CLIMATE AS TESTED BY FOSSIL PLANTS.[1]

PROBLEMS connected with the climates of past ages have long exercised the minds of scientific writers, both from the astronomical point of view and from the point of view of the gradual development and distribution of plants and animals, since the earliest periods that have left recognisable records in the earth's crust. My task this evening is to deal with the nature and value of the evidence afforded by plants as to the climates at different periods of the world's history. Even before the study of fossil plants attained the dignity of a science (1706) the opinion was expressed that certain leaves preserved as impressions in Palæozoic strata in Germany bore a closer resemblance to existing tropical genera than to any European forms; and as investigation of the botanical records of the rocks progressed it became increasingly evident that fossil plants often exhibit a close agreement with species characteristic of regions warmer than those where the fossils are found. Plants, it has been said, "are the thermometers of the ages, by which climatic extremes and climate in general through long periods are best measured." It seems a simple matter to draw conclusions as to the climates of former ages from the nature of the vegetation embedded in the rocks; but the more we consider the facts the more fully we recognise the difficulties of interpretation.

At the outset of our inquiry we must endeavour to obtain some general conception of the relation of existing plants to the diverse influences to which they are exposed in order to appreciate their plasticity or power of modifying form and structure in response to the demands of the environment. Plants have generally been preferred to animals as indices of climatic change on account of their inability to escape from uncongenial or injurious conditions unless the change in climate is sufficiently gradual to allow time for migration by the precarious method of travelling afforded by the adaptation of fruits and seeds to dispersal by wind, water, or animal agency. Plants must either become acclimatised or suffer extinction, while animals, unless faced by impassable barriers, can change their home. It is therefore of importance to obtain some general idea of the power of plants to accommodate themselves to changed conditions, and to inquire how far the factors influencing plant-life are able to cause alteration in form or structure and so maintain equilibrium between the organism and its environment. It is well known that closely allied plants can exist under very different conditions, but we are unable to give any satisfactory explanation of this power of adjustment inherent in the constitution of a species. As Prof. Judd reminds me, tropical species in St. Petersburg live through the winter in semi-darkness in glass houses with the roof darkened by a thick covering of matting and snow. The same species is occasionally met with in both temperate and tropical regions: the bracken fern, which monopolises wide stretches of British moorland, grows in tropical Africa, in the Alps and Himalayas, China, the Malay Peninsula, Tasmania, and many other parts of the world where it is exposed to a wide range of climatic conditions. In contrast to this and other cosmopolitan types there are many instances of ferns and flowering plants characterised by a narrowly circumscribed geographical range: some of the genera now confined to a comparatively small area in the tropics are survivals from a remote past when they, or closely allied forms, were widely spread in northern countries. If we take the climatic environment of the surviving species as an index of the conditions under which their predecessors flourished, their presence in European sedimentary rocks points to tropical or subtropical conditions in the Mesozoic era in latitudes now characterised by a temperate or even an Arctic climate. It is, however, very probable that the last strongholds of these ancient and possibly enfeebled types are characterised by climatic conditions less rigorous than those under which their more robust ancestors were able to exist. The "big trees" of California, the genus Araucaria, and the Malayan ferns Dipteris and Matonia afford striking examples of genera now restricted to a small area but formerly very widely distributed. The two surviving species of Sequoia (the redwood and the mammoth tree), now confined to a narrow strip of land bordering the Pacific coast, are the last members of a family that has left many traces of its existence in Tertiary Europe and in other parts of the world. Similarly Araucaria, one of the most venerable of our Conifers, is now confined to Chile and Brazil in the west, and to the eastern part of Australia, New Caledonia, and other Australasian islands, whereas in the Jurassic period species closely allied to the monkey puzzle (*Araucaria imbricata*) and the Norfolk Island "Pine" (*Araucaria excelsa*) flourished in North America, Europe, and other regions north of the equator. A similar history of retreat from northern latitudes to a much more limited tropical home has been deciphered from the remains of Mesozoic ferns that have their modern counterparts in the Malayan genera Matonia and Dipteris.

