and also very jejune hypotheses have been put forward, all of which have this one characteristic in common, that in some one particular or another they are strongly opposed to the actual facts, and have therefore no validity. With our present knowledge, any explanation is quite impossible. We must content ourselves with recognizing that the cooling was simultaneous, and, as far as research has yet gone, extended over the whole of the globe. It is, then, obviously impossible to attribute it to a displacement of the pole, for in that case a part of the earth must have experienced an increase of temperature; and, in addition to this, we certainly cannot suppose any considerable change in the position of the pole within so comparatively short an interval as separates us from the Glacial epoch. The uniform extension of the phenomenon excludes all those attempted explanations which appeal to geological or geographical changes of the earth's surface, a different distribution of land and sea, changes in the ocean currents, &c., and all points to some agency external to the earth, and therefore acting on it as a whole.

We must specially notice one other circumstance in connection with the Glacial period. It has been observed in many places that the glacial deposits with their scratched pebbles and irregular heaping of their materials do not form a continuous mass, but that, between a lower and upper deposit of glacial character, there is an intermediate bed showing no trace of ice action; at different places, the remains of animals and plants have been met with in this intermediate bed which indicate a somewhat warmer climate, though slightly colder than the present. Thus, in the slaty coal of Utznach and Dürnten in Switzerland, which belongs to this formation, have been found only the remains of plants still growing in the neighbourhood, with the single exception of the mountain pine, which no longer exists in the low plains of Switzerland, but has withdrawn to Alpine heights. These so-called inter-glacial deposits attain in places to a considerable thickness. They show us that during the great Glacial period there intervened a very decided recurrence of a warmer temperature, during which the great ice masses melted away; and from all the indications, this interval, according to human reckoning, must have lasted thousands of years. This page of the earth's history has for us this especial interest, that the oldest certain indications of man's existence in Europe are found in these inter-glacial deposits.

Similar evidence of an interruption of the Glacial period by one of greater warmth is met with in many other parts of the Alpine region, and also on the plains of Northern Germany, in Scandinavia, England, and in different parts of North America, and we must therefore conclude that it was of general occurrence, and that the changes of temperature which brought about the glaciation of an enormous extent of land, and subsequently set it free from its icy covering, were not regularly progressive, but consisted of many changes and oscillations. . . .

Thus we have sketched in a few hasty outlines what we know of the climatic conditions of three periods of the earth's history which are of especial importance for judging such questions. The first of these, of hoar antiquity, was that of the Coal-measures. We have ascertained the existence of distinct floral regions, which in all probability were determined by differences in the distribution of heat; moreover, we have found in deposits far distant from each other evidence of ice action. But in all other points the conditions are so far removed from any of which we have experience, that any further inference is hardly possible. At the utmost we may conclude from the limitation of the greater coal-beds to the temperate zone that the position of the earth's axis and of the pole did not differ very greatly from those of the present day.

When we turn to the much younger formations of the Tertiary age, the conditions are somewhat clearer. In them we recognize, in the first place, the operation of purely local agencies, the distribution of land and water, of ocean currents, &c., but we must also confess that these play but a subordinate part. We have also seen that in certain regions, viz., in Europe, Greenland, Grinnell Land, &c., there prevailed a much warmer climate, which, however, we do not recognize in America; while in Japan, as inferred from the vegetation, the temperature of Tertiary times seems to have been lower than it now is; and we have found in a displacement of the pole and the earth's axis the only probable explanation of these phenomena.

This cause does not, however, suffice to explain all anomalies, and we must assume for all parts of the earth the prevalence of a somewhat warmer climate, an increase perhaps of a few degrees only, which manifests itself particularly in the vegetation of the polar regions.

In the Pleistocene epoch, which is, comparatively speaking, so near to our own, the problem is so far simplified, that one of the two principal factors which determined the deviation from our present climatic conditions—the displacement of the earth's axis—was no longer present; or rather, having regard to the shortness of the time that has since elapsed, was so unimportant that its influence is not traceable. Apart from purely local circumstances, we have, as far as we can judge, only to deal with uniform oscillations of temperature over the whole earth anomalies of the same general character as brought about the general elevation of climatic temperature in the Tertiary age.

If we follow the march of these vicissitudes of temperature, evidently determined by some cosmical agency, we find at the beginning of Tertiary times a moderately warm climate; then a rise during the Eocene, and then a gradual cooling, interrupted possibly by some oscillations, down to a degree nearly corresponding to that now prevailing, at the beginning of the Pleistocene epoch. Then the cooling continued below the present temperature, to a minimum at the time of the greatest glaciation of the land; then a re-warming in the inter-glacial period nearly up to the present temperature; after which cold and glaciation regained the upper hand, finally to give way to the present conditions, which are about midway between the greatest warmth of the Tertiary age and the greatest cold of the Pleistocene.

One fact stands out conspicuously, viz. that these changes progressed very irregularly, and were subject to much oscillation, and the period during which we can approximately follow the course of the change is much too short to enable us to learn the law that regulated it. We cannot decide whether oscillations like those of the Pleistocene will be repeated, and we are now progressing towards another temporary Glacial period, or whether we have to expect the return of a warmer temperature such as prevailed in Tertiary times, or, finally, whether the outcome of all the deviations will be a lasting refrigeration of our climate.

Just as little can we determine at present by what agency all these vicissitudes are brought about; most plausible and simple would it certainly be were the sun a variable star that at different periods emits different quantities of heat; but for this or any other assumption there is no proof forthcoming. This enigma, like so many others, will some day be solved by man's searching intelligence, but, like all other acquisitions of science, this goal can be won only by assiduous and patient labour. Haply the triumph may not be for our generation; but what we may certainly accomplish is to prepare the way to it, by an accurate and critical collection of the facts.

