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ART. XXVI.—*Classification of the Cycadophyta**; by G.
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Extension of the knowledge of cycads, cycad-like plants, and their remoter relatives, has now gone on for just 90 years. When Buckland in 1828 came to give closer attention to the “crow’s nests” of the Isle of Portland, he happily emphasized the cycad-like character of these petrified stems in the generic name *Cycadeoidea*; while the great contemporary botanist Robert Brown suggested the family name *Cycadeoideæ*. Brown evidently regarded the abundant ramentum, and free lateral budding, as the main characters indicating the new family. He doubtless recognized that the fructification must vary; but as Buckland very soon sought to give even more emphasis to a cycad relationship by inadmissibly using *Cycadites* for *Cycadeoidea*, it is evident that only the simpler outer characters were the ones held mainly in mind.

The first evidence to deeply affect the classification was forty years in appearing. In 1870 came the two notable papers of Williamson and Carruthers. Williamson associated the *Zamites* fronds, “pyriform axes,” and the “collars” or “disks” of the Yorkshire coast; while Carruthers described the Isle of Wight trunk *Cycadeoidea* (Bennettites) *gibsoniana* with its unique ovulate

* To give all of the references bearing on this classification would require undue space. The reader should refer to the chronologic list of literature on the Williamsonian Tribe, this Journal, vol. 32, p. 465, Dec., 1911. See also the bibliography in my American Fossil Cycads, Carnegie Institution of Washington Publication 34, vol. II, 1916. The dates here freely given will facilitate such reference in most instances. The two volumes on the American Fossil Cycads now constitute an extensive catalogue to which there is constant occasion to refer. Accordingly it is wished to use an abbreviated reference form, thus, *Am. Fos. Cy.*, Vol. I, Vol. II.

cones. In these he saw the type of a new family—the “Bennettiteæ,” in which were included the Isle of Portland specimens as well as the historic Dresden trunk “*Raumeria*” [*Cycadeoidea reichenbachiana*]. The latter had only twelve years earlier received the attention of Goeppert, unfortunately without significant result. Carruthers’ observations should be recalled:

“Were Buckland’s name [*Cycadeoidea*] unobjectionable it ought to be retained, because of its priority by a month or two The remarkable stems of this genus [*Cycadeoidea* or *Mantellia*] have been fully investigated in the important memoir of Buckland The fossils differ from *Bennettites* in their form, as well as in the more distinctly rhomboidal petioles and the elongated secondary axis. They agree in the nature of the tissues and the method in which they are built up in the stem. The petioles are clothed with a dense ramentum, and they have numerous axillary branches which bore small, simple, linear-lanceolate leaves. The branches, when full-grown, are broken off at the point where they leave the bases of the petioles. Sometimes they are undeveloped, and still exist as unexpanded leaf-buds, terminating the shortened branch. These buds are composed of leaves, protected by a very dense and very abundant ramentum. The branches precisely agree with those in *Bennettites*, and have been, I have no doubt, like them, the supports of the organs of reproduction; only the fruits, having been borne at the ends of elongated and consequently unprotected branches, have been broken off. Some stems have no lateral buds. These may have been male plants; and their staminal flowers were perhaps cones, produced at the termination of the main axis.”

On the question of the position of his Bennettitean group Carruthers makes an incisive statement, the most interesting in his memoir:

“In comparing the structure of this plant with the inflorescence of the recent Cycadeæ, the points of difference are more obvious than those in which they agree. The most important correspondence is to be found in the structure of the seed and its envelopes. The fossil is truly gymnospermous, the pollen having access to the embryo-sac through the tubular openings in the covering of the seed and not through a style developed from an investing carpellary organ. The most remarkable difference is to be found in the compound fruit of the fossil. In the recent members of the order, the fruit, whether borne on slightly modified leaves, as in *Cycas*, or on the peltate or imbricated scales of a cone, as in the other genera, is always

produced on foliar organs. In the fossil, on the other hand, it is borne at the end of the axis. In this respect, however, it agrees with *Taxus*, except that it possesses innumerable seeds; it must be considered to hold the same relation to the other *Cycadeæ* that *Taxus*, with its succulent, cup-shaped pericarp, does to the cone-bearing *Coniferae*."

