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Work in Fossil Botany

Scientific Specialties.

Every scientific man in these times has his specialties and those who have the patience to accompany him in his travels may expect more or less to be bored with them. In the present case I propose to put such matters into a chapter of reminiscences.

My early life was spent on ~~the~~ Coal formation and when a mere boy I happened to notice the tracings of leaves of ferns on the shales exposed in quarries and road cuttings which are characteristic of that formation. My earliest natural history collections in so far as I can remember were of such fossils, and I first learned to know their significance by reading a series of excellent articles on Geology which appeared in one of the early volumes of the Penny Magazine of that useful but now half forgotten body, the agents of so much useful cheap literature the Society for the diffusion of useful knowledge. The coal plants thus formed the basis of my natural history studies and before I had the opportunity of receiving any training from specialists in natural science I had made myself familiar with many of the forms of vegetable and animal life that flourished in that ancient period when the great beds of coal or at least the greatest of them were accumulated. From that starting point I have been induced by circumstances to extend my work backward into the vegetation of the Silurian and Devonian and forward into that of the Cretaceous and Tertiary; and removed in early middle life from the coal-formation to the Silurian districts of Canada I have been induced to range over the geology of that country from the old Laurentian with its much

debated Eocene up to the equally debated
Pleistocene with its modern arctic
shells and evidences of ice action.
In other circumstances than these of
a new country where men are expected
to turn their hands to many things
my speculations might have taken
a narrower range & the advantages
of their profundity might not of their
breadth. What I have stated
will however account for the fact
that in Britain the old world
I helped to discuss with friends
there some of the more difficult
points over which I had been
puzzling in the comparative
relations of my Canadian work.

My friend Dr Williamson of Man-
chester was president of the Geological
Section at Southport and it was a
source of satisfaction to me in some
points that an opportunity was
thus given in the open address of

the Section to direct attention to this branch of geological investigation, and after the meeting I spent a week with him in Manchester, enjoying under his guidance perhaps the most precious collection in the world of microscopic sections of the structures of plants of the Coal period. Dr Williamson ~~[illegible]~~ has converted a well lighted attic room into a microscopical work room and with every sort of mechanical facility there pursues the investigations on which he has communicated so many valuable memoirs to the Transactions of the Royal Society. His garden in like manner is a miniature botanical garden full of rare and curious examples of modern plants illustrative of those of ~~most~~ ancient times.

The workings of collieries and quarries as well as natural exposures in every coal-district of the world turn out great quantities of remains of plants, often preserved in such a manner as to afford very beautiful specimens. In some respects however these are very unsatisfactory in a botanical point of view. They are often mere impressions or casts in inorganic substance or shallow from which the minute structures are not preserved. The specimens obtained are usually fragments — parts of the roots, stems, branches, leaves or fruits disconnected from the other parts, and it is extremely rare to obtain all the parts of a plant so associated as to enable one to form a definite opinion on its whole parts. To make matters worse those who study and write of these specimens often have not studied them in situ but have merely had access to specimens obtained by collectors who may have had little knowledge of what is most important to the botanist or who may not have taken pains to seek out or to keep together the parts belonging to the same plant. On the other hand when specimens are found showing the internal structures and these are sometimes admirably preserved they frequently fail to show the external form and in nearly all cases are mere fragments of stems or perhaps detached fruits. Hence in a great number of cases the fossil botanist has to give separate names to roots stems leaves and fruits which may all have belonged to the same plant and he has to describe parts of plants with very little knowledge as to the tribes of the vegetable kingdom to which they may have belonged. In connection with these studies with Prof. Williamson and the opportunities I have had of studying specimens and discussing difficult points with other fossil botanists I may notice here some of the points on which certainty may be supposed to be attaining in regard to the oldest known plants.

It is a curious fact that we know very little ~~of~~ with certainty of the ~~older~~ lowest forms of vegetation in the oldest rocks. Of the Fungi or Moulds mushrooms we ——— we have scarcely any certainty.+

But nearly all the Pal fungi of authors are spurious. The Mosses and Lichens are also unknown though as many examples of them have been preserved in later formations there seems no reason why they should not have been previously.

