as to the general character of them—in this one the greater part of the shell is preserved; (*b*) shows only a cast—nearly all the shell having chipped away. The drawing is full size.

The shells are extremely thin and fragile, but the structure and markings are perfectly preserved and the nacreous lustre is still quite brilliant. I have no doubt but a palæontologist visiting the locality, and having leisure to make a careful examination, would find many perfect specimens capable of determination, and probably other species as well. In the mean time it is right to place the matter on record—seeing that this place is, so far as I know of, the only locality in the British Isles yielding lacustrine fauna of Pliocene date.

NOTICES OF MEMOIRS.

I.—On Certain Pre-Carboniferous and Metamorphosed Trap-Dykes and the Associated Rocks of North Mayo, Ireland.[1] By William A. Traill, M.A.I., F.R.G.S.I.; H.M. Geol. Surv., Ireland.

THE author first described the locality as situated in the N.W. of the Co. Mayo, between Downpatrick Head and Broad Haven; and referred to the geological map of Sir Richard Griffith. The physical features of the district presented precipitous coast sections, attaining elevations of 352 ft. at Keady Point; 640 ft. at Benwee Geevraun; and 829 ft. at Benwee Head, and would compare favourably for grandeur and boldness of scenery with many better known localities. The geological formations composing the district belong to the Carboniferous and Metamorphic rocks. The older or Metamorphic rocks lie to the westward, extending from Broad Haven to the Glenglassera river, and consist of flaggy quartzites and micaceous schists, with partings of mica-schist; the mica is often largely crystallized out in hexagonal plates in nests or veins. Foliation is seldom developed, but the original bedding is still clearly retained, with a primary dip E.N.E. at variable angles. They are often much crumpled, contorted, and overlapped, more particularly in the western portions.

The newer or Carboniferous rocks lie to the eastward, and include the Carboniferous Limestones to the S.E. of the district, and the Lower Carboniferous Sandstones and Shales, the bottom beds of which are brought to the surface near the Glenglassera river. These latter comprise white, yellow, and red sandstones, with partings of red and green shales. They dip E.N.E. at from 3° to 8°.

They rest unconformably on the Metamorphic rocks. At Fohernadeevaun, at the mouth of the Glenglassera river, this most remarkable example of unconformability is best seen; it occurs at one side of a fault along which the sea has worn a narrow but deep chasm; the flatter Carboniferous beds dipping at 5° rest on the more highly inclined Metamorphic rocks dipping at 25° to 30°.

[1] Read before the British Association for the Advancement of Science, Section C Geology, Glasgow, September, 1876.

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The lowest or basal bed of the Carboniferous series is a conglomerate of from one to four feet in thickness, composed chiefly of fragmental vein quartz and pieces of the Metamorphic rocks; it merges imperceptibly into the overlying sandstone beds, and there is no break of continuity. In the geological map referred to, there was represented a band of Devonian rocks intermediate between the others, which he (the author) in all due deference called in question, and which he believed did not exist, the thin conglomerate bed undoubtedly belonging to the Carboniferous series.

The intrusive igneous masses which so abundantly penetrated the rocks of the district, as Trap-dykes, occur in both the Metamorphic and Carboniferous areas, but more abundantly within the former, and belong to very different ages; the one set being Pre-Carboniferous, and the other Post-Carboniferous, and possibly of Tertiary (Miocene) age.

Both classes of dyke may be considered as primarily belonging to the basaltic type, but the one seems in part at least to have been considerably altered by subsequent metamorphic actions. Both sets penetrate the older or Metamorphic rocks, but only the second set the Carboniferous beds.

Though in many respects closely resembling each other, there are certain characteristic distinctions peculiar to each, specially the peculiar weathering of the older dykes, which on the exposed surfaces showed a crystalline white mottling of the weathered felspar crystals through the dark green base.

The junction of the Carboniferous with the Metamorphic rocks being mostly obscured, the direct evidence of the older dykes ending off at that junction was not obtainable, and not finding any *in situ* in the Carboniferous area was only negative evidence; but after long search, undoubted fragments of those characteristic older dykes were found in the conglomerate or basal bed of the Carboniferous rocks, thus proving unquestionably the Pre-Carboniferous age of those dykes.