So rested the central problem in the classification for the next twenty years. Saporta (1875) had made as little direct progress with the material he held in hand as had Goeppert (1853), but was led to certain interesting suggestions as to the forerunners of the angiosperms. So, too, Nathorst's earlier work on the Rhætic forms but vaguely foreshadowed the brilliant results that later followed. Solms, however, after restudying the cone of "*Bennettites gibsonianus*" came to a very direct conclusion (1887):

"It is possible that the seed-stalks may prove to be carpophylls of a peculiar kind; in that case we should be obliged to separate the Bennettiteæ altogether from the Cycadeæ, and to regard them as an intermediate group between Gymnosperms and Angiosperms. We should then have a typical case of that which Saporta and Marion call proangiospermy, though we could not perhaps assume a direct derivation of Angiosperms from this plant, and though it may have belonged to a line of development which never reached our era."

Then Potonié in Engler and Prantl's *Natürlichen Pflanzenfamilien* (1897) separated all the fossil trunks from the cycads as the Bennettitales. This separation, be it noted, was not based on renewed study, or new materials. It was, however, at once adopted by Ward (1899), though he had at first included the petrified trunks in the Cycadaceæ, as had been done in practice for fifty years. But Ward (as he remarked to me) was much impressed with the fact that the foliage, the flowers, and so much of the structure remained unknown; while Zeiller and Scott (1900) adhered to the earlier Cycadean grouping. In this I followed a year later. The determination of the Cycad-like foliage of *C. ingens* (1899) had completed the vegetative parallel; and (1901) it was urged that the staminate frond, despite campanulate emplacement, afforded an analogue to the carpellary leaf of *Cycas*. These features were also held significant by Zeiller. Their discovery was in fact easily the most signal since Carruthers sectioned *Cycadeoidea gibsoniana*; though

Nathorst's elaboration of *Wielandiella* with its Nilssonioid foliage, small freely bifurcate stems, and reduced flowers, soon followed. The supplementary discoveries affecting the cycad classification most profoundly were thus made in rapid succession. The American studies proved the floral type to be one theoretically plastic; and Nathorst's determinations showed (with some further study) the presence of far greater variety in foliage as well as small reduced stems and flowers. It had become evident that much if not most of the cycadeous vegetation of the Mesozoic had more affinity to *Cycadeoidea* and *Wielandiella* than to modern forms. In fact fossil types positively referable to the latter are few, and cannot be cited beyond the Jurassic, although theoretically the ancestry must go back to the Paleozoic as a discrete line.

It was at this point (1902) that Nathorst proposed as a term of convenience the Cycadophyta to include all plants with cycadeous foliage existing and extinct. That many relatives with types of foliage not distinctly cycadeous must formerly have existed was at the same time emphasized. The usability of the term Cycadophyta was presently recognized, and in 1907 Bessey, a keen systematist, suggested the following extension: CYCADOPHYTA.—I, Cycadofilices, Lyginopterideæ, Medulloseæ, Cladoxyleæ, Protopytæ, Araucarioxyleæ; II, Cordaitineæ; III, Bennettitineæ; IV, Cycadineæ, V, Ginkgoineæ. The logic of Bessey's suggestion is firmly grounded on both the paleontologic record and well-known structural features. It properly emphasizes the lapse of time through which the cycadeous foliar structures have apparently dominated the vegetation of the globe—from the Devonian to the Cretaceous. The question is thus raised as to whether the dicotyl blade is equally longevous. And just as there is the proximate question of mid-Mesozoic transition from Cycadophytes to dicotyl foliage, so there is the ulterior question as to mid-Devonian transition from the *Bornia-Pseudobornia* foliage to more bladed types like *Archæopteris*, theoretically leading into the earliest Cycadophyta.

