Catalogue of the Mesozoic plants in the Department of Geology British Museum (Natural History).

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CATALOGUE

OF THE

MESOZOIC PLANTS

IN THE

DEPARTMENT OF GEOLOGY

PART II.

CATALOGUE

OF THE

MESOZOIC PLANTS

IN THE

DEPARTMENT OF GEOLOGY

BRITISH MUSEUM

(NATURAL HISTORY).

THE WEALDEN FLORA.

PART II.—GYMNOSPERMÆ.

PLATES I.–XX.

BY

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PREFACE.

The first part of this Catalogue of the Wealden Plants contained figures and descriptions of the Algæ, Characeæ, Equisetinæ, and Filicinæ; the present volume is devoted to the Cycadeæ and the Coniferæ.

In the Author's conclusions he gives a summary (pp. 233–241) of the Wealden flora comprised in these pages, from which it appears that the Thallophyta are represented by 2 sp.; the Charophyta by 1 sp.; the Bryophyta by 1 sp.; the Equisetinæ by 3 sp.; the Filicinæ by 23 sp.; the Cycadeæ by 24 sp.; the Coniferæ by 17 sp.; uncertain forms, 5 species: total, 76 species.

Mr. Seward considers that "the general characters of the vegetation certainly seem to point to a tropical climate, and there can be little doubt that the temperature was considerably higher than the Wealden districts enjoy at the present day" (p. 239). He further adds that, "Looking at the Wealden plants collectively, we notice a very striking agreement with the flora of the underlying Jurassic strata, and it would be difficult to point to any well-marked or essential difference between the plant-life of the two periods. The evidence of palæobotany certainly favours the inclusion of the Wealden rocks in the Jurassic series." Mr. Arthur Smith Woodward informs me that the fishes of the Wealden beds bear testimony to the same Jurassic alliance. We are thus led to conclude that whereas the palæontological evidence, derived from the more purely marine deposits, would induce us to place the Wealden beds with the overlying and *newer* Cretaceous series—the peculiar estuary, or lake conditions, of these mostly fresh-water deposits, full of remains of terrestrial organisms, both of plants and animals, would, by their close relationship with the underlying and *older* Purbecks and Oolites, fix a Jurassic date to this ancient land surface upon which the Wealden flora once flourished.

HENRY WOODWARD.

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November 16*th*, 1895.

AUTHOR'S PREFACE.

In the present volume the same method of treatment has been followed as in Part I.

My thanks are again due to Mr. George Murray, Mr. Carruthers, and to the Assistants of the Geological and Botanical departments generally; also to Mr. Rufford and Mr. C. Davies Sherborn.

To the Director of the Royal Gardens, Kew, I am indebted for the facilities afforded me of repeatedly examining the exceptionally large collection of cycadean plants in the Kew Herbarium.

I wish also to gratefully acknowledge communications from the late Marquis of Saporta, Sir William Dawson, Prof. Nathorst, Prof. Lester Ward, and others; and to express my thanks to Miss Gertrude Woodward for the great care and artistic skill with which she has executed the lithographic plates.

I am indebted to Mr. Gepp, of the Botanical Department, for the negative from which Plate VIII. has been printed.

A. C. SEWARD.

CAMBRIDGE,
November 16th, 1895.

NOTES.

The names of authors in the footnotes, when followed by a number in brackets, or without a number, will be found in the list of works at the end of the present volume (Part II.); those followed by A. in brackets will be found in the bibliography of Part I.

The great majority of specimens described in Part II. are from Ecclesbourne and Fairlight, near Hastings, and form part of the Rufford Collection.

In addition to these, there are a few fossils from the Beckles Collection, and from the collections of Mantell, Dawson, and others.

ERRATA.

P. 65. For *Otozamites Klipsteinii* var. *superba*, read *Otozamites Klipsteinii* var. *superbus*.

P. 68. For *Otozamites Klipsteinii* var. *longifolia*, read *Otozamites Klipsteinii* var. *longifolius*.

P. 89. For **V. 2742**, read **V. 2743**.

Plate II. Figs. 1 and 2. For *Saportaia*, read *Withamia*.

LIST OF FIGURES IN THE TEXT.

Group SPERMAPHYTA (PHANEROGAMIA).

In Engler and Prantl's invaluable work, *Die natürlichen Pflanzenfamilien*,[1] we find certain innovations as regards the classification of plants: conspicuous among the changes suggested are the terms *Embryophyta zoidiogama* and *Embryophyta siphonogama*, the former being applied to the *Bryophyta* and *Pteridophyta*, and in the latter are included the *Phanerogamia*.