The Algae or sea weeds one would have supposed would be plentiful forms and a great number have been described and figured but of these the larger number are problematical. I have myself shown that many of the things so described are mere tracks of animals while others are impressions of shrubs and such things — Nathorst has carried this still further and has by a series of elaborate experiments demonstrated

+ Peronosporites Williamson X I R. 299. See Lesquereux

that many so called sea weeds are
merely animal traits. Two examples may
serve to show the difficulties of this subject
Many years ago certain flattened cylindrical or glandular
objects marked with transverse lines dividing
the surfaces into rectangular areas were
figured in the Reports of the New York Survey
and Prof Hall was kind enough to give
me specimens for examination in connection
with a memoir on Devonian Plants in . I could
find no structure in the specimens and
was content to refer to them as
algae; but many years afterwards in
the New York Museum Prof Whitfield
was kind enough to show me a specimen
in which an evident spicular framework
was present — At once it was evident
that this was a sponge allied to the
modern Venus Flower basket and
the Dictyophytons have become Dictyospongiae.
In his researches in Gaspé in 1841 Logan
found some peat shaped trunks in the Devonian
Sandstones there which I examined

Some years ago these structures were altogether peculiar appearing to me to resemble more than anything else the young undeveloped wood or the old half rotten tissues of coniferous trees, Hence I gave the name Prototaxites. Subsequently spores associated with these trunks globular seed like bodies with a similar fibrous structure arranged so as to form a radiating texture or outer coat. In Canada these trees are Lower Devonian & Upper Silurian and they have been found in rocks of similar age in England. But English botanists have referred both the trees and their seeds to algae and have supposed owing to all the facts connected with their mode of occurrence in Canada that they were not land plants at all. So the matter remains at present neither party being willing to give in.

In the modern world an obscure and humble group of plants a little more complex than the mosses and algae lives in ponds and swamps and is known to botanists as Rhizocarps. They are little known by any common names but are Psilotums. In the Upper Silurian and early time a plant allied to these Psilophyton which may be supposed to be better developed sort of Psilotum with creeping roots like those of some ferns stems about as well developed as those of some Club-Mosses was perhaps the most widely dispersed and abundant plant in the Northern hemisphere and must have covered vast areas of flat and swampy ground in some parts of which it accumulated thin beds of coal. At the same period there must have been other plants known to us only by their spores and spore-cases allied to the Salvinia of modern ponds and which existed in such quantity that beds of

Shale extending over hundreds of square miles in Western Canada and the United States are filled with these little round spores, and are thereby rendered highly bituminous. One American geologist Orton has conjectured that the vast stores of bitumen or petroleum in some of the formations of the U States are mainly derived from these spores. Similar strata occur in immense quantity in Brazil where they have been found by Mr Derby and Williams and Wethered have shown that they occur in immense quantities as ingredients of English coal. The Curious White Coal of Australia or deposits of mineral age is also apparently made up of these structures. This is a curious example of the ancient importance of a group of plants now reduced to insignificance.

It is a remarkable fact that the oldest known forests those of the Devonian or Erian period which preceded the Carboniferous were composed of plants of types which still exist and some of which still occupy an important place in the world.

The ferns or brakens are world wide in their distribution but the tree ferns are confined to tropical regions and warmer parts of Southern hemisphere. The oldest tree ferns known are in Ohio where stems in the cabinet [in Ohio] of Dr Newberry and which show the structure of Psaronius occur in the Corniferous limestone equivalent of Eifel limestone of Germany & older than old red of England. Trunks of tree ferns have been discovered by Prof Hall in beds of a little newer ~~by Prof~~ in N York and these are standing erect in the bed in which they grew the oldest fossil forest known. What their foliage was we do not know that any fern leaves are known of as great age but from what is known of our Paleozoic ferns we have a right to believe that their foliage & fructification may have resembled those of the Marattias and others ferns still extant in the Southern hemisphere