Though we cannot make any definite statement as to the mode of action of heat on the living protoplasm of a plant, it is possible to formulate some general rules governing response to external factors as illustrated by differences in habit and anatomical characters. The striking contrast in the environment of land and water plants means a considerable difference in the conditions affecting the working of the plant-machine. A species surrounded by water has no need to take measures for the reduction of evaporation or, more accurately expressed, transpiration: the superficial cells require no waterproof covering to prevent loss of moisture from the internal tissues; the water-conducting tissue (or wood) is much less developed in a plant that is not dependent on its roots alone for a supply of raw material. If we cut across the stem of an aquatic flowering plant, *e.g.* the mare's-tail or the water milfoil, we find that the feebly-developed conducting strands are nearer the centre than is the conducting tissue of a land plant. The tensile strain to which the stem is exposed renders desirable a concentration of the strongest tissue, in this case the wood, towards the axial region as compared with the more peripheral disposition of the corresponding tissue in a stem exposed to the bending force of the wind. The stem of the water-plant contains large air-spaces which ensure the provision of an internal atmosphere and an adequate supply of oxygen to the living cells; the support afforded by the surrounding water renders superfluous any special strengthening tissue such as characterises the stems of land-plants in which it is so arranged as to secure maximum efficiency with the least expenditure of material.

Plants growing in dry climates where water is available only at certain seasons, often separated by long intervals of drought, are characterised by structural features correlated with the economising or storing of water. A relatively thick cuticle—an impervious film on the surface of the aerial organs—reduces the loss of water in the form of aqueous vapour from the system of intercellular spaces permeating the internal tissues. The minute pores or stomata regulating gaseous exchange between the plant and the

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[1] Lecture delivered before the Royal Meteorological Society on March 18 by Prof. A. C. Seward, F.R.S. Reprinted from the Quarterly Journal of the Society.

external air, and by which aqueous vapour escapes, are often sunk below the level of the epidermis, or the leaves are variously modified in response to the need of reducing evaporation. The formation of water-storing tissue may result in the development of a succulent habit; hard spines replace the flat green leaves, thus by a reduction of exposed thin surfaces effecting a considerable diminution in the amount of water evaporated. In some cases the leaves persist as fleshy storage-reservoirs. Occasionally special cells occur in the leaves of dry-climate plants, in plants the water-supply of which is precarious, which act as small reservoirs to be drawn upon in times of stress. The intercellular spaces that form large cavities in the stems and leaf-stalks of aquatic plants are reduced to the minimum consistent with adequate aeration. Such anatomical features are by no means the monopoly of members of desert floras; they are characteristic of plants growing under conditions in which for various reasons economy in the use of water must be exercised. In salt marshes the water, though abundant enough, contains a relatively high percentage of salt, and this checks absorption by the roots; to avoid the danger of a greater loss of water from the leaves than can be made good by the roots, the plant assumes a habit and anatomical features similar to those characteristic of desert forms. Habitats where water may be plentiful, but to which plants react by acquiring the appearance and structure of species growing in dry regions, have been termed physiologically dry. A salt-marsh plant lives in a physiologically dry habitat; desert plants live in a physically dry locality, and though the environments differ they induce a similar reaction on the part of the two sets of plants. Peat-bogs afford another example of a physiologically dry habitat: the abundance of humic acids in the soil retards water absorption and so reacts on form and structure. In the swampy soil of a fen oxygen is scarce, and the horizontal underground stems of fen-plants tend to avoid the deeper water-logged soil by growing unusually near the surface.

The action of heat and cold is less easy to analyse; the thick covering of bark on the stem of a woody plant is primarily a protection against drought and not against cold. It is rather in the habit of plants than in any specific anatomical features that exposure to cold is reflected. In Russian Lapland it has been shown that it is not the low temperature but the effect of the dry winds that sets a limit to the northward extension of the forests; the young shoots, exposed to the desiccating influence of the air, lose more water than the roots can replace by their enfeebled power of absorption from the cold ground.

The contrast in habit and anatomical structure between individuals of the same species grown at high elevations in the Alps and in the lower meadows is due in part to the action of light and to other factors affecting water-supply. Plants grown before a continuous light under conditions similar to those in high latitudes, afford evidence in their power of response to a changed environment of the remarkable plasticity of vegetative organs; the stems are shorter, the amount of wood and fibrous tissue is reduced, and the cell-walls are thinner than in plants grown under normal conditions. The difference in the intensity of light on the sunny as compared with the shaded side of a tree leaves an impress on the structure of the leaves; a sun-leaf is thicker and is richer in the so-called palisade cells, that is, the cells containing chlorophyll elongated at right angles to the surface of the leaf, than the leaves which grow in diffused light.

