GROUP OF PLANTS AND THE BOURNEMOUTH VALLEY IN "BAGSHOT" TIMES.

ORDINARY MEETING, JANUARY 5TH, 1877.

WILLIAM CARRUTHERS, Esq., F.R.S., President, in the Chair.

The following Donations were announced :—

“Abstracts of the Proceedings of the Geological Society,” No. 326; from that Society.

“Journal of the Society of Arts,” December, 1876; from that Society.

“Synopsis of the Acrididæ of North America,” by Cyrus Thomas, Ph.D.; from Dr. F. V. Hayden.

“First, Second, and Third Annual Reports of the United States Geological Survey of the Territories for 1867, 1868, and 1869;” “Supplement to the Fifth Annual Report for 1871;” and “Bulletin, Nos. 1 and 2,” first and second series; from Dr. F. V. Hayden.

“Meteorological Observations in Utah, Idaho, and Montana,” by Hy. Garrett; and in Colorado and Montana Territories, by G. B. Chittenden; from Dr. Hayden.

“Synopsis of the Flora of Colorado,” by T. C. Porter and J. M. Coulter; from Dr. Hayden.

“Descriptive Catalogue of the Photographs of the U.S. Geological Survey,” 2nd edition, by W. H. Jackson; from Dr. Hayden.

The following were elected Members of the Association :—

Arthur Bourne Briant, Esq.; Mrs. Murray; James W. Nevins, Esq.; R. T. Graham Nevins, Esq.; George Philip Nowers, Esq., M.A.; Ernest Westlake, Esq.

The following Paper was read :—

ON THE LOWER BAGSHOT BEDS OF THE HAMPSHIRE BASIN.

By JOHN STARKIE GARDNER, Esq., F.G.S.

Our President asked me, when we were at Bournemouth together during the past summer, to read a paper on the Flora of the Lower Bagshots of that district. This I, with some hesitation, undertook to do, and soon found that I was placed in this difficulty—I can give scarcely any *details* of the flora found in these beds, although it is, perhaps, one of the richest in the world, as but little is known with certainty respecting it, and any

determinations I might now hazard would only imperfectly forestall the careful work which Baron von Ettingshausen and myself intend to bestow on a monograph for the Palæontographical Society. Nor can I give a complete account of their geological problems, as there are still some few data in connection with them that require examination. I will, however, give a general account of the beds, their sequence, and the conditions, as they appear to me, under which they were deposited.

I will first endeavour to give some idea of the aspect of this district. [A bird's-eye view taken from near Corfe Castle looking in an easterly direction, and a series of diagrams showing portions of cliff sections, representing in detail the appearances presented by the cliffs, were exhibited in illustration of this portion of the paper.] It is from the cliffs principally, and from the deep cuttings of the recently-constructed railway from Bournemouth to Parkstone, that our knowledge is derived. There are, in addition, the diggings carried on for commercial purposes.

Let us commence by visiting the diggings near Wareham. If we examine the cliffs and banks we there see, we find them composed of clays dark or white, or red and white mottled, of layers of coarse grey grit, and of sands of every shade of red, yellow, and white, and some are variegated. Often the sands have angular lumps of clay imbedded in them. The quarrying is mostly done in open pits, the clay being dug out perpendicularly with a long and narrow spade. Some of the deeper seams are mined, and a considerable depth is reached in Mr. Pike's workings; and at Branksea similar pipe-clay is worked under the sea level.

Overlying the pipe-clays we find another series of deposits, which are not here quarried for use, but are looked upon as refuse, but near Bournemouth are dug into in many places for the brick-earth contained in them. They are easily distinguished by the darker colour and more sandy nature of the clays. These drab clay basins are of smaller extent, and are full of remains of decayed leaves, and contain actual seams of coal, which is burnt by the villagers.

In the sheltered bay of Studland we can see but little of the cliffs, as they are now mostly overgrown to the very beach. We are struck, however, by the coloured sands, which forcibly remind those of us who are familiar with them of the still more brilliant

hues of the sands at Alum Bay. After crossing the inlet of Poole Harbour, and walking along the beach towards Bournemouth, we find the coast for the first mile composed of hills of blown sand, beyond which the cliffs we have been viewing from a distance rapidly rise.