Marestails or Equisetums are also regularly of not universally distributed denizens of marshy grounds, and they too go back to the Middle Silurian long before the Coal period. But in that early age they presented some peculiar features. Some of them at least had divided or forky leaves. None of them seem to have had the sheath-like organs on the joints possessed by modern Equisetums. But they were of large size and as Williamson has shown possessed a much more complex stem than their modern representatives — a stem also which is of great interest in connection with the mechanical contrivances for support which it contains. In plants while certain structures are used more exclusively for conveyance of sap others are used for support. Rigidity when required is given by cells having their walls hardened by a dense woody deposit. Toughness is given by slender cells drawn out into

fibres. The shell of a nut or the stone of a
peach is an example of one & the tough
fibres of wood or of flax of the other.
Now a Calamite which might be
20 or 30 feet in height and only a
few inches in diameter needed some
support. This was given first by a
hollow cylinder of barred vessels arranged
in wedge like bundles around its pith
but which probably possessed only very
moderate strength and were mainly
useful as sap-conductors. But outside
this was another cylinder of tough
fibres and outside this a dense
cellular bark probably of great hardness
as it certainly was of great density and
Similar principles in Lepidodendrons & Sigillarias which were great trees
durability. It is curious to notice
that other mechanical contrivances
were employed in other contemporary
plants. In Psilophyton & its allies
there was a dense external cylinder of
fibrous tissue with a thin fibrous
bark separated by some delicate cellular

matter. In the ferns there was an entirely different arrangement. The stem here was made up of separate leaf-stalks attached together. Each of these leaf stalks contained a bundle of hard fibres arranged in a complex form usually in such a horse-shoe or   so as to give added strength & more protection. A number of these leaf stalks united by cellular tissue constituted a stiff stem and to give further support bundles of slender aerial roots grew at the base of the stem and penetrated the ground constituting a cone of roots to hold up the stem and its leafy crown. These arrangements are as perfect in the old Era tree ferns as in any modern ones. In the greater part of our modern trees rigidity is given to the stem by woody fibres arranged in the first place in wedge-like bundles and then as growth proceeds in sweeping rings of these while the pith becomes very small and the bark without thick usually with tough fibres is of small thickness. This plan also was followed in the earliest forests for there we have as I shall shortly mention pine trees constructed precisely on this principle. It is certainly remarkable that in the earliest land plants known to us all these complicated mechanical arrangements based on deep principles of construction combined with those for circulation of sap and with perfectly formed cellular vascular woody and bark tissues are found in as great perfection as in any that now exist. If this was a product of spontaneous evolution the forests of the Devonian must have been preceded by ages of development entirely unknown to us and at least as long as those which have passed since the first known forests came into being

widely distributed
Still another of past modern plant is that of the Club Mosses or Lycopods. In modern times these are all small none of them reaching to the degree of trees. But in the old Carboniferous forests the Lepidodendra reached great size and many trunks which attained to actual dimensions which exceeded those of many modern period. These were club-mosses furnished with lofty ascending stems akin in mode of growth to those of the enormous trees though the mode of reproduction seems to have been similar to those of modern & degenerate Lycopods. The structures of Lepidodendra have been illustrated by Williamson & others and examples are not wanting which enable us to restore these trees from actual specimens. That given is for a tree of which I saw here the whole except a large stalk of

Sandstone at [illegible] Nebraska
Lastly the Pines and their allies are perhaps of all [illegible] trees most widely [illegible] in range. Pines they [illegible] the [illegible] of their own [illegible] only in 4 or 5 species [illegible] as far [illegible] in Middle Dunes in U States and Canada & Germany & Scotland. They belong to a type which has [illegible] [illegible] to [illegible] trees and it has been supposed that some of them bore fern like leaves [illegible] [illegible] and that some of the [illegible] [illegible] [illegible] [illegible] [illegible] are then produce. It seems certain [illegible] that some of the later ones had spine-like branches & leaves to which name Walchia has been given and others seem to have had flat [illegible] leaves like Japanese podocarpus

and to have been allied to them are
plants with lined sedges the leaves
known as Cordaites, and curiously
to unite these ancient pines with
the modern cycads.

I have desired to illustrate here
the identity in plan of oldest flora
with modern forms – note however
that most abundant now are the
Dicot exogens the true fruit bearing trees
and their variety. Also in papers
of Williamson, Renault, Zeiller, Brongniart
etc. many strange vegetable forms as
yet little understood and only
known by parts of structures – but
which gradually come into line with
existing forms.