Now, having recalled the larger outlines of the Cycadophyta, and the more crucial discoveries leading up to recognition of this gymnospermous leaf-type as a forest constituent, let attention be turned to the appended provisional classification based on the general structure,

known or inferred. Obviously such a classification essays first the orderly presentation of facts; but yet it can only be usable as discovery progresses, if it has both flexibility and impermanence. Nor are the uncertain boundaries an objection. Indeed one chief function is to present inferences from the known facts.

		(A)	Zamia Microcycas Ceratozamia Dioön.
	Zamiæ		
		(B)	Encephalartos Stangeria Macrozamia Bowenia
	Cycadaceæ		
		Cycadeæ	Cycas
	Cycadales (Cycads)		
		Pseudocycadeæ	Pseudocycas Cycadites Stangerites
	(incertæ sedis)		
		Podozamiteæ	Podozamites Plagiozamites Sphenozamites
CYCADOPHYTA			
		Cycadeoideæ (The Petrified series)	Cycadeoideæ Fittonia, etc. Amphibennettites, etc.
	Pericycadeoidaceæ (Pericycadeoids)		Williamsonia Bucklandia Zamites
		Williamsoniæ (The William- sonian tribe)	Ptilophyllum Otozamites Pterophyllum Glossozamites Dictyozamites Cycadolepis
	Hemicycadales (Cycadeoids)		
		Microfloræ	Wielandiella Williamsoniella
		Apocycadeoidaceæ (Apocycadeoids)	Anomozamites Nilssonia Tæniopteris Ctenis Pseudoctenis Ptilozamites Macrotæniopteris
		Holophytæ	
	Primitive and Hypothetic Groups:		
	Cycadofilicales, Medulloseæ or Paracycadales, Proangiosperms, Hemiangiosperms.		
(Wieland, 1918 Revision)			

In this new classification, then, it is primarily aimed to give due homogeneity to the grouping of the Mesozoic Cycadophyta. This cannot be done if the term Bennettitales, as first used and defined, is retained. While it would take us far afield to discuss at full length the questions of mere priority relating to the use of Bennettitales, there are simple and good reasons for letting this name fall into disuse. As already noted the boundaries are greatly extended; there are now without much question several groups ranking as high as the Cycadales within the Cycadophyta; while the Bennettitales as used, neither expressed such relationship nor gave sufficient recognition to the vegetative equivalence between the silicified stems, at first the only ones included, and the existing cycads. It was this latter fact that largely influenced the retention of the fossil cycads in the Cycadales in both Volumes I and II of my American Fossil Cycads. Approach from the paleontologic side led to the same comparisons with cycads that had obtained for seventy years; although it was freely admitted at all points that the discussions of relationship must be inherently tentative.

The vegetative characters of the Cycadeoids bear such a general resemblance to, and present so many points of agreement with those of the cycads, that an ancient contact is indicated. The facts were summed up in the American Fossil Cycads, Vol. I, page 226 *et seq.*; and the additions to our knowledge of the anatomy since made confirm rather than disprove a degree of vegetative affinity. It is difficult to admit that such a complete similarity is in entirety the end result of homoplasy. All recognize, however, that the reproductive organs must indicate an exceedingly ancient separation—perhaps even mid to early Paleozoic. Scott says:

“It is a striking fact that in their reproductive organs, that is to say, in the very characters on which systematists are accustomed to rely, the Bennettitæ differ *toto coelo* from the Cycadaceæ. The organisation of the flower is so different from that of the cones of any recent Cycad that it is difficult to determine with any certainty the homologies of the parts in the two groups. It is, of course, possible that future palaeontological discoveries may reveal the existence of types of fructification intermediate between those of Cycadales and Bennettitales; at present, however, it seems as if their development had followed different lines from a very early stage.”

If anything this overdraws the reproductive divergence. A cycadeoid with short more peltate micro-sporophylls organized into cones, would nearly close the gap between *Cycas* and the cycadeoids; while it can be held certain that the Cycadophyte types presented in the early Mesozoic many vegetative similarities which were later obscured.