These cliffs are themselves of rather monotonous appearance, being devoid of the brilliant colouring so conspicuous at Alum and Studland Bays. Their colour varies from buff to white, and from white to slate colour. We notice apparently endless successions of clays, sands, and grits deposited at different angles and without any single bed being traceable for more than a few yards. The cliffs extend, preserving the same characters, for a distance of four miles, to near Boscombe, where we notice a change in their composition. The clays are now black and still more sandy; the upper parts of the cliffs are far less steep, and seem composed of loose white sands and shingle, with a thick capping of gravel.

At length, still further east, in consequence of the general dip of the strata, these beds disappear beneath the sea. The sand beds which follow, when they cap the cliffs, are recognised from a great distance by their greater slope from the cliff shorewards, for they are so loosely composed that every wind blows the sand away in clouds, and leaves the shingle to rattle down on to the beach. So loose is this material that that part of the coast line which had cliffs composed of this sand has now but cliffs of insignificant height; all the sand has been blown by wind and wasted by rain, until the shingle only has been left. This is the cause of the land connecting Hengistbury Head being much lower than any other in the neighbourhood. The shingly beds are ancient sea beaches, and the slope of them to the ancient sea can still be seen in places. So long have they been exposed that the flint pebbles in them are sometimes almost decomposed, the familiar white coating of the flints being an inch or more thick.

At the peninsula of Hengistbury Head, about six miles beyond Bournemouth, the cliffs again rise, being at first composed of black, chocolate-coloured, and white sands, with pebbles; and, further on, of green clayey sands containing nodules of large irregularly-shaped concretions of sandy, argillaceous ironstone disposed in layers. Beyond Christchurch Harbour we have cliffs of white sand, which, according to my views, close the series. No order of arrangement is at first apparent in these beds, but

by going backwards and forwards over the ground attentively there is, it seems to me, a very well-marked and recognisable sequence.

I would refer to this diagram where I have expressed my reading of this district. This lower fresh-water series is seen in the neighbourhood of Corfe, and forms part of the cliffs at Studland. It is characterised by abundance of pipe-clays, and forms a thickness of possibly 200 feet.

The Middle Fresh-water series, also met with near Corfe and at Studland, forms the whole thickness of the cliffs between Poole Harbour and Bournemouth. We thus have a magnificent section four miles long and 100 feet in height. Branksea Island is also formed of this series. The entire thickness cannot yet be accurately estimated, but may be put down at some 300 feet. This series is characterised by the clays contained in them being usually brick-earth.

The next series above is Marine, and some 400 or 500 feet thick. The base beds are dark sands and clays, succeeded by pebble beds and sands, then more sandy clays with pebbles, and ending with a thick deposit of white sands. This Marine group of strata occupies the cliffs between Boscombe and High Cliff.

That this is a correct interpretation of the order of deposition of these beds is shown by the Alum Bay section, where the whole of these beds are upheaved vertically. We see in succession the lower pipe clays, the brilliant sands, the darker clays, sands, and pebble-beds one after the other, so that we can examine them in detail within the space of a few hundred yards. The thick pipe-clays and quartzose grits which we find at the bottom of the series can without the slightest hesitation be referred to the result of the wearing away of granitic rocks.

At Studland the grits are not so coarse, and at Alum Bay, a long way east, the sands are very fine; so that any one knowing the district can tell which of two specimens came from either

place. Each clay patch represents a small lake, first scooped by the running water out of the beds just previously deposited, and then filled in by sediment. The size of these old lakes is very well seen now wherever a clay basin has been quarried away, and seems to have been from about one quarter to three-quarters of a mile in circuit, whilst their depths have varied from 30 to 60 feet. These clays extend under the surface eastward, for they are worked at Branksea under the sea level, as well as at Parkstone, and near Bourne. At Alum Bay they are tilted up, and are full of fossil leaves.