Note as to coal not spores

see my paper

Slackie gardens very superb by

Lepidodendron being. by cross — differs from Dadoxylon in

the stoppage of being glandular — ? of because

short lived ? of stem growth.

Calamites said by Saporta to be different

from Calamodendron — latter large crossing

long — prunes none or small — roots

different — ? leaves & fruit ? grai

Sequoia and Marion Brown working to
argue a Phylogeny of Plants. The
first one gives some of publication
Algae which I believe to be really
~~beginning~~ of any. The second pretty
surely by what to ... is more
ambitious and tries to ...
~~...~~ Phaenogams. ...
the Conifers ... but ...
the ~~"Ruta~~ Gymnosperms" which are supposed
and ... Gymnosperms ... in Devonian ...
to lead to them. ~~...~~ ... is
certain that in Carboniferous ~~Gymnosp~~ ...
... - ... the ... ...
~~...~~ and ... ...
~~to~~ ... ... and that ...
thus a ... ... ~~...~~ ... & ...
than ... - ... ... to ...
& ... - ... to ... ...
... of ... ...
... in ... & ... almost
... to them. ... ...
... ... that ...
... ...
of ... ...

Zone Botany

SUPPLEMENTARY SECTION

ON THE BEARING OF DEVONIAN BOTANY ON QUESTIONS AS TO THE ORIGIN AND EXTINCTION OF SPECIES.

[The theoretical views contained in this section, though necessary to give completeness to the subject, are not suitable for an official report, and are, therefore, printed separately by the author, for circulation to those who may be interested in them as matters of science.]

Fossil plants are almost proverbially uncertain with reference to their accurate determination, and have been regarded as of comparatively little utility in the decision of general questions of palæontology. This results principally from the fragmentary condition in which they have been studied, and from the fact that fragments of animal structures are more definite and instructive than corresponding portions of plants.

It is to be observed, however, that our knowledge of fossil plants becomes accurate in proportion to the extent to which we can carry the study of specimens in the beds in which they are preserved, so as to examine more perfect examples than those usually to be found in museums. When structures are taken into the account, as well as external forms, we can also depend more confidently on our results. Farther, the abundance of specimens to be obtained in particular beds often goes far to make up for their individual imperfection. The writer of these pages has been enabled to avail himself very fully of these advantages; and on this account, if on no other, feels entitled to speak with some authority on theoretical questions.

It is an additional encouragement to pursue the subject that, when we can obtain definite information as to the successive floras of any region, we thereby learn much as to climate, and vicissitudes in regard to the extent of land and water; and that, with reference to such points, the evidence of fossil plants, when properly studied, is, from the close relation of plants to those stations and climates, even more valuable than that of animal fossils.

It is necessary, however, that in pursuing such enquiries we should have some definite views as to the nature and permanence of specific forms, whether with reference to a single geological period, or to successive periods ; and I may be excused for stating here some general principles, which I think important for our guidance, with special reference to the palæozoic floras which form the subject of this memoir.

(1.) Botanists proceed on the assumption, vindicated by experience, that, within the period of human observation, species have not materially varied or passed into each other. We may make, for practical purposes, the same assumption with regard to any given geological period, and may hold that for each such period there are specific types, which, for the time at least, are invariable.

(2.) When we inquire what constitutes a good species for any given period, we have reason to believe that many names in our lists represent merely varietal forms or erroneous determinations. This is the case even in the modern flora ; and in fossil floras, through the poverty of specimens, their fragmentary condition and various states of preservation, it is still more likely to occur. Every revision of any group of fossils detects numerous synonyms, and of these many are incapable of detection without the comparison of large suites of specimens.

(3.) We may select from the flora of any geological period certain forms, which I shall call *specific types*, which may for such period be regarded as unchanging. Having settled such types, we may compare them with similar forms in other periods, and such comparisons will not be vitiated by the uncertainty which arises from the comparison of so-called species which may, in many cases, be mere varietal forms, as distinguished from specific types. Our types may be founded on mere fragments, provided that these are of such a nature as to prove that they belong to distinct forms which cannot pass into each other, at least within the limits of one geological period.