The older dykes occur mostly in large sheets from 10 to 150 feet in thickness, and are approximately interbedded among the Metamorphic strata, and often contorted with them, though often themselves the cause of the minor crumplings; occasionally they are folded back on themselves, forming large *S* curves.

Instances of these were described and specimens exhibited, from Benmore, and from Belderg Harbour, where the exposed part seems to be the top surface of the sheet, consisting of large humps and bosses protruding through the quartzites and schistose beds. In this typical example, the effects of the metamorphic action at different depths was well shown, the central part being a hard, heavy, and splintery dark steel-blue, micro-crystalline basalt, passing into a fibrous hornblendic schistose rock, with soft green chlorite and nests of green hexagonal chloritic mica, and towards the exterior becoming very schistose, platy, and micaceous, resembling a black or bronze mica-schist; in part these might be considered as Diabases. The felspar seems to be plagioclastic or triclinic, and on the weathered parts shows as characteristic white crystalline mottlings through the finely crystalline greenish base.

Adventitious minerals are developed in this and other similar dykes, in nests and aggregations, such as mica, chlorite, epidote, garnets, hornblende, quartz, calcite, and varieties of felspar and iron pyrites.

At Laghtmurragha and Glencalry other dykes were described, belonging to this class. Among these the hexagonal and spheroidal structures are never developed, and they are scarcely ever found to be vesicular or amygdaloidal.

The second series or Post-Carboniferous dykes are probably of Tertiary age, and seldom here attain a thickness of over 25 feet, and generally run in straight and definite directions W.N.W. and E.S.E., apparently filling vertical cracks or fissures, or along lines of faults. When occurring together, they always cut the sheet-like dykes of the older series; they are basalts with local variations, and are frequently hexagonal or spheroidal in structure, often amygdaloidal and decomposing, thereby leaving the original fissures open or enlarged into narrow chasms penetrating the cliffs. One of these separates Illanmaster from the mainland, another forms a chasm between vertical walls 450 feet deep, and in part scarcely 10 feet wide, and separates four small islands from their respective headlands, the view looking down this cleft, with its four pairs of opposing perpendicular cliffs on either side being almost unique.

II.—Geologists' Association—Inaugural Address by the President.

Evolution of Plant Life.

On November 3rd, Mr. W. Carruthers, F.R.S. (the Keeper of the Botanical Department of the British Museum), gave the Presidential Address to the Geologists' Association, in the Library of University College, his subject being a comparison of the history of plant life preserved in the rocks so far as we know it, and its relation to the theory of evolution.

The origin of the existing organic forms has always been a question of interest. Until a comparatively recent period little diversity of opinion prevailed in regard to this matter amongst students of science in Europe. The position stated by Moses in the opening sentences of the Old Testament, in which all matter, organic and inorganic alike, is traced to the operation of an external and supernatural Creator, was universally adopted, though it was often misunderstood and misinterpreted by its expounders.

In the beginning of this century Lamarck proposed his Evolution theory, according to which all organisms are derived from some few simple original forms, which had come into existence by spontaneous generation out of inorganic nature. Although Lamarck's theory found a few supporters, it was comparatively neglected by men of science until Darwin, in 1859, published his "Origin of Species by Means of Natural Selection," which, at least in this country, has wrought an almost complete change in opinion as to the origin of our present life forms. His theory of development as applied to the Vegetable Kingdom may be thus briefly stated:—The characters of plants are transmitted to their descendants. New characters besides those inherited may arise in some descendants which were not possessed by the parent. When these new characters are transmitted, and are permanent, the plants possessing them become a variety. Some plants have a special tendency to variation; others are remarkably constant in their characters. No explanation has been given of the reason for these differences in the nature of plants or of the cause of the appearance of new characters. The differences are at first small. Their continuance depends on external causes. In course of time new characters appear, or the old become intensified, and in the struggle for existence the varieties only which possess the characters best fitted to resist the prejudicial influences that surround them are able to maintain their ground. The less fortunate varieties perish, and in this way the connecting links between the common descendants of the original stock are destroyed. These descendants becoming more pronounced in their characters are recognized as species. The only difference between a variety and a species is the amount of divergence and the constancy of the characters. Further, this in a greater degree is the only difference between a species and a genus. It is accordingly concluded that all the forms now observed in the vegetable kingdom are due to the continual accumulation of differences in the genetic evolution of these plants from the one or the few simple original forms. It is held that the natural system of plants is the external expression of this phylogenesis, or genetic relationship, that the development of a plant from the embryonal cell to the perfect individual is a short and quick repetition of the genetic development of the tribe to which it belongs, and that the rocks of the earth reveal, so far as the record of life is preserved, the various steps by which the phylogenesis actually was accomplished.