The next series of beds above mark a great change in the conditions of the land. The clay patches are of smaller extent, being the filling in of mere ponds or puddles. The change indicated by these beds is one from the valley in which the last described beds were deposited to a broad low-lying tract in proximity to the sea. That this tract became gradually lowered and lowered down to the sea level is shown by the fact that in the cliffs near Poole, which are slightly lower in position than those farther east, we get only leaves of evergreens and forest trees, whilst as we work our way east, so as to meet with beds on a higher level, or, which is the same thing, of more recent age, we get a mixture of ferns and other plants, which require much moisture; whilst farther east still we get assemblages of plants that could only have lived in absolute swamps.

Low as the land appears to have become, we have no evidence whatever, throughout the whole thickness of this part of the series—amounting to 300 feet at least—that it was low enough to be inundated by the sea, as the few shells that have been found are of fresh-water kinds, with this exception—the occurrence of logs of wood bored by the *Teredo*. This isolated fact for some time presented a grave difficulty, but happening to read in Mr. Gwyn Jeffries' interesting account of the habits of this creature, I not only found that he relates the occurrence of similarly bored wood 300 miles up the river Gambia, but the distinct statement that there is a species which lives in fresh water. Therefore this supposed indication of marine condition may be disregarded, and we may safely infer that these Middle beds are fresh-water.

We now come to the third series of beds. A still continued sinking of the area brought this swamp so low that the sea

was no longer kept out, and, bursting through, formed great salt-water lagoons teeming with life, for we suddenly find crowds of marine forms imbedded in what was formerly blackmud.

In this series of marine beds we have at the bottom lagoon beds, as I call them, indicating the former existence of mud-banks left dry or shallow between each tide. We still find here leaves of trees, many of them doubtless overhanging the lagoons, which have so slowly decayed that they are overgrown with Polyzoa. Crowds of oysters are met with. We find the remains of shore-crabs, which overran the muddy shore, and the *Callianassa*, which bored through the mud; *Calyptræa*, *Arca*, *Corbula*, and many other shell-bearing molluscs. The Crustacea I have placed in the hands of Mr. Woodward for examination. The Mollusca are in the condition of casts, but are quite recognisable. They are forms, however, which are mostly common to both the Bracklesham and the Barton beds.

This lagoon condition continued until the gradual sinking had permitted the ever-encroaching surf to break over the lagoon barrier, and to overwhelm them with rolled shingle and sea-sand. Evidence of the lagoon condition can be traced for a mile or so east, where it has left cigar-ash coloured sands, impregnated with salt and coloured by a dark tint of carbonaceous matter. These sands contain very imperfect remains of branches of a coniferous tree resembling the genus *Dacridium* and large pieces of *Cactus*. It should be mentioned that this is the earliest cactus known, and that the spines are found to be still flexible. The sands are in other places crowded with fossil fruits, notably the Pandanus fruit, *Nipadites*, something like those met with at Sheppey. Unfortunately the salt contained in them effloresces and splits all these specimens into fragments.

We have in the series of beds, the aspect and formation of which I have endeavoured to describe, a total thickness of perhaps somewhere about 1,000 feet. We read in Lyell's "Principles of Geology," and other works, that river and delta deposits are accumulated with comparatively great rapidity, as in the case of the Rhone delta above Geneva, which has advanced $1\frac{1}{2}$ miles in historical times. Throughout the Bournemouth district we have, in the great and sudden deposits of coarse grit, evidence of quick deposition. We also find leaves folded over with half an inch of sediment between the folds, and leaves sun-cracked and divided with

that or more difference in level between the segments, which also shows extreme rapidity of deposition; and although we have proof that we in some cases see the actual soil in which *some* of the smaller plants grew still penetrated by their roots, there is no evidence of its having been long occupied, or that it indicates more than a rapid fern growth between recurring floods. We have further the fine state of preservation of some of the leaves, which have been doubtless buried before decay set in, and in the breaking up and redeposition of beds, evidences of rapid accumulation; yet we must not hastily conclude that the time required for the formation of these vast deposits, was, even geologically speaking, short; for, on the other hand, beds are seen one above another which have been cut through and carried away after they had become consolidated—that is, after the muds had become so hard that they have resisted the dissolving power of water, and been rolled and redeposited as pebbles and boulders.