The occurrence of the same or closely related species of existing plants under very different climatic conditions is a serious obstacle in the way of employing fossil plants as indices of climate. While it is possible to draw certain general conclusions from the facies of a flora as represented by fossils that can be identified with recent forms, the difficulties are enormously increased when the fossils are extinct types and too distantly connected with living species to afford any safe guide as to the conditions under which they were able to live. It is, for example, certain that in the Tertiary and Cretaceous epochs the vegetation of Arctic regions was such as could not have withstood the low temperature that now characterises Greenland, Spitsbergen, and other ice-covered countries. It is probably safe to assert that in latitude 70° N. in the Cretaceous and the succeeding Tertiary period the temperature was at least as high as that in southern Europe at the present day. This statement is based on the present geographical distribution of recent plants with which the numerous fossils discovered on the west coast of Greenland are most nearly related. It is, of course, impossible to say to what extent the fossil species differed from their surviving relatives in the power of resisting unfavourable conditions, but the fact that many of the Greenland fossils are very closely related to plants now confined to tropical and subtropical countries carries more weight than if the evidence rested on one or two isolated cases. The occurrence in Lower Cretaceous rocks on the west coast of Greenland of fossil ferns very similar to living species of the common tropical genus Gleichenia affords one of several instances of the vicissitudes and changing climates to which groups of plants have been exposed.

The preservation of plants as petrifactions affords valuable data in connection with climatic questions, but it is unfortunately only in comparatively rare instances that the relics of ancient floras retain their tissues in a state that admits of microscopical investigation. In some of the Lancashire and Yorkshire coal seams there are calcareous nodules containing numerous petrified fragments of the stems, leaves, roots, seeds, and spores of plants that flourished in the Carboniferous forests, and by cutting transparent sections of these blocks of stone the tissues can be examined as thoroughly as in thin sections of existing plants. For the most part the trees and smaller plants of the Coal period were converted into coal. A mass of vegetable débris accumulated on the swampy site of a forest, and after submergence and sealing-up under superposed sediments it passed by slow degrees into more or less homogeneous coal. In a few places patches of this peaty material were petrified by the deposition of carbonates of magnesium and calcium derived from mollusc shells and so preserved as samples of the coal-forming vegetable detritus. From thin slices of these patches it has been possible not merely to glean information as to the affinities of Palæozoic plants, but to learn something at least of the conditions under which they lived. It is noteworthy that in addition to the plant-containing nodules embedded in the coal itself, others are found in the roofs of the seams, and in these are occasionally preserved pieces of stems and other organs associated with numerous marine shells. It is probable that while the fragments preserved in the nodules from the seams formed part of the débris accumulated on the actual site of the forest, those from the roof-nodules are waifs and strays drifted by sea-water from the vegetation of higher ground. It has often been stated, though without adequate reason, that the Coal period was characterised by tropical conditions. It is at least certain that the conditions were favourable to luxuriant growth, and it is by no means unlikely that the atmosphere was richer in carbon in the form of carbon dioxide than it is to-day. The flora that has left scanty records in the roof-nodules differs in certain respects from the richer flora preserved in the coal itself, and the differences are such as lend support to the view that the forests which furnished the coal-producing material grew in swampy ground, while the roof-nodule plants grew on dry land.