The researches of Hofmeister, and the more recent investigations of Strasburger and others, have brought to light a multitude of facts, by which we have been led to a more exact knowledge as to the natural affinities between the several plant groups. Developmental study, and our more accurate perception of the homologies existing between the different families, have tended to emphasize the points of contact between the various divisions of the vegetable kingdom. Any system of classification is to be welcomed which best enables us to give expression to recognized leading characteristics, and at the same time to bring out in a concise phraseology the differences and resemblances between class and class. Engler's new terms, if not used to supersede the older and widely known designations, may at least be recognized as marking a definite advance towards a better understanding of phylogenetic problems.

In dealing with fossil plants we have constantly to face the difficulties of classification. With some writers there is a tendency to strain the known points of resemblance between living and extinct forms, and to include both in one family or sub-class; in other cases, needless isolation may be given to fossil genera by separating them from existing types. Undoubtedly the most natural plan is to endeavour as far as possible to fit together the representatives of Palæozoic, Mesozoic, and Cainozoic genera, with present day plants, in a common scheme of classification. It is obviously impossible in the vast majority of fossil specimens, to discover anything of those characters on which a modern

[1] Teil ii. p. 2.

classification of plants is based; but we have to discriminate as best we can between valueless and important taxonomic features, and to accept within legitimate limits the assistance of evidence founded on analogy. To exclude fossil plants from a classification based on living types would be at once thoroughly unscientific and unnatural. Recent botany and the botany of past ages have too often been treated from different standpoints, and the great aim of palæobotanical study has thus been entirely lost sight of. The more we recognize the fact that plant-life, with its innumerable problems awaiting solution, is not confined within the limits of one age in the history of the earth, the sooner ought we to attain to a natural system of classification.

The more important characters of the *Spermaphyta* (*Embryophyta siphonogama*) may be thus briefly summarized:—

In the great majority of cases the body of the plant is differentiated into root, stem, and leaves. The embryo is formed as the result of fertilization, by means of a pollen-grain tube, of an egg-cell enclosed in a macrospore; the fertilized egg-cell develops into an embryo, which more or less completely fills up the macrospore and macrosporangium. The seed may or may not be enclosed in an ovary. The gametophyte (sexual or oophore generation) is considerably reduced, and the sporophyte (asexual or sporophore generation) has become much more conspicuous than in the *Pteridophyta*.

Class GYMNOSPERMÆ.

Seeds naked, not enclosed in an ovary. Fertilization of the egg-cell by means of a pollen-tube. Vegetative structures capable of secondary growth in thickness.

Order CYCADACEÆ.

Stem rarely branched, leaves large and generally pinnate. In the recent genera flowers always diœcious, and without a perianth.

The Order *Cycadaceæ*, like the *Marattiaceæ* among ferns, affords an instance of a series of plants of which few survive at the present day, but which was abundantly represented in the vegetation of former periods. The recent cycads are usually divided into nine genera and two families: the *Cycadeæ*, including one genus, *Cycas*; and the *Zamieæ*, with the genera *Zamia*, *Ceratozamia*, *Macrozamia*, *Dioon*, *Encephalartos*, *Stangeria*, *Bowenia*, and *Microcycas*.[1]

None of the living cycads occur outside tropical or subtropical regions. In Tertiary times the family does not appear to have had a wide distribution, nor to have been represented by many genera; possibly, however, a closer acquaintance with extra-European Tertiary strata may bring to light a greater number of cycads from these beds than are at present known. In the Mesozoic period cycads occupied a prominent position, and had an extended geographical range. The Jurassic strata afford abundant evidence that cycadean plants reached their maximum development in that era; less numerous in the Triassic vegetation, the *Cycadaceæ* dwindle down to a few representatives in the Permian and Carboniferous floras.

Before giving a summary of the earlier geological history of this exceedingly interesting section of the *Gymnospermæ*, we may take note of some of the difficulties which beset any attempt to trace the geological history of cycadean plants. As in the case of ferns, and indeed of all fossil plants, so here again we have to deal in nearly every instance with detached and isolated specimens of stems, fronds, flowers, and seeds. The fronds are often abundant enough, and their preservation frequently good; but the characters which are made use of in generic and specific determinations are such as preclude any certain conclusions as to precise botanical affinity. The nature of cycadean flowers, and their manner of occurrence on the plant, separated as they are from the sterile fronds, present an obstacle to exact determination. On the other hand, the fronds alone afford, in many instances, convenient data on which to found a provisional classification; their form and general habit of growth are fairly uniform, and they do not present the same striking variation in leaf form which constitutes one of the many difficulties associated with the fronds of fossil ferns. Among recent cycads we have a phyllopodium exhibiting, in the majority of species, certain distinct and easily recognized characters; usually a pinnate structure, with stout and more or less closely set segments