H. F. B.

NOTES.

It is expected that about fifty foreign men of science will be present at the Leeds meeting of the British Association. A good many manufacturing firms have promised to open their works during the time at which the meeting is being held; and a Guide to Leeds and the surrounding district, with accounts of the various industries, is being prepared. There will, of course, be excursions to the more interesting places within easy reach of Leeds. The first *soirée* will be given by the Mayor, the second by the Executive Committee. The Yorkshire College will give an afternoon reception.

The London Mathematical Society has awarded the De Morgan Memorial Medal (given triennially) to Lord Rayleigh, Sec.R.S., for his researches in mathematical physics. The previous awards have been to Profs. Cayley and Sylvester. The medal will be presented at the annual meeting in November next.

The *conversazione* of the Society of Arts, as we have already announced, will take place at the Natural History Museum, Cromwell Road, on Friday, June 27. The galleries will be lighted with electricity, so that the authorities of the Museum will have a good opportunity of judging how far the electric light is suitable for the building. If the experiment is successful, the system will no doubt soon be permanently established. It may be hoped that in that case the public will not be excluded during an interval between twilight and the lighting of the electric lamps. That plan has been tried at the British Museum, and the results are not encouraging. If the national collections are to have a fair chance of attracting visitors, they must be open continuously from morning until the hour when they are closed for the night.

The anniversary meeting of the Royal Geographical Society was held on Monday, Sir E. M. Grant Duff, the President, occupying the chair. Mr. Douglas W. Freshfield announced that the Patron's Medal had been awarded to Emin Pasha, and the Founders' Medal to Lieutenant F. E. Younghusband. The Murchison Grant was awarded to Signor Vittorio Sella, for his journey in the Caucasus; the Cuthbert Peek Grant to Mr. E. C. Hore, for observations on the physical geography of Tanganyika; and the Gill Memorial to Mr. C. M. Woodford, for three expeditions to the Solomon Islands. Scholarships and prizes were awarded to students in training colleges. Dr. R. W. Felkin attended, upon instructions by telegram from Zanzibar, to receive the medal for Emin Pasha. The President, in handing the medal to Dr. Felkin, congratulated him upon having done much to make the work of Emin known in England. The Society was not based upon politics, and they simply saw in Emin Pasha one who had from early life given a great deal of attention to botany, natural history, and other subjects. Dr. Felkin, in acknowledgment of the medal, referred to the great services rendered by Emin Pasha to science. Afterwards the Report of the Council was read, and Sir E. M. Grant Duff delivered his presidential address.

At the meeting of the Scientific Committee of the Royal Horticultural Society on June 10, Mr. Morris called attention to the fact that the Royal Society had assigned £100 "on the recommendation of the Government Grant Committee, for an inquiry into the composition of London fog, with special regard to the constituents of fog injurious to plant life." An informal conversation followed with reference to chemical investigations to be undertaken at the laboratory of University College, under the superintendence of Dr. Oliver.

A deputation from the Sanitary Institute lately visited Brighton, and met the Mayor and other members of the Committee for the purpose of further considering the Congress and Exhibition to be held in the Pavilion buildings at the end of August. The large dome of the Pavilion, the Corn Exchange, and the Picture Gallery, are all devoted to the Exhibition, but the applications for space are considerably in excess of previous years, and probably some difficulty will be found in accommodating exhibitors. Sir Thomas Crawford is the President. At one of the meetings of the Congress a lecture will be delivered by Mr. W. H. Preece, F.R.S. Dr. B. Ward Richardson, F.R.S., will address a meeting of the working classes.

The thirty-seventh Report of the Department of Science and Art has been issued.

A lecture on the use of alloys in art metal-work, delivered by Prof. Roberts-Austen at the Society of Arts on May 13, is printed in this week's number of the Society's Journal. It is a lecture of great value and interest, and all who read it will cordially agree with the author that "an effort should be made to induce British artificers to employ the materials and methods which their Japanese brethren have used for centuries with such remarkable effect."

In France much interest is being taken in the question whether a University shall be established in Paris. At a meeting of the General Council of the Paris Faculties, held last Saturday at the Sorbonne, it was agreed that a University with five faculties (Protestant theology, law, medicine, science, and literature), and an upper school of pharmacy, should be formed. "The principal effects of the constitution of the University," says the Paris correspondent of the *Times*, "will be to permit the faculties to make arrangements for the organization of instruction (under the form of schools or institutes) of which the elements are at present scattered in several faculties, and to facilitate a sort of general instruction of a philosophical character, to which the professors of all the faculties will contribute, and which will be addressed to the students. The University will grant, besides professional degrees, diplomas of purely scientific studies to native and foreign students."

M. Deflers has just returned to France from his extremely arduous exploration of Southern Arabia at the instance of the Minister of Public Instruction in France. He has brought back large collections of both living and dried plants for the Museum of Natural History.

The Museum of Natural History in Paris has also received a considerable collection of dried plants gathered in Madagascar by M. Catat.

M. Balansa is about to return to Tonkin for the purpose of continuing his botanical explorations there; and M. Thollon to the Congo, from which he has already sent interesting collections.

A Laboratory of Vegetable Biology was opened at Fontainebleau on May 15. It is under the control of M. G. Bonnier, Professor of Botany at the Sorbonne, Paris, to whom applications for leave to pursue researches in the Laboratory should be addressed.