The same spots may have been again and again silted up and denuded before the beds finally remaining were covered up; the same material has been rearranged by different currents perhaps a great number of times, whilst the constant unconformability of the strata may indicate periods of rest or great lapses of time. All our facts as to the depression of areas tend to show that it is an extremely slow and imperceptible process, slower still when the general depression is intermittent. We have further a totally different kind of evidence, which to my mind is still stronger, of the vast ages that rolled away during the deposition of these beds. This is the significant fact that the entire marine fauna was completely changed. By this I mean that we have in the London Clay a fauna which migrated away—a fauna familiar to us, and characterised by great nautili and other shells, and Crustacea peculiar to it. In the succeeding Bracklesham Beds we have another totally distinct fauna, so that the time of the land period was sufficiently great for the fauna of the London Clay sea to be entirely changed before the return of the sea whose fauna we have recorded in the Bracklesham Beds. In the Barton Beds which overlie the Bournemouth deposits we have again an extensive fauna most distinctly characterised and widely separated from that of either of the preceding beds just mentioned. In many cases it is recognised that variations in fauna are

dependent upon the depth of the sea ; but such cannot be the case in this instance, since we get species belonging to the same genera so closely resembling each other that we cannot but infer that they lived under similar conditions. And when we come to see, as we do, that this applies to all the groups, the inference drawn from one individual group accumulates to an evidence which presents itself as at any rate approaching certainty.

The well-known case of the differences in the fauna of the Red Sea and the Mediterranean, which are separated by so narrow a strip of land, has been often referred to as a possible explanation of how different fossil faunas occurring close together may have existed contemporaneously, and do not imply any lapse of time during which changes of climate occurred ; but although in many cases it is impossible when a purely hypothetical theory is brought forward to bring an argument to disprove it, yet in this case there is no evidence whatever in its favour, and what little evidence there is bearing on the question is directly opposed to it ; therefore the other seems the more reasonable explanation.

The great changes in the flora, which I shall mention to you, although principally due perhaps to the great change of level of which we have other indications—may also indicate long lapse of time—long enough, as I have said, for the marine fauna of Bracklesham to develope—to disappear and give place to that of Barton.

I do not know whether we shall ever be able to estimate geological time, but astronomers tell us that a cold period recurs about every 26,000 years, and it seems to me to be probable that we may get some data in this direction on which we may build our hypotheses. In the English Eocene we appear to have the deposits of a cool period as shown by the Mollusca of the Thanet Sands. The Plastic Clay may represent a cold period, the London Clay indicates, as we all know, a hot period, becoming cooler in the Lower Bagshots and again reaching a tropical character in the Bracklesham Beds epoch. The overlying Barton Beds indicate a slightly cooler condition, again becoming tropical in the Headon Beds of Hordwell ; the Bembridge and Hempstead Beds show a decreasing temperature, quite temperate at the top of the latter. In the Miocene, Heer has ascertained that there was an increasing temperature. Each cool period was not necessarily a glacial one, and even had glacial conditions ever prevailed in Eocene times, it

is hardly possible to conceive that land vestiges of glaciers could have escaped complete obliteration.

I will now call your attention to the leaves.

These leaves are found in various conditions of preservation. In most cases the impression only of the leaves in the clay is met with, but in some cases they are so well preserved that the actual substance has been retained, although chemical changes have altered its composition, and will peel off and blow away. In some of the clays the masses of leaves are so decayed and rotted that they cannot be recognised, and are not worth our collecting. Where the preservation is good we can readily distinguish the various original textures of the leaves by comparing their general aspect and colour both among themselves and with existing forms. For instance, those which are thick, as evergreens; thin, as convolvulus; hard, as oak; or soft, as lilac; or even velvety, as the common phlox, can all be recognised. Their colours, in most of the beds, vary from buff to brown. Whilst these various shades of dark buffs and browns are in many cases the result of chemical change that has taken place after the leaf was covered up, yet I believe that in many cases this change had occurred, at least partially, before the covering up, just as we saw a few weeks ago the changed colours of the fallen leaves of autumn. In the darker clays the remains are black and completely carbonised; where this is so the finer venation is indistinct and the remains difficult to save, so that we may discard them unless the outline of the leaf is of unusual form. The darker browns, I take it, indicate hard and evergreen leaves; for instance, the laurel-like leaves are always of a deep colour, whilst both the thin and the succulent leaves are always of light colour, as in the leaves which we suppose to be fig, some species of *Smilax*, &c. No other colours have been met with, with one remarkable exception; fragments of a reed-like aspect are found of a deep violet, staining the surrounding clay mauve for a considerable distance.