Mr. Carruthers proceeded to draw attention to this last aspect of the subject, as that which specially affects geologists. It deserves careful investigation, for if the theory of evolution be true, then the fossils which have come to our knowledge represent as far as they go the extinct progenitors of existing plants, and on this account possess a higher interest to us than their comparative anatomy or systematic position can give to them. Reference was made to the imperfection of the geological record, but it was urged that it was right to compare our knowledge of it as far as it goes with the theory. What, then, is the phylogeny of the Vegetable Kingdom? The most rudimentary plants are either Fungi or Algæ. The elementary fungal forms are believed by some to be the original stock of the vegetable kingdom, while others hold the primitive forms were Algæ. Mr. Carruthers argues against Fungi being the earliest, on the ground chiefly that they fed on organized substances, and stated that evolutionists must look for the earliest plants among the Algæ. What is the testimony of the rocks as to the plants existing during the long early periods of the earth's history? Mr. Carruthers showed that the vegetable markings preserved in the earliest rocks are, though indistinct, referred to sixteen species of Algæ. But the nature of the plants which could flourish in the conditions under which these deep-sea deposits were found, and the changes that have taken place in the primal strata since their deposition, prevent us expecting any extensive representation of these early floras. So far as the plant remains go, they meet the requirements of the evolutionist who looks upon the Algæ as the primeval plants.

In the phylogenesis of the Vegetable Kingdom we next come to the evolution of Fungi, Lichens, Mosses, and Hepaticæ, all of which are cellular plants. They came into existence, it is supposed, with the Devonian period—the beginning of the newer Palæozoic series. As, however, no trace of any of these groups, except the mycelium of one or two species of fungi, has been detected in any of the Palæozoic rocks, they supply no evidence for or against the hypothetical account of their evolution.

The later Palæozoic rocks abound in plant remains. The first evidence of land plants on the globe is met with, as far as our knowledge at present goes, in the Devonian rocks. Here the three principal groups of vascular cryptogams appear together in highly differentiated forms. All of them—Ferns, *Equisetaceæ* and *Lycopodiaceæ* — possess the same essential structure as their living representatives, and in all the subordinate points in which they differ they possess characters indicative of higher organization, whether in the vegetative or reproductive organs, than are found in existing forms. The three orders appear together in these later Palæozoic rocks, and that not in simpler or more generalized types, but with more varied and more complex structures than are found in their living representatives. Thus, among Ferns there is lost a remarkable group with a fundamentally different stem structure, which was contemporaneous in the Palæozoic ages with the type of Ferns that have been represented all through the epochs, and are now abundant on the globe. The *Equisetaceæ* were represented by a larger number of generic groups than are found in our present Flora. Their stems were arborescent, the leaves large, and their fruit cones protected by special scales, but the spores were similar in size and form to those in the humbler living species, and were even furnished with hygrometric elaters. The *Lycopodiaceæ* were also huge trees, and represented by several generic groups. The stem structure, while fundamentally agreeing, like those of the arborescent *Equisetaceæ*, with the structure of the stems of their living representatives, was more complex, being suited to their arborescent habits.