All in all, therefore, the extinct group of cycadeoids to which *Cycadeoidea* has afforded the structural key, are half-cycads,—in the most exacting sense of the word, HEMICYCADALES. That this is a cosmopolitan and a homogeneous group of varied stem and floral structure is now known. It is also a feature of the group that so far as can be detected the large stemmed forms are nearest the cycads. They are therefore the true Pericycadeoids.

Of these PERICYCADEOIDACEÆ, two family groups appear to view. The first is Bucklands Cycadeoideæ (1828), in the synonymy of which is included a plethoric series of generic names. These were in part reviewed by Ward (1900) when he sought to establish his *Cycadella*. The material has afforded the most exacting and complex of all redintegrations of ancient plants. The broader outlines of the second family, the Williamsoniæ (Carruthers, 1870), are only less well attested. Doubt as to the character of the genera attributed here, can occasion no great inconvenience. It would, for instance, be rash to believe that all the Pterophyllums can belong to any one family.

In the second greater order of the hemicycads, so far as the first necessities of a preliminary classification are concerned, the characters are fairly enough established to indicate a steady departure from the pericycadeoid forms. These are, therefore, the apocycadeoids or APOCYCADEOIDACEÆ, also with two families. The first, or MICROFLORÆ, includes the typically small-flowered *Wielandiella* and *Williamsoniella*. The small freely bifurcate stems bear their small bladed leaves in close set whorls, or more diffusely, and may have pertained to larger forest trees of semi-magnoliaceous habitus; but unfortunately the stem structure remains inferential. The second hemicycad family is a hypothetical one of mainly large-leaved imprints, numerous and cosmopolitan, presumably allied here. It can be given an arbitrary name, the HOLOPHYTÆ, or the all-leaf-family, with both fruit and stem inferential. The genera included are, *Anomozamites*, *Nilssonina*, *Taeni-*

opteris and *Macrotaeniopteris* (not necessarily all forms), *Ctenis*, *Pseudoctenis*, *Ptilozamites*.

Reasons for this grouping are, however, neither lacking nor solely inferred. Thomas and Bancroft (1913) have shown that *Nilssonia*, *Tæniopteris*, and *Ptilozamites* have characteristic stomata suggesting the existence of a provisional great group—the Nilssoniales. The facts they adduced, position of the genera in time, certain leaf features, and the probability of departure in the fructification from *Wielandiella*, led me to use this classification (1916). But reasons for such a wide separation are less evident. The fact that *Tæniopteris vittata* leaves of the Yorkshire coast, which are hardly distinguishable from some of the smaller *Nilssonia* foliage, pertain to small fruits not remote from *Wielandiella*, is important (Thomas, 1915). This new type, *Williamsoniella*, thus falls into the better defined Microfloræ, and at the same time suggests that Tæniopterids in general, and doubtless Macrotaeniopterids, are truly cycadeoid. It accordingly seems preferable to drop the term Nilssoniales¹ and so leave the several genera in question as the terminal family of the apocycadeoids, or HOLOPHYTÆ.

This family group appears to have its most striking development in the Rhætic, and attention has elsewhere been called to the fact that while many macrophyllous forms occur in the Trias of Virginia and North Carolina, microphyllous forms are a feature in the Rhætic of Argentina. There too the *Ptilozamites* types are seen.

Evidently there was an ancient line which led toward the Cycadales, Hemicycadales, and Ginkgoales—the Paracycadales it might be called. As members of a group, leading toward the Ginkgoales, yet in all probability but slightly removed (if at all), from the Holophytæ, there

¹ Thomas, H. Hamshaw. On *Williamsoniella*, a New Fruit Type of Bennettitean Flower. Phil. Trans. Roy. Soc., vol. 207, p. 113.