These deposits, which have been neglected by geologists, are of extreme importance, as being one of the few records we have of land surface. The rocks in which organic remains are found are aqueous rocks, principally marine; the remains of aquatic animals are more numerous than of those living on land, and are for the same reason far more numerous than remains of plants. Such facts as these give great interest to series of land remains of so

complete a nature. We can form an idea of how incomplete our terrestrial records are when we consider that whilst upwards of 4,400 plants are found growing in Great Britain, about 700 only are known fossil, whilst 513 testaceous Mollusca now inhabit Great Britain, and 4,590 were known fossil as far back as 1862. The beds are believed to be of the same age as the great series of beds at Bagshot Heath, described by Prestwich, in 1847.

The Bournemouth flora appears to consist principally of trees or hard-wooded shrubs, comparatively few remains of the herbaceous vegetation being preserved.

Parasitic fungi are abundant. Ferns, extremely rare in the lower part of the series, become abundant, as far as the remains go, almost to the exclusion of other vegetation towards the close of the middle period. The prevailing group seems that of *Acrostichum*, of which several species are present. We can also determine with almost certainty the presence of *Angiopteris*, *Anemia*, *Nephrodium*, *Gleichenia*, *Lygodium*; there are, besides these, several undetermined forms.

Of conifers we have *Cupressus* and *Taxodium* determined by De la Harpe, with the addition of *Dacridium*, and indications of *Pinus*. Cycads have disappeared.

Fig. 2.

BRANCH OF CONIFER

Of Monocotyledons we have plentiful remains of reeds and rushes. Screw-pines are represented by *Nipadites*. Palms are very abundant, especially in the lowermost beds of Corfe and Studland, and the upper middle beds of Bournemouth. Massolongo has determined *Chamæcyparites*, in addition to which many fan and feather palms exist belonging to *Flabellaria*, *Sabal* and *Phœnicites* and a genus new to the Eocene, *Iriarteia*. A gigantic Aroid is also very abundant, and the *Smilacææ* occur in all the fossiliferous beds throughout, and are represented by at least five or six species.

The Dicotyledons are most abundant, and it is probable that a vast number of species will be determined from these beds. De la Harpe's list included, in 1856:—

APETALÆ.—*Populus*, *Ulmus*, *Laurus*, *Quercus*, *Artocarpidium* ; and *Daphnogene* is since added, fide Massolongho ; to which we may now add *Carpinus*, *Fagus*, *Castanea*, *Salix*, *Platanus*, *Ficus* (abundant), *Celtis*, numerous *Proteaceæ*, *Cinnamomum*.

Fig. 3.

GROUP OF MONOCOTYLEDONS

POLYPETALÆ.—*Elæodendron*, *Rhamnus*, *Prunus*, *Juglans*, *Cluytia*, have been already noticed by De la Harpe. We add, fide Massolongho, *Ceratopetalum*, and, as new to the Bournemouth flora, *Acer* (Many sp.), *Dodonæa*, *Celastrus*, *Eucalyptus*, and a number of *Leguminosæ*.

MONOPETALÆ.—De la Harpe has determined *Diospyros*. To this may perhaps be added *Porana*.

To Eocene Dicotyledons we may here add for the first time, amongst many others, *Cactus* and *Stenocarpus*.

In addition to these we have probably represented almost every genus described from Continental Eocene floras, but it is premature, for the reasons already stated, to go farther into this question at present. The forms I have mentioned will give a general idea of the composition of the flora.