Before dealing with the anatomical structure of a few Carboniferous plants further reference may be made to the question of climate. It used to be asserted that in the Coal period the climate was uniform over almost the whole world. In recent years it has been shown that whatever may have been the temperature in the northern hemisphere, there is good reason for believing that in India, South Africa, South America, and Australia the climate was different. During the latter part of the Carboniferous period the vegetation of Europe, North America, and part of China was fairly uniform in composition, and these regions were also characterised by similar physical conditions. The precise correlation of rocks in widely separated localities is often difficult, but it is safe to say that in India and the southern hemisphere strata occur corresponding in geological position with Upper Carboniferous and with Permian rocks in North America, Europe, and China; these southern rocks, conveniently termed Permo-Carboniferous, contain many plants some of which are closely allied to typical northern species, while others are distinct, notably a genus known as Glossopteris, a fern-like plant, though probably a member of an extinct group intermediate in some respects between ferns and seed-plants. From the extraordinary abundance and wide geographical range of Glossopteris in South America, South Africa, India, and Australia, this southern flora is spoken of as the Glossopteris flora; it differs from the contemporaneous northern flora not only in the presence of Glossopteris and several other types unknown in the coal-fields of Europe, but in the absence of many of the most abundant northern plants. With the Glossopteris strata are associated extensive boulder beds, clearly pointing to the existence of glaciers or water-borne ice, and these beds sometimes rest on a platform of solid rock, exhibiting in its rounded outlines and smooth, grooved surfaces unmistakable evidence of moving ice. The conclusions drawn from these and other facts point clearly to the existence of two botanical provinces in the Permo-Carboniferous era, for the most part sharply contrasted, but in a few places intermingling. In the southern hemisphere, and stretching north of the equator into India, was a vast continent, occupying a large portion of what is now the southern ocean, and of this lost continent remnants are preserved in South Africa, South America, and Australia. The abundance of boulder beds and ice-scored rocks in the southern hemisphere demonstrates the prevalence of conditions favourable to the formation of glaciers, a marked contrast to the physical environment of the swamp forests north of the equator.

It is unfortunate that the plants preserved in the southern hemisphere strata are very seldom met with in a petrified state; they occur almost exclusively as casts or impressions. A few specimens of petrified stems recently received from South Africa and India, with others previously described from Australia, afford one piece of evidence bearing on the problem of climatic conditions, namely, the presence of well-defined rings of growth in the wood. Stems from Carboniferous and Permian strata in the northern hemisphere do not as a rule possess any regular rings of growth; their wood is composed of water-conducting tubes of uniform diameter denoting an absence of seasonal changes. A tree growing in a district where a period of inactivity or winter rest is succeeded by a vigorous awakening in the spring, registers the contrast by the production of large vessels in response to the greater demands on the water-supply consequent on the sudden increase of activity in the life of the plant; the production of these water-tubes of wider bore in juxtaposition to the narrower vessels formed in the previous autumn at the close of the growing period gives the appearance of an annual ring. In tropical countries similar annual rings are formed when alternating dry and wet seasons replace spring and autumn, and it occasionally happens that several rings are produced in one year. An extreme case is afforded by a tree of *Theobroma cacao,* the cocoa tree, planted in Ceylon in the summer of 1893, and felled in January, 1901, in which during a period just above seven years twenty-two rings were formed. In this instance the tree shed its leaves three times a year, and each break in the uniformity of its life-processes was marked by the juxtaposition of wide and narrow water-conducting tubes. In many tropical trees and in stems of some plants growing in water there are no annual rings because there are no seasonal disturbances to interfere with the even tenor of existence. As a general rule, however, the rings are annual and afford a fairly accurate measure of age. The occurrence of well-marked rings in the South African and Indian stems of Palæozoic plants is therefore of some interest as an indication of regularly recurring seasons in contrast to the more uniform conditions characteristic of the more or less contemporary northern flora. Petrified stems from Jurassic, Cretaceous, and Tertiary rocks in the northern hemisphere usually show well-defined rings of growth.

An interesting illustration of the employment of the relative breadth of concentric rings of growth in trees as a guide to climate is given in a recent paper by Mr. E. Huntington in a Smithsonian Report for 1912. This author, from observations made in the drier regions of Central Asia and other countries, was led to the conclusion that during the last 3000 years there were periods characterised by a greater amount of moisture, the climatic changes being of a fluctuating kind. He afterwards extended his observations to California, Arizona, and New Mexico, where ruins of prehistoric settlements afforded evidence of less arid conditions than now prevail. Evidence derived from different sources points to the occurrence of three main periods of relative prosperity in both the eastern and western hemispheres. To test this hypothesis an examination was made of the growth-curve of certain forest trees in relation to the rainfall during the last forty years; this showed a close agreement and justified the use of the measurement of rings in trees, reaching in some cases an age of more than 3000 years, as an index of external influences. A curve of growth based on the relative breadth of the rings in several stumps of old Sequoia trees showed marked pulsations which on the whole coincide with climatic changes as deduced from other data