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[1] Engler and Prantl, Teil ii. p. 6. See also De Candolle.

traversed either by a single midrib or by a number of equal and parallel veins. There are, however, certain variations from the familiar cycadean type, even in some of the living genera. In the South African genus *Stangeria*,[1] originally described in 1835 as a fern, the pinnæ possess a fern-like venation, forming a strongly marked contrast to the usual *Zamia* or *Cycas* type. Writing of this plant in 1854, Smith[2] notes that the peculiar character of the leaf segments renders untenable the criterion of venation, usually relied upon in discriminating between fossil ferns and cycads. Among fossil leaves there are various genera which have been assigned to cycads or ferns according to the preference of different authors. The well-known genus *Nilssonia* has been placed by Schenk and others among the *Filicinæ*, but it is usually referred to as an extinct member of the *Cycadaceæ*; the widely distributed *Tæniopteris* has been assigned to both ferns and cycads, but it is generally regarded as a genus of fossil ferns. The genus *Dictyozamites*[3] and numerous others might be cited as examples of doubtful forms which cannot with any certainty be assigned either to the *Pteridophyta* or *Gymnospermæ*.

In a recent work on the Coal-Measures of Gard, Grand'Eury[4] includes certain leaf forms in the class of gymnosperms, but by other writers these have usually been described as ferns. To settle such doubtful cases as these, Bornemann[5] undertook a minute comparative examination of the epidermal cells of recent ferns and cycads, and found what he considered fairly safe guides in the rectangular or wavy outlines of the epidermal cells of the leaves of these two sets of plants. Schenk[6] has followed Bornemann's example in making use of this anatomical character in the case of carbonized epidermal tissues of doubtful fossil leaves, but the fern-like wavy walls in the epidermal cells of *Stangeria* leaves preclude any trustworthy reliance on such a method of separating ferns and cycads.

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1 Hooker, Bot. Mag. Pl. 5121, vol. xv. [3] 1859. Reference given to Kunze, etc.

2 Smith, p. 88.

3 Nathorst (1).

4 Grand'Eury (1), p. 301.

5 Bornemann.

6 Schenk (A. 1), Flor. foss. Grenz. Keup. Lias.

As a general rule, the fronds of recent cycads are simply pinnate; but in the Australian genus *Bowenia*,[1] with its bipinnate leaves, we have an exception to this rule; and it is by no means improbable that this character may have been shared by many extinct genera. The late Dr. Stur, of Vienna, expressed his belief that the well-known Coal-Measure fossils *Neuropteris* and *Alethopteris* should be included in the list of Palæozoic cycads, and this opinion was partly founded on the resemblance of the Carboniferous fronds to the branched leaf of *Bowenia*. The absence of any clearly proved fructification in these so-called ferns has been referred to by Stur and others in favour of a cycadean relationship. Kidston[2] has recently recorded the occurrence of a fertile *Neuropteris* frond, but the facts he publishes cannot be regarded as finally settling the position of these genera. He figures a terminal portion of a specimen "ending in a number of dichotomous branchlets, the ultimate divisions being about 8 mm. long, and bearing the fruit at their summits." Unfortunately the very small pinnules associated with this fragment do not furnish all the evidence one could desire as to the real nature of the specimens.

Another aberrant form of a recent frond is afforded by the Australian cycad *Macrozamia heteromera*, Moore,[3] in which the pinnæ are in some varieties of the species repeatedly forked, reminding one to some extent of the Mesozoic species of *Baiera*. Specimens of *Macrozamia heteromera*, var. *Narrabri*, and var. *glauca*, in the Royal Gardens, Kew, show very clearly this striking and unusual character in cycadean fronds. (Pl. XIII. Figs. 1 and 2.)

A further variation in the form of cycadean leaves is seen in such species as *Zamia Skinneri*, Warscew, *Z. picta* (=*Z. muricata*, Willd.),[4] *Z. Wallisii*, A. Gr., etc.: the pinnæ of these forms reach an unusually large size, and differ in shape from those of most members of the family. A single pinna of *Z. Wallisii* in the Kew Herbarium measures 37 × 13 cm.; the lamina is traversed by a few prominent and forked veins, and exhibits another peculiarity in the possession of a short petiole. If we have to rely on leaves

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[1] Hooker, Bot. Mag. Pl. 5398, vol. xix. [3] 1863.
[2] Kidston (1), p. 150, pl. viii. fig. 7.
[3] Moore, p. 122.
[4] De Candolle, p. 541.

alone we must necessarily expect to fall