(4.) When we compare the specific types of one period with those of another immediately precedent or subsequent, we shall find that some continue unchanged through long intervals of geological time, that others are represented by allied forms regarded either as varietal or specific, and as derived or otherwise, according to the view which we may entertain as to the permanence of species. On the other hand, we also find new types not rationally deducible on any theory of derivation from those known in other periods. Farther, in comparing the types of a poor period with those of one rich in species we may account for the appearance of new types in the latter by the deficiency of information as to the former; where many new types appear in the poorer period this conclusion seems less probable. For example, new types appearing in poor formations, like the Lower Erian and Lower Carboniferous, have greater significance than if they appeared in the Middle Erian or in the Coal Measures.

(5.) When specific types disappear without any known successors, under circumstances in which it seems unlikely that we should have failed to discover their continuance, we may fairly assume that they have become extinct, at least locally ; and where the field of observation is very extensive, as in the great coal fields of Europe and America, we may esteem such extinction as practically general, at least for the northern hemisphere. When many specific types become extinct together, or in close succession, we may suppose that such extinction resulted from physical changes ; but where single types disappear, under circumstances in which others of similar habit continue, we may not unreasonably conjecture that, as Pictet has argued in the case of animals, such types may have been in their own nature limited in duration, and may have died out without any external cause.

(6.) With regard to the *introduction* of specific types we have not as yet a sufficient amount of information. Even if we freely admit that ordinary specific forms, as well as mere varieties, may result from derivation, this by no means excludes the idea of primitive specific types originating in some other way. Just as the chemist, after analyzing all compounds and ascertaining all allotropic forms, arrives at length at certain elements not mutually transmutable or derivable, so the botanist and zoologist must expect sooner or later to arrive at elementary specific types, which, if to be accounted for at all, must be explained on some principle distinct from that of derivation. The position of many modern biologists, in presence of this question, may be logically the same with that of the ancient alchemists with reference to the chemical elements, though the fallacy in the case of fossils may be of more difficult detection. Our business at present, in the prosecution of palæobotany, is to discover, if possible, what are elementary or original types, and, having found these, to enquire as to the law of their creation.

(7.) In prosecuting such questions geographical relations must be carefully considered. When the floras of two successive periods have existed in the same region, and under circumstances that render it probable that plants have continued to grow on the same or adjoining areas throughout these periods, the comparison becomes direct, and this is the case with the Erian and Carboniferous floras in North-Eastern America. But when the areas of the two formations are widely separated in space, as well as in time, any resemblances of facies that we may observe may have no connection whatever with an unbroken continuity of specific types.

I desire, however, under this head, to affirm my conviction that, with reference to the Erian and Carboniferous floras of North America and of Europe, the doctrine of "homotaxis," as distinct from actual contemporaneity, has no place. The succession of formations in the Palæozoic period evidences a similar series of physical phenomena on the grandest scale throughout the northern hemisphere. The succession of marine animals implies the continuity of the sea-bottoms on which they lived. The head-quarters of the Erian flora in America and Europe must have been in connected or adjoining areas in the North Atlantic. The similarity of the Carboniferous flora on the two sides of the Atlantic, and the great number of identical species, proves a still closer connection in that period. These coincidences are too extensive and too frequently repeated to be the result of any accident of similar sequence at different times, and this more especially as they extend to the more minute differences in the features of each period, as, for instance, the floras of the Lower and Upper Devonian, and of the Lower, Middle, and Upper Carboniferous.

Another geographical question is that which relates to centres of dispersion. In times of slow subsidence of extensive areas, the plants inhabiting such areas must be narrowed in their range and often separated from each other in detached spots, while, at the same time, important climatal changes must also occur. On the re-emergence of the land such of these species as remained would again extend themselves over their former areas of distribution, in so far as the new climatal and other conditions would permit. We would naturally suppose that the first of the above processes would tend to the elimination of varieties, the second, to their increase; but, on the other hand, the breaking up of a continental flora into that of distinct islets, and the crowding together of many forms, might be a process fertile in the production of some varieties if fatal to others.

Farther, it is possible that these changes of subsidence may have some connection with the introduction, as well as with the extinction, even of specific types. It is certain, at least, in the case of land plants, that such types come in most abundantly immediately after elevation, though they are most abundantly preserved in periods of slow subsidence. I do not mean, however, that this connection is one of cause and effect; there are, indeed, indications that it is not so. One of these is, that in some cases the enlargement of the area of the land seems to be as injurious to terrestrial species as its diminution.

Applying the above considerations to the Erian and Carboniferous floras of North America, we obtain some data which may guide us in arriving at general conclusions. The Erian flora is comparatively poor, and its types are in the main similar to those of the Carboniferous. Of these types a few only re-appear in the Middle Coal formation under identical forms; a great number appear under allied forms; some altogether disappear. The Erian flora of New Brunswick and Maine occurs side by side with the Carboniferous of the same region; so does the Erian of New York and Pennsylvania with the Carboniferous of those states. Thus we have data for the comparison of successive floras in the same region. In the Canadian region we have, indeed, in direct sequence, the floras of the Upper Silurian, the Lower, Middle, and Upper Erian, and the Lower, Middle, and Upper Carboniferous, all more or less distinct from each other, and affording an admirable series for comparison in a region whose geographical features are very broadly marked. All these floras are composed in great part of similar types, and probably do not indicate very dissimilar general physical conditions, but they are separated from each other by the great subsidences of the Corniferous limestone and the Lower Carboniferous limestone, and by the local but intense subterranean action which has altered and disturbed the Erian beds towards the close of that period. Still, none of these changes was universal. The Corniferous limestone is absent in Gaspé, and probably in New Brunswick, where, consequently, the Erian flora could continue undisturbed during that long period. The Carboniferous limestone is absent from the slopes of the Appalachians in Pennsylvania, where a retreat may have been afforded to the Upper Erian and Lower Carboniferous floras. The disturbances at the close of the Erian were limited to those eastern regions where the great limestone-producing subsidences were unfelt, and, on the other hand, are absent in Ohio, where the subsidences and marine conditions were almost at a maximum.

Bearing in mind these peculiarities of the area in question, we may now group in a tabular form the distinct specific types recognized in the Erian system, indicating, at the same time, those which are represented by identical species in the Carboniferous, those represented by similar species of the same general type, and those not represented at all. For example, *Calamites cannæformis* extends as a species into the Carboniferous; *Asterophyllites latifolia* does not so extend, but is represented by closely allied species of the same type; *Prototaxites* disappears altogether before we reach the Carboniferous.

TABLE OF ERIAN AND CARBONIFEROUS SPECIFIC TYPES.

Erian Types.	Represented in Carboniferous—		Erian Types.	Represented in Carboniferous—	
	by identical types.	by related forms.		by identical types.	by related forms.
1. Syringoxylon mirabile		*	27. Cordaites Robbii		*
2. Nematoxylon		•	28. C. augustifolia		
3. Prototaxites			29. Cyclopteris (Archæopteris)		
4. Aporoxylon			30. C. (Aneimites)		*
5. Ormoxylon			31 C. Brownii		
6. Dadoxylon		*	32. C. varia		*
7. Sigillaria Vanuxemii		*	33. Neuropteris polymorpha		*
8. S. palpebra		*	34. N. Serrulata		*
9. Didymophyllum			35. N. Dawsonii		
10. Calamodendron		*	36. N. retorquata		*
11. Calamites transitionis	*		37. N. resecta		
12. C. cannæformis	*		38. Sphenopteris Hœninghausi	*	
13. Asterophyllites scutigera			39. S. Harttii		*
14. A. latifolia		*	40. Hymenophyllites curtilobus		
15. Annularia laxa			41. H. obtusilobus		*
16. Sphenophyllum antiquum		*	42. Alethopteris discrepans		*
17. Cyclostigma			43. Pecopteris serrulata		*
18. Arthrostigma			44. P. preciosa		
19. Lepidodendron Gaspianum		*	45. Trichomanites		*
20. L. Veltheimianum		*	46. Callipteris		*
21. Lycopodites Matthewi		*	47. Psaronius		*
22. L. Richardsoni			48. Cardiocarpum		*
23. L. Vanuxemii			49. C. Crampii		
24. Lepidophloios antiquus		*	50. Antholithes		*
25. Psilophyton princeps			51. Trigonocarpum		*
26. P. robustius					

Of the above forms, fifty-one in all, found in the Erian of Eastern America, all, except the four last, are certainly distinct specific types. Of these only four reappear in the Carboniferous under identical species, but no less than twenty-six reappear under representative or allied forms, some at least of which a derivationist might claim as modified descendants. On the other hand nearly one half of the Devonian types are unknown in the Carboniferous, while there remain a very large number of Carboniferous types not accounted for by anything known in the Devonian. Farther, a very poor flora, including only two or three types, is the predecessor of the Erian flora in the Upper Silurian, and the flora again becomes poor in the Upper Devonian and Lower Carboniferous. Every new species discovered must more or less modify the above statements, and the whole Erian flora of America, as well as the Carboniferous, requires a thorough comparison with that of Europe before general conclusions can be safely drawn. In the meantime I may indicate the direction in which the facts seem to point, by the following general statements :—

1. Some of the forms reckoned as specific in the Devonian and Carboniferous may be really derivative races. There are indications that such races may have originated in one or more of the following ways :—(1) By a natural tendency in synthetic types to become specialized in the direction

of one or other of their constituent elements. In this way such plants as *Arthrostigma* and *Psilophyton* may have assumed new varietal forms. (2) By embryonic retardation or acceleration,* whereby certain species may have had their maturity advanced or postponed, thus giving them various grades of perfection in reproduction and complexity of structure. The fact that so many Erian and Carboniferous plants seem to be on the confines of the groups of Acrogens and Gymnosperms may be supposed favourable to such exchanges. (3) The contraction and breaking up of floras, as occurred in the Middle Erian and Lower Carboniferous, may have been eminently favourable to the production of such varietal forms as would result from what has been called the "struggle for existence." (4) The elevation of a great expanse of new land at the close of the Middle Erian and the beginning of the Coal period, would, by permitting the extension of species over wide areas and fertile soils, and by removing the pressure previously existing, be eminently favourable to the production of new, and especially of improved, varieties.

2. Whatever importance we may attach to the above supposed causes of change, we still require to account for the origin of our specific types. This may forever elude our observation, but we may at least hope to ascertain the external conditions favourable to their production. In order to attain even to this it will be necessary to inquire critically, with reference to every acknowledged species, what its claims to distinctness are, so that we may be enabled to distinguish specific types from mere varieties. Having attained to some certainty in this, we may be prepared to inquire whether the conditions favourable to the appearance of new varieties were also those favourable to the creation of new types, or the reverse—whether these conditions were those of compression or expansion, or to what extent the appearance of new types may be independent of any external conditions, other than those absolutely necessary for their existence. I am not without hope that the further study of fossil plants may enable us thus to approach to a comprehension of the laws of the creation, as distinguished from those of the continued existence of species.

In the present state of our knowledge we have no good ground either to limit the number of specific types beyond what a fair study of our material may warrant, or to infer that such primitive types must necessarily have been of low grade, or that progress in varietal forms has always been upward. The occurrence of such an advanced and specialized type as that of *Syringoxylon*, in the Middle Devonian, should guard us against these errors. The creative process may have been applicable to the highest as well as to the lowest forms, and subsequent deviations must have included

* In the manner illustrated by Hyatt and Cope.

degradation as well as elevation. I can conceive nothing more unreasonable than the statement sometimes made that it is illogical or even absurd to suppose that highly organized beings could have been produced except by derivation from previously existing organisms. This is begging the whole question at issue, depriving science of a noble department of inquiry on which it has as yet barely entered, and anticipating by unwarranted assertions conclusions which may perhaps suddenly dawn upon us through the inspiration of some great intellect, or may for generations to come baffle the united exertions of all the earnest promoters of natural science. Our present attitude should not be that of dogmatists, but that of patient workers content to labour for a harvest of grand generalizations which may not come till we have passed away, but which, if we are earnest and true to nature and its Creator, may reward even some of us.