It has been very generally noticed by students of the fossil Tertiary floras, that the Eocene vegetation presents us with types

Fig. 4.

LEAVES OF DICOTYLEDONS.

peculiar to the Southern Hemisphere, and related to those of Australia and the adjacent islands. We may cite, for example, the *Eucalyptus*, Proteaceæ, many Leguminosæ, and Coniferæ, whilst of the figs, although we cannot speak of them so positively, we see that they bear a striking similarity to forms now existing in Australia.

Unger* has speculated upon the manner in which the vegetation of a continent situated at our very antipodes could have found its way hither, and supposes that the route they have taken must have been by way of Asia, as the ranks of this Australian flora seem to have been largely recruited on the way by Asiatic forms. The Challenger chart, however, affords another hypothesis.

* "New Holland in Europe," Journal of the Botanical Society, January, 1865, p. 12.

Mr. W. S. Mitchell, who some time ago devoted much time to the study of these floras, called attention to this in "Nature," a fortnight ago, in the following note:—"There is a narrow belt of sub-oceanic highlands extending in a sinuous course down the length of the Atlantic, as shown in the Challenger chart, which removes a difficulty that has been present to students of fossil botany. When the area was land, these hills would probably form a ridge sufficiently high to have a temperature cool enough to explain the migration across the tropics of plants living in a temperate or even cooler climate." We may, therefore, now infer from the presence of *Banksia* and innumerable other instances of Australian forms, both faunal and floral, that a once continuous area has been broken up, and that many physical changes have taken place. As an additional proof of this I may mention, that it is stated by Unger that many European plants existed in Australia before it was discovered by us.

A fact still to be ascertained is whether the flora now confined to Australia predominated in all suitable regions of our hemisphere during Eocene times, and especially whether it *then* grew in Australia—whether it spread from Australia here, as Unger supposes, and has perished everywhere but in its habitat; or whether its original *centre* was in Europe in Eocene times and has since *migrated* to Australia. The *Miocene* flora is distinctly stated by all who have investigated the subject, to have remarkable generic and ordinal analogies with that which prevails in North America at the present time. A certain proportion of Western forms, such as oak, maple, poplar, is seen in the list I have read of our Bournemouth flora to be mingled with the Australian-like vegetation just mentioned, foreshadowing the greater arrival of Western forms which occupied Europe at a later time. The almost complete change of flora in the Miocene, from the flora prevailing in the Eocene, is not such a change as we should find brought about by lapse of time alone. It may more probably be accounted for by the intervening occurrence of a cold period such as we see shadowed in the Hempstead Beds at the close of the Eocene, during which the colder temperature closing in from the north drove the existing vegetation south. On the recurrence of suitable conditions, the western flora occupied the grounds, which we may suppose the southern forms were unable to re-occupy from some cause, such as the impossibility of their recrossing the

Equator owing to the depression of the high-land ridge, or other causes which are so obvious that it is needless to bring them forward here. It is probable, on botanical evidence, that this American fauna, came by way of the Aleutian Islands* and Asia, and not direct by way of an Atlantic continent or island, as supposed by Unger.

Jukes' remarks that "there is perhaps a closer relation between those recently extinct European genera of animals and plants and the existing North American ones, than there is between the latter and the present European genera." "The present European flora may be of more recent date than that of North America; genera and species once common to both have remained less changed in North America than in Europe, where they have become extinct and been replaced by other forms. The climate has possibly altered less there in Glacial times than here." As the present North American flora has not materially changed since Cretaceous times, there can be no doubt that it is the progenitor of a large portion of the European Miocene flora. If the Australian flora should be found to be more ancient than our Eocene period, it would follow that the greater part of the European Tertiary floras known to us were not indigenous, but introduced from other lands.