We may next briefly consider the nature of the evidence afforded by anatomical features exhibited by petrified plants from English coal seams. One of the commonest genera in the forests of the Coal period was that known as Calamites, similar in habit to modern Horsetails, but attaining the proportions of a tree with a thick woody stem. The leaves of slender foliage shoots occasionally preserved in the calcareous nodules from the coal are characterised by palisade cells disposed radially and at right angles to the surface, an arrangement correlated with fairly bright illumination rather than dull diffused light. The structural features on the whole suggest a plant living under conditions where the output of water from the leaves was kept within prescribed limits. The roots of Calamites contain large air-spaces in the cortex similar to those in the stems and roots of recent water-plants. Another common type in the Coal-period forests was Lepidodendron, an arborescent member of a class including the existing club mosses and similar plants, which reached a height of at least 100 ft., and had the power of producing an ever-widening cylinder of wood like that of a pine or an oak. The stem rose from a dichotomously branched subterranean organ that grew to a considerable length in a horizontal position a short distance below the surface of the ground, precisely like the underground organs of plants in the partially water-logged soil of a modern fen. The leaves were well provided with stomatal pores situated in grooves on the under surface, an arrangement suggestive of life under conditions requiring economy in the expenditure of water. Certain anatomical features in the stem suggest that the tree grew in swampy soil or possibly with the lower part of the trunk immersed in water, like the plants in a tide-swept mangrove swamp. A different type of Palæozoic plant is illustrated by Lyginopteris, a remarkable generalised genus with the habit of a slender tree-fern, but agreeing with the higher plants in the possession of true seeds. The stem bore aerial roots characterised by a covering of thin-walled cells, which may have enabled these organs to absorb water from a moist atmosphere. Another extinct genus from the Coal Measures, Sphenophyllum—so called because of its wedge-shaped leaves—affords in its long and slender stem and certain anatomical peculiarities evidence of a climbing habit, and suggests a genial climatic environment. The genus Cordaites, particularly abundant in some of the French coal-fields, and met with also in English localities, resembled in habit, and to some extent anatomically, the Kauri Pine (*Agathis australis*) of New Zealand. The wood is uniform in structure and in specimens from the northern hemisphere without regular rings of growth. The long, flat leaves reveal a distribution of supporting tissue in the form of I-shaped girders as efficient mechanically as the corresponding tissue in leaves of existing plants adapted to resist the force of the wind. Groups of small lateral roots of Cordaites have been found in a petrified condition, containing in their cortex the delicate tubular cells of a fungus, and it is believed that this association of fungus and root affords an example of symbiosis, the two organisms living together to their mutual advantage. It is noteworthy that certain recent trees, such as the Alder, inhabiting swampy ground, are characterised by an association of a fungus with short fleshy roots similar to those of Cordaites, the fungus assisting the roots to absorb water from a soil rich in humic acid. It may be, therefore, that this discovery of symbiotic relationship in the roots of a Coal-period tree supplies additional evidence in favour of a swampy habitat.