But the Flora of these later Palæozoic rocks include higher elements even than vascular cryptogams, for in the Devonian series we have coniferous plants, increasing greatly in number and variety in the Carboniferous period; and in the Calciferous Sandstones at the very base of the Carboniferous measures, there has been found an undoubted angiospermous plant. The step from the spore-producing cryptogam to the seed-bearing phanerogam is a very great one. No doubt there is a general external resemblance between a lycopod and a conifer, and many points of analogy between the development of the seed and the various stages through which a lycopod passes from the germination of the spore to the growth of the fertilized archegonium. But like is here, as it is often elsewhere, an ill mark, for the resemblance is purely superficial. The minute tissues of the conifer, as well as the method in which they are arranged, differ entirely from anything either in the existing or extinct lycopods, while the production of a seed, even though it be without a protecting ovary or fruit, at once distinguishes the gymnosperm from the spore-bearing cryptogam. According to Haeckel, the gymnosperm sprang out of the *Lycopodiaceæ* during the Carboniferous, or possibly in the Devonian period. But undoubted coniferous wood was discovered by Hugh Miller in the Lower Devonian rocks of Cromarty, and several anomalous woods have been described by Unger from the Thuringian rocks of the Devonian age which are referred by him to *Coniferæ* without any positive evidence except the absence from them of ductiferous tissue. Had these woods been of earlier age than Miller's Cromarty wood, they might have been looked upon as one of the steps leading up to the true coniferous structure, but they occur in beds of Upper Devonian age. The Calciferous Sandstones at the base of the Carboniferous period contain numerous and fine specimens of coniferous wood. Some trees at this time had attained to an immense size. The first appearance of the gymnosperms is not in the form of a generalized type, but both the wood and the fruits present a remarkable variety of genera and species as highly differentiated as the existing forms. In connexion with this remarkable development of *Taxineæ* in the Palæozoic rocks, it deserves to be noticed that this section of the *Coniferæ* are all diœcious, while in the other groups the flowers are generally monœcious.

The history of monocotyledonous plants, as far as it is preserved in the rocks of the earth, is very curious. We have to take it up here, for the first true monocotyledon is the stem and spike of an aroideous plant, of which one well-preserved specimen was discovered nearly forty years ago by Dr. Paterson in the Calciferous Sandstones near Edinburgh. Additional specimens of this or an allied species have been recently described by Mr. Etheridge, jun., from the same beds. Four species of monocotyledons have been found in the Trias, seven in the Lias, the same number in the Oolite, 15 in the Chalk, 97 in the Eocene, 185 in the Miocene, and two in the Pliocene. We find, then, that the three groups of vascular cryptogams, and the seed-bearing gymnosperms, appear together in the Devonian rocks, and that monocotyledons appear in the lowest beds of the immediately succeeding Carboniferous system. Further, that these earliest plants are not generalized forms of the various tribes to which they belong, but that they are as highly specialized as any subsequent representatives of the particular tribe, and that wherever they differ from later plants, it is in the possession of a more perfect organization. It would be contrary to the theory of evolution to suppose that the highly-organized cryptogams, the gymnosperms, and the monocotyledons, were each developed at one step from the cellular plants which formed the only vegetation of the pre-Devonian periods. No doubt there is in the older Palæozoic rocks a great absence of any records of land life. But the evolution of the vascular cryptogams and the phanerogams from the green seaweeds, through the liverworts and mosses, if it took place, must have been carried on through a long succession of ages and by an innumerable series of gradually advancing steps; and yet we find not a single trace either of early water forms or later and necessarily still more numerous dry land forms which should represent these intermediate forms. This cannot be due to the physical conditions connected with the preservation of organic remains, for the conditions that permitted the preservation of the Fucoid in the Llandovery rocks at Malvern, and of similar cellular organisms elsewhere, were at least favourable to the preservation of such plants as these must have been if they ever existed.

Mr. Carruthers then entered on the consideration of the higher or dicotyledonous division of flowering plants. Their testimony for or against the theory of evolution is the more important, because—first, of their higher organization, by which, as regards their vegetative organs, they are sharply separated from the monocotyledons, and as regards both vegetative and reproductive organs from the gymnosperms; secondly, from the existence of numerous differences which supply generally obvious and well-defined characters for their systematic classification, and which would consequently assist in following the steps of their evolution; and thirdly, from their appearance in strata of comparatively recent age, and which are consequently much better known than the Palæozoic deposits. Dicotyledons are usually divided into three groups—*Apetalæ*, *Monopetalæ*, and *Polypetalæ*.