It is solely, with the exception of glacial and possibly pluvial evidences, from the nature of the animals and plants that have left their remains in the rocks, that we can draw any certain conclusions as to the kind of climate possessed by different parts of the earth where animals and plants lived. When we find in the British Islands the remains of crocodiles, turtles, large nautili, together with palms and other plants of tropical aspect, we cannot resist the conclusion that the climate of the British Islands must have been more like that found in the Tropics than that which they at present possess. From the abundance of palms and figs, and other tropical plants, we might infer extreme heat, whilst the *predominance* of evergreens implies at least an absence of severe winter cold. The presence of more temperate forms has, however, to be taken into consideration.

The question arises as to how it is possible that the tropical forms, such as the ferns, palms, aroids, *Cactus*, *Pandanus*, &c., could have grown alongside of the apparently temperate forms, as, for example, the oak and beech, and the Australian *Myricaceæ*,

* Olliver, "Natural History Review," April, 1862.

Proteaceæ, Cupressinæ, &c., which also denote a climate but little warmer than ours. There have been for the area which is now England many alternations of long periods of heat and cold. Whenever the area became warmer, the descendants of semi-tropical forms would gradually creep further and further north, whilst the descendants of cold-loving plants would retreat from the advancing temperature *vice versâ*, whenever the area became gradually colder, the heat-loving plants would, from one generation to another, retreat further and further south, whilst the cold-loving plants would return to the area from which their ancestors had been driven out. In some cases the palms may be but remnants of the retreating vegetation preserved in sheltered spots near the sea-shore, and protected by the influence of warm currents.

It must, too, be borne in mind, that it is not so much the mean temperature of a whole year which affects the possibility of plants growing in any locality, as the extremes of summer and winter temperature. For example, one place may have a mean winter temperature of 50°, and a summer one of 70°; while another place might have a mean winter temperature of 20°, and a summer one of 100°, and yet both have a mean *annual* temperature of 60°. At Glengariff, in the West of Ireland, in the midst of a northern vegetation, we find sub-tropical forms as *Trichomanes radicans*, *Hymenophylla*, mosses, Hepaticæ and lichens now only elsewhere met with living in the Antilles and Mexico.

I have repeatedly been surprised in North Germany to find large palm-houses kept at temperatures which struck me as quite chilly, no heat being applied in summer, and but just sufficient in winter to keep the frosts out. At Hanover there is an example of this, in which case the palms have so far outgrown the size of the house that they have to be sunk in wells several feet deep, and have so spread that they seem in danger of suffocating each other. In a fernery of our own, simply glazed, the European palm and sub-tropical ferns grow without any artificial heat whatever, and withstand a considerable amount of frost. It is not so much the cold during the period of winter quiescence which destroys plants as the unexpected chills of spring, after the sap has commenced to rise. Southerly forms may, therefore, grow many degrees further north, where, with even a severe winter, the spring is unbroken.

Darwin reports that the island of Chiloe 42° S. lat., which enjoys but little summer heat, and is enveloped in continual rains

and mists, possesses an extraordinarily rich flora, recalling that of Brazil. The tropical forms push farther south, in spite of apparently less favourable climatal conditions, in consequence, probably, of the more equable temperature produced by the greater preponderance of sea. Perhaps Europe in Eocene times, divided and in great part submerged, approached nearer in climate to Chiloe. Looking, however, at the extremely tropical nature of the fauna of the Bracklesham and the London Clay beds, there can be no doubt that a high temperature did prevail—at all events, during a part of this period. The fact of the existence of remains of plants being found opposite Disco, in latitudes which at present have three or four months' darkness and a cold temperature, is still most difficult to explain.

When we draw inferences as to climate from plant remains we must consider how far differences of level account for different floras. According to the height of the land on which the trees grew, of which leaves were floated down, might depend the more or less tropical or temperate aspect of the flora. On the southern slopes of the Tyrol I have frequently passed from an Alpine region to plantations of sugar-canes, oranges, &c., in a few hours. Ascending from the sea at the Equator to the summit of the snow-capped mountain, we should find as much change for every hundred feet vertically as we should in travelling towards the Pole in hundreds of miles laterally. According to Meyer, we should reach the level of figs at 2,000 feet, myrtles and laurels at 4,000 feet, and evergreens at 6,000; European dicotyledons at 8,000. Supposing the leaves to have been brought down from these different levels, we should have an explanation of the mingling of forms and the localised character of the flora of each clay-patch. But I fear this explanation must be rejected, as we have no evidence in the condition of the leaves of any such distant transport as this would imply, but the evidence tends to show that the leaves must have grown close to the spot in which they are buried.