Attention may now be directed to the vegetation of a more recent geological period, namely, that known as the Jurassic. Sedimentary rocks of this age are often rich in fossil plants, but as yet the present dominant class, the flowering plants, had not begun to assert itself in the struggle for existence. Jurassic floras are known from the Arctic regions, many parts of North America, Europe, and Asia, from South America, and so far south as Graham Land, also from India, China, Australia, and elsewhere. There is conclusive evidence of the almost world-wide distribution of certain plants during this period of the earth's history, and despite our imperfect knowledge of the floras, we are justified in stating that the available data afford no satisfactory evidence of any well-marked differences in the nature of the vegetation in various latitudes such as might fairly be expected had there been climatic zones comparable with those of the present era. Identical or closely allied species of Jurassic and Cretaceous age are recorded from Greenland, England, India, and Graham Land, and, so far as it is possible to base any conclusions as to climate on a comparison of these extinct plants with modern forms, they indicate an environment characteristic of subtropical or tropical regions. A remarkable example of wide distribution is afforded by some large fronds described from Lower Cretaceous rocks in Greenland by the late Oswald Heer, belonging to a class of seed-plants known as the Cycadales or Cycads, now represented by a few genera for the most part tropical in their distribution; the most northerly members of the class occur in Florida, while the great majority grow in southern countries. Fossil cycadean fronds very similar to those from the west of Greenland are common in the Jurassic plant-beds at Whitby and other localities on the Yorkshire coast, also in strata of the same age in India, Siberia, California, and many other parts of the world. A few years ago members of a Swedish expedition discovered several Jurassic plants in Graham Land (lat. 63° 15′ S.), on the edge of the Antarctic circle, among which were cycadean leaves almost identical with the slightly more recent (Lower Cretaceous) specimens from Greenland. Cycadean plants of Jurassic and Lower Cretaceous age are represented in several parts of Britain, in most cases by impressions of leaves, but sometimes, as in the Isle of Portland, by large stems and occasionally by petrified flowering shoots; the latter have supplied important information as to the affinity of these extinct members of the class, and incidentally their structure points to circumstances necessitating efficient protection against drought

By treating with acid the carbonised film that can often be detached from an impression of a fossil plant preserved in shale, it is sometimes possible to obtain a preparation of the mummified cuticle or superficial covering of a leaf suitable for microscopical examination. Such specimens furnish information as to the structure and number of the stomata, and the data may be of value as criteria of climatic conditions. The carbonised impressions of cycadean fronds from the Jurassic plant-beds of Yorkshire, recently investigated by Mr. Hamshaw Thomas, of Cambridge, furnish particularly good preparations of the resistent cuticle, the only part of the leaf that has escaped destruction, and these supply a clue not only as to systematic position but also with regard to the structure of the mechanism by which the plants regulated their output of water and gaseous exchange with the atmosphere. Although it is rash to institute a close comparison between extinct types and their nearest living representatives as regards climatic conditions, the data obtained by a study of Lower Cretaceous and Jurassic floras throughout the world point to a greater uniformity in the vegetation, and indicate the prevalence of a higher temperature in Arctic and Antarctic regions than at the present day. It has recently been stated by Dr. Gothan, of Berlin, that the comparative study of petrified wood affords evidence of seasonal changes in Arctic lands as opposed to a greater uniformity of conditions—as indicated by the absence of annual rings—in tropical regions; but the data are at present scarcely sufficient to justify any definite pronouncement as to the occurrence of climatic zones during the Jurassic period.

Our knowledge of the more recent geological periods is as yet too meagre to warrant any very precise conclusions as to their climates. The older Tertiary floras are characterised by several flowering plants closely related to modern species in subtropical and tropical countries; fossil seeds from the London clay and from beds of similar age in Belgium and practically identical with those of Nipa, a palm which flourishes in the swampy ground of tropical estuaries. As the buoyant seeds of Nipa now abound in the waters of the Ganges, the seeds of their Tertiary predecessors floated in the river by which the muddy sediments were deposited that now form the London clay. The subtropical flora of England was gradually modified and partially exterminated as the result of changes in physical conditions which culminated in the Ice age.

It has long been known that in many parts of the British coast there are exposed at low tide stretches of peaty soil containing stumps of forest trees; these submerged forests, or Noah's Woods as they have been locally named, in reference to their supposed connection with the Deluge, point to a higher level of the land subsequent to the Glacial period. It is probable that at the time represented by the oldest submerged forest the whole of the southern part of the North Sea "was an alluvial flat connecting Britain with Holland and Denmark, and to some extent with France."[2] The prevalence of the oak indicates a mild climate: the fauna and flora as preserved in the submerged forests are described by Mr. Clement Reid as poor and monotonous, characteristic of a period of transition between the Ice age and the climatic conditions of modern times. In the alternate succession of old forest-beds and estuarine silts we have an epitome of changing level and fluctuating climates, in part at least during the Neolithic age and extending into the period when man used polished flint implements; the Arctic plants had disappeared, and at a later stage, as the climate improved, more southern species were able to establish themselves on British soil.