[In giving my classification of the Cycadales (Amer. Fos. Cy., vol. II, p. 26), I was unaware of this important paper. While on the other hand my inclusion of a great group Dioönitales was a *lapsus calami*, due to having after a time overlooked the later notes of Nathorst on *Dioönites spectabilis*. These leaves are, as recalled, associated with what at first suggested a decompounded spore or *antherangium*; found on later study by bettered methods to belong to a lax seed cone of the *Beania* type. The so-called *Beania* is rather difficult to place anywhere, though more cycadeous than cycadeoid. Seward (Fossil Botany, p. 502) notes the resemblance of this two seeded megasporophyll type to abnormally paired *Ginkgo* seeds; and I called attention to a certain sporophyll resemblance between *Zamiostrobus* or *Stenorrachus* of Nathorst and *Cycadeoidea* (Am. Fos. Cy., vol. I, p. 232).]

may be enumerated, *Zamiopsis* (Fontaine)², *Ctenopsis*, *Thinnfeldia*, and *Dicroidium*.³ The furcate Cycadophytan leaf type is so striking in the Rhætic that evolution of Ginkgoid leaves from more fern-like forms seems to go on before one's eyes.

That Bessey was justified in including within the Cycadophytes a great *Ginkgo* series is as certain as anything in paleobotany. But such a group or equivalent family is not added here because discovery within it may any day lead to a more felicitous nomenclature than is now possible to propose. These Ginkgoid forms, with the Araucarineæ, represent the older boundary lines.

More terminal is the approximation of the Holophytæ to the dicotyls. These forms must be regarded as a relatively generalized line. A certain degree of specialization in the ovulate cone need not mislead us. That would be less evident in the few seeded forms which must certainly have occurred. The disk is entirely plastic. The leaves present variety and are not highly xerophyllous; the stems may be small, and were capable of variation in branching. There is excellent reason for believing that large, normally forest-making tree types are included.

Hardly one of these facts is true of the Cycadaceæ, and the suspicion is always strong that far back in time the spinose or highly xerophyllous and *Podozamites*-like fronds belong either to the Pericycadeoids or the Cycads. There need be little hesitation in making of such forms an arbitrary group and placing it terminally to the Cycadaceæ, next to the Pericycadeoids as done herein. Inclusion of *Stangerites* (McClellan) is theoretic; but this leaf type could as readily go with carpels as with cones [*Zamiæ*]. *Stangerites* has scarcely had the attention it merits. Also, this doubtful boundary has on its remoter side the Holophytæ.

The generalized plastic Apocycadeoids therefore lie near to the theoretic persisting type. The Pericycadeoids were the Proangiosperms of Saporta, but these Apocycadeoids come near to or into actual contact with the theoretic ancestors of the angiosperms, the Hemiangiosperms of Arber and Parkin (1907).

² Fontaine, W. M., The Older Mesozoic Flora of Virginia, Monographs of the U. S. Geol. Surv., vol. 6, Washington, 1883, pp. 144, pl. LIV.

³ Anteus, Ernst. Die Gattungen *Thinnfeldia* Ett. und *Dicroidium* Goth. Kungl. Svenska, Vet. Ak- Hand., 51, No. 6, 1914, pp. 69, pls. 5.

DIAGRAM 1. Cycadophyta: Time range and approximate relationship of characteristic types.

Completer accounts of the genera composing the several families just outlined, with notes on the abundance and relative range of important forms would find a place here. But such extended treatment may fairly be left over for incorporation in studies of floræ. The two diagrams appended will, however, throw some further light on the main facts on which the Cycadophyte classification must rest.

In the first diagram the approximate time-range and relationships of the better known or the more characteristic Cycads and Hemicycads are given. To the left are the two great persistent diœcious lines with strobili of increased size [reaching a weight of 100 pounds]. It is unlikely that large strobili have uniformly characterized the cycads. Earlier views have implied this; but neither the record nor theoretic considerations can be here invoked. The reduction and consolidation of sporophylls into cones is ancient; and nearly all through the Permian and the Trias, sporophylls are small and cones lax. The marvelous conservation of the cast *Lepidostrobus browni*, a compact sizable cone, shows that larger sclerous cones are preserved as fossils, fortuitously. In North America just one good *Araucaria* cone has been recovered.⁴

The two Cycadalean arrowheads fix the present in the diagram then, as the era of specialized great cones, seen in conifers also; while the succeeding arrows show the relative persistence, known and inferred, of the lines more and more Hemiangiospermous. In a sense these are also the more and more generalized groups; though it is doubtless consistent to regard small bisexual flowers as denoting specialization. The point is that these were near the lines destined to persist; and such, while making fundamental changes early, must from period to period hold to some structural mean, passing which always ends in extinction. There is then found in these groups, combined with varying degrees of specialization, a profound underlying relationship to the forms leading on to the dominant races of today.