Some of the patches contain leaves which appear to have had a very barren and sandy soil to grow upon, and are characterised by small hard lanceolate leaves, as if of scrub bushes. Where in these patches a leaf is met with which is common to other beds, it is dwarfed. Other beds seem to show an extremely luxuriant soil and very sheltered condition.

It will have been gathered from the anniversary Addresses of

our President that the remains of plants are, if possible, of more interest and importance than those of marine animals, as whilst we have already *some* idea of the succession and development of animal life, especially of the more purely marine Orders of Crustacea, Mollusca, Echinodermata, &c., we know very little of the history of the development of plant life. Our President laid stress on the somewhat sudden occurrence of dicotyledons as being unfavourable to the hypothesis of evolution in descent. I concur with him fully that it is difficult to realise that the absence of dicotyledons can be due to any cause but their absence from the then existing vegetation; yet there are certain causes tending to make their preservation difficult, which, perhaps, may be taken into account.

Some kinds of coniferous plants resist decay when immersed in water more completely than do almost any dicotyledons, and this resistance may, owing to their resinous nature, be very greatly increased when the immersion is in sea water. This supposition is borne out by a fact I have noticed, that in some Eocene beds, such as the marine beds at Bournemouth, the Bracklesham Beds, and the Bembridge Marls, coniferous remains preponderate, whilst from the two latter places I have never seen remains of dicotyledons at all, although there is evidence in these cases that dicotyledons were abundant on surrounding land areas. This may partly account for their complete absence in marine Cretaceous rocks in England, where, as in the Gault, &c., foliage, fruit, and resinous gums in the form of amber, the remains of Coniferæ, are preserved. The foreign Cretaceous rocks in which dicotyledons are met with, are principally, I think, of fresh-water origin. It should be borne in mind that our Chalk period contains a deep sea fauna, and we have no record in England as to what were the prevailing contemporaneous forms of life on land in other regions.

I have great doubts as to the correct position of many of the foreign so-called Cretaceous beds. Those of America, from which most of the list of dicotyledons of this period are derived, appear to me, from the character of their fauna, to, perhaps, fill in the gap between our Chalk and the Lower Eocene. Most of the shells have a marvellously Eocene-like aspect, and I take it that the presence of ammonites and some few other forms of shells, which in England do not range above the Chalk, should not be taken as conclusive evidence of the antiquity of

a bed, as, although extinct in our seas, they may very well have survived in other regions. It is inconsistent to assume that no ammonite lived in any part of the world to a more recent period than that of our Chalk. The finding of *Pleurotomaria* and other supposed extinct Cretaceous shells in Australian waters should not be forgotten. The same doubts apply to many of the European leaf-deposits. Many of these are isolated patches, and their age has been inferred rather from the character of the leaves than from their stratigraphical position. The age of many of the so-called Miocene leaf-beds is admitted now to be extremely doubtful. What little evidence we may expect to find in these beds seems to me likely to be in *favour* of the theory of evolution, although, until the flora has been worked out, it is premature to offer an opinion. By far the greater number of the plants belong to the lowest division of the dicotyledons, the Apetalæ, a minority are polypetalous, whilst not one, as far as I know, can with certainty be assigned to the highest (according to Haeckell) group—the Monopetalæ.

Professor Ettingshausen has traced the gradual development of some of the Miocene forms into existing species—notably that of *Castanea atava* to *Castanea vesca*. When he was here last summer, and saw my collections, he especially picked out the *Castanea* from Bournemouth as carrying the history of this genus a step farther back, linking it with the oak, as it possesses an oak-like character of venation.

I would merely add that many botanists, as Unger, Schimper, and others who have studied fossil plants, are profoundly impressed with the amount of evidence that has already been brought forward in support of the theory of evolution.