After a *résumé* of Haeckel's scheme of the phylogeny of these groups, Mr. Carruthers proceeded: Now let us see what is the record preserved to us in the rocks. Dicotyledonous plants make their appearance in strata which are referred to the Upper Cretaceous series. No trace of these plants has yet been detected in any earlier stratum. There is no palæontological foundation for the suggestion that the *Apetalæ* existed in the Trias and Jura periods. It is difficult to realize that the absence of dicotyledons can be due to any cause but their absence from the then existing vegetation. The conditions favourable to the preservation of Ferns, gymnosperms and monocotyledons, in the Secondary rocks, must have been favourable also to the preservation of dicotyledonous plants. Not only are dicotyledons entirely absent, but there has not been discovered a single specimen of a gymnosperm or monocotyledon which exhibits in any point of its structure a modification towards the more highly-organized dicotyledon. Further, when the dicotyledons appear in the Upper Cretaceous beds, representatives of the three great divisions are found together in the same deposit. Moreover, these divisions are not represented by generalized types, but by differentiated forms which, during the intervening epochs, have not developed even into higher generic groups. Thus, amongst the *Apetalæ* the *Myricaceæ* are represented in the Cretaceous rocks by two congeners of our bog-

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myrtle; the *Cupuliferæ* by six species of oak and one of beech; the *Salicaceæ* by six species of willow and nine of poplar; the *Moreæ* by six species of fig; and the *Laurineæ* by a laurel and six species of sassafras. Then following Haeckel's order of evolution, among the *Polypetalæ* the *Araliaceæ* are represented by a species of *Aralia*; the *Anacardiaceæ* by a species of *Rhus*; the *Sapindaceæ* by a maple, and the *Magnoliaceæ* by five species of *Magnolia* and two of the tulip-tree. And among the *Monopetalæ* the *Asclepiadaceæ* are represented by a species of *Nerium*, the *Ebenaceæ* by a *Diospyros*, and the *Ericaceæ* by an *Andromeda*.

While the rocks give no evidence of any plant leading up to these various orders of dicotyledons, it is, as it appears to me, equally important to notice, in its bearing on the theory of mechanical evolution, that the generic groups I have just named have persisted from the first appearance of dicotyledons throughout the whole of the intervening ages, and still hold their places among the existing forms of vegetation. The persistence of generic and specific types is very significant in its bearing on this theory, and our certain knowledge of the life of many existing species of phanerogams and cryptogams which have come down from the glacial beds has not been sufficiently considered. Let us take a case: None can be better suited for the purpose than the small willow, *Salix polaris*, detected in the lowest pre-glacial beds at Cromer and in deposits of the same age at Bovey Tracey. This plant still lives in the Arctic regions of both the Old World and the New. The genus *Salix* is a singularly variable one, and should supply satisfactory data for an evolutionist who is working out his theory. Mr. Carruthers proceeded to speak of the 160 species, 222 varieties, and 70 hybrids known of the genus *Salix*. It is easy to construct a phylogenetic tree of the genus. The small branch which represents the species *S. polaris* represents in time the period between the pre-glacial beds and our own. The six allied species lead up to the group branch, the four groups to the sub-genus, and the seventeen sub-genera to the genus. But having reached the branch representing the generic form, we have made but little progress in the phylogenesis of *Salix*. We have to lead up the allied genera to the generalized ordinal form, and these ordinal forms to a generalized and simple parent apetalous plant. Still further we must go by some utterly unknown and to me inconceivable series of types backwards to the monocotyledon and gymnosperm, and from them back to the primal and spontaneously developed *Monera*. The time required for such evolution is, Mr. Carruthers says, beyond conception, and vastly greater than even the largest estimate of geologic time that has ever been made. That the rocks testify to a development of some kind is beyond doubt, but development is not necessarily the sole property of the mechanical evolutionist. At present we have no data to guide to a solution of the question as to the *mode* by which the development was accomplished. One thing is certain, that the whole testimony of the Vegetable Kingdom, as it is known to us from the remains preserved in the stratified rocks, is opposed to the doctrine that the development is due to evolution by descent.