The testing of climate by means of fossil plants becomes easier the nearer we approach the present era; the greater the contrast between the floras of the past and those of the present the more hazardous it is to draw conclusions as to temperature. It is from a careful study of the anatomical characters of extinct plants that we are enabled to form opinions, not so much as to temperature, but as to the relation of the plants to water and light as indicated by those structural features which in recent species afford the safest index of external conditions. As our knowledge of recent plants increases and we learn more about the operation of the several factors concerned in the moulding of structure, the better able we shall be to speak with confidence as to the conditions under which they lived and extracted from the atmosphere the carbon from which we now regain the energy originally absorbed as sunlight by the green leaves of Palæozoic plants. As additional facts accumulate with regard to the geographical distribution of the plants of former ages we shall be in a better position to confirm or to modify the conclusions based on the material now available as to the comparative uniformity of climatic conditions in the Jurassic period. Much of the palæobotanist's work necessarily consists in the collection and identification of material preserved in sedimentary rocks, but one of his aims should be to acquire such knowledge of the present relation between plants and their habitats as may enable him to interpret with greater confidence the botanical records of former ages.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

Lord Kitchener has been elected rector of the University of Edinburgh by the unanimous vote of the students.

Dr. Sydney Chapman, who was elected a fellow of Trinity College, Cambridge, last year, has now been appointed to the staff of the college as lecturer in applied mathematics, and has resigned his position as chief assistant at the Royal Observatory, Greenwich. Mr. John Jackson, Trinity College, Cambridge, has succeeded him at Greenwich.

A copy of the new issue of "The Cambridge Pocket Diary, 1914–15" has been received from the Cambridge University Press. The diary appeals especially to teachers and students in institutions of higher education, because it covers the academic year instead of following the ordinary calendar.

By the will of the late Mr. William Gibson the sum of 10,000*l.* is bequeathed to Queen's College, Belfast, upon trust for investment and to form a "Gibson Scholarship Fund," of which the income is to be applied in the encouragement of education in agriculture by the establishment of Gibson Scholarships for resident undergraduates of the college, being sons of farmers in the counties of Down or Antrim.

The Manchester School of Technology possesses particulars of more than 550 students who were in attendance at the college during the academic year 1913–14 and are now serving in various branches of his Majesty's forces. With a view to the completion of a roll of honour, which shall also include the names of past students engaged upon military service, the registrar will be glad to receive any information from such persons themselves or from their relatives or friends.

The Martell Scholarship in Naval Architecture has been awarded by the council of the Institution of Naval Architects to Mr. F. J. A. Pound, H.M. Dockyard, Portsmouth, who is now proceeding to the Royal Naval College, Greenwich. The scholarship is of the value of 100*l.* per annum, and tenable for three years. The fund which is being raised in connection with the Institution of Naval Architects as a memorial to Sir William White has now reached a total of nearly 3000*l.*, and it has been decided to devote the principal part of the fund to the establishment of a scholarship for research work in naval architecture, particulars of which will be announced in due course.

It is announced in *Science* that Baker University, Baldwin, Kan., has completed its 100,000*l.* endowment fund, of which the general education board of New York gave 10,000*l.* The rest was contributed by 10,000 persons, the largest gift from any one of them being 5000*l.* The people of Baldwin, a town of 1200 population, gave 9000*l.* Central College, Fayette, Mo., too, our contemporary says, has completed a campaign to increase the productive endowment of the college by 60,000*l.* Of this amount the general educational board contributed 15,000*l.* This fund increases the endowment of Central College to 100,000*l.* The grounds, buildings, and equipment are valued at 60,000*l.*

An interesting indication of the effect of the war on American universities, says the *Scientific American*, is afforded in a statement given out recently from the chemistry department at Columbia University. According to that department, students who prior to the war had arranged to go to Germany to study now seek information as to the courses afforded in the United States, and it was estimated that when the University opened, the registration at Columbia in all of its departments would be materially increased through the students who cannot pursue their studies abroad. One of the courses which is especially attracting those who had contemplated a winter at the German institutions is that afforded in industrial chemistry.

The following free Chadwick Public Lectures will be delivered in London during the months November, 1914, to January, 1915:—November 14, 21, and

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[2] "Submerged Forests." Clement Reid.