Taking the Zamia, it is curious to find so fern-like a frond as *Stangeria*, and one so aberrant as *Bowenia*. These forms are more ancient than the record indicates, as also the strobilar crown of *Cycas*. There is no reason

⁴ This is the *Araucaria hespera* (Wieland, 1908), now being more carefully studied in the course of a joint investigation by Dr. Neil E. Stevens and myself, taking up the aplosporophyllous gymnosperms.

for uniting these two Cycadalean lines anywhere in post-Paleozoic time; and what is true of them is true of all the main Cycadophytan types. Thus *Pseudocycas* suggests relationship to the Cycadeæ, just as does *Podozamites* to the Zamia; though both are clearly old. So too the borderline frond type *Stangerites*.

Coming to the Pericycadeoid division of the hemicycads, the macroflorous Cycadeoideas persist nearly as long as the cycads—being last found in the Upson shale of Texas, high up in the Upper Cretaceous, and not known earlier than the Jura. Taking the record as it stands, the Microfloræ are an older line than the Cycadeoidea, but generalized in the sense that so far as appears, they tend less to extreme types. *Pterophyllum*, with an exceedingly long history, must be hemicycadeoid. The Permian-Carboniferous *Plagiozamites*⁵ is an old cosmopolitan form (*incertæ sedis*) of short range. *Tamiopteris*, *Nils-sonia*, *Ctenis*, are hemicycads of longer range, unless the slightly net-veined *Ctenis* be excepted. The very fact of extinction implies that these genera reached a degree of specialization; but it is improbable that they bore heavy cones. Entirely too little consideration has been given the possibility that many of these leaf types may be those of forest-making trees, flowered like the magnolias. Much less has it been noted that with only a slight inner-ervation,—invasion of a marginal veinule, in any bladed type with well separated pinnate venation netted types could easily arise. Recall once more that leaf-hiatus between *Tumboa* and *Gnetum gnemon*.

In the Permian the several Cycadophyte lines are more uncertain, but shown as discrete. Using these terms in a purely adjective sense, there must be the Eocycad, Eocycadeoid, and the Apocycadeoid groups. Finally the pro- or hemiangiosperm arrow has the position laid down, except that the head representing the actual appearance of the angiosperms might be placed at the close of the Jura.

Not to add theory to theory; but rather to give a simple form of expression to basic conceptions sometimes overlooked, a second diagram has been arranged to show the Cycadophyta in their larger relationships. As plotted, the object is first to accentuate the very earliest appear-

⁵ See the paper by Harvey Bassler; A Cycadophyte from the North American Coal Measures, this Journal, vol. 42, pp. 21-26, July, 1916.

ance of typical forest trees, groups or phyla; and where there is comparative evidence for earlier origin than the fossil record shows, the fact is in a general way indicated. But such a scheme is always provisional. The upturned lines are used because, as well known, the study of invertebrates, vertebrates and plants shows that when new types first appear, the evolution of species is rapid, and the later decline slow.

Secondly, the terminal gymnosperm lines show an inherent relationship so far back in time that it is not always consistent to speak of these more specialized terminations as absolutely extinct. They are only relatively so. The record proves rather that the forward movement was always widespread, with the extinct forms always structurally near the persisting mean. Specialization rises little beyond oddity of outer feature. Of this the Ginkgos are a notable instance.

Those who work much with the recent types, or those relatively recent, like the mammalia, may be led to regard evolution as one vast series of adaptations and specializations, and thus become ardent culturists of paleontologic trees. Such must ever express the facts too superficially; the main or greater course of change is far better defined as one of modification, reduction, and the avoidance of specialization.

The exceedingly long plant series permits a glimpse of the average course of upward change, and the great rôle of reductions. Its study, so often severely histologic, also brings into closer view the climatic factors. But the study is only just begun. Hence the introduction of the brief climate characterizations in diagram 2, is only meant to emphasize the fact that there is continuity in the changes going on from age to age. Geologists may even object to these terms,—in that case because the compilation is faulty. [The continental area curve is from Schuchert.]⁶ Similarly, terms correspondent to the Siluro-Devonic, Carboniferous, Permo-Triassic, and

⁶In bringing climate into the time scheme, the main uncertain factors are cloudiness and atmospheric composition, both unmeasurable. Climate and diastrophism are, however, inseparable factors, whether in dealing with successive floræ precise inferences can at once be gained or not. Certain periods have been cold and arid, others wetter in both time and space. A continent-wide soil change is thus also ever going far to control forest limits and types. With the appearance of bipolar ice caps a kind of culmination is reached. These are the greater factors which led during transition time for instance to the specialized stem of an oak, one of the highest plant products yet seen.

recent, long continental emergences are required. Here, *Archaic*, *Ancient*, *Transition*, and *Recent*, may serve to indicate the four great land plant worlds of the past, following the Eopaleozoic aquatics.

The view here emphasized is not new, but goes back to Saporta (1881), and has been only recently again brought forward by Clements in his *Plant Succession* (p. 288). It will be observed however that the terms suggested are used in the physical as well as phytologic sense, and that both the divisions and events are set back much further in time. This is held absolutely justifiable from both the plant and diastrophic records.

In lieu of a *résumé*, let the fact be emphasized that the various "paleobotanic trees" and gymnosperm classifications still include features irreconcilably divergent. One of the most suggestive "trees" is that of Lignier (1903), written out as follows:

- I. LYCOPODINALES (*Lycopodineæ*).
- II. PROTOPTERIDEANS (*Filicinales*, *Filices*)
- III. $\left\{ \begin{array}{l} B \\ A \end{array} \right\} \begin{array}{l} \text{CYCADALES (Cycadaceæ)} \\ \text{SALISBURIALES (Salisburiaceæ)} \\ \text{BENNETTITALES} \\ \text{CORDAITALES (Gnetales, Angiosperms)} \end{array} \left\{ \begin{array}{l} 1. \text{Euconifers} \\ 2. \text{Taxineas} \end{array} \right.$

Now Lignier's "tree," viewed in the light of his later critical studies of the Gnetales, gives a degree of expression to that extreme homoplasy which becomes with every succeeding year of investigation, more and more evident, especially in the four great gymnosperm lines. But it has the lack inherent to all such schemes. They always somewhere detach or separate important groups, here the cycads and cycadeoids. Plotted on a cylinder (better a hemisphere), this difficulty is partly met.

It is worth while to give and to examine diagram 3, the sectors being movable (and also to be taken in the spherical sense). This diagram, while showing the Cycadophyte-Coniferophyte division, is not given as a formal classification, but as a first step in reaching one. It is believed to be a better form than any other for bringing out certain inconsistencies in the classification—taken from the paleobotanic viewpoint. Ampliation is much simplified; at the center are the early Lycopods and "seed-bearing quasi-ferns." Dicotyledony is not bracketed; most spermatophytes have been dicotyledonous far

back in time, as they are today. But I follow R. B. Thomson in regarding *aplospory* and *diplospory* fundamental. Also, Van Tieghem's view that the *Ginkgo* sporophyll is simple (diplosporous), I am forced to adopt, as earlier inclined (*Am. Fos. Cy.*, vol. I, p. 232). For this and other reasons, as well as inferences from fossil types like *Beania* and *Dicroidium*, *Ginkgo* is put hard by the Cyca-

DIAGRAM 3. The gymnosperm phylum.

dales. Placing the Abietineans next to the Ginkgoales, however, partly accords with Lignier's scheme, above; though some botanists would certainly bring the yews nearer the Cordaites. The Araucarians are perhaps the most difficult of all the gymnosperms to place; theory has run the entire gamut from separate derivation through a lycopod stock, to Mesozoic origin from the Abietineæ. The latter view is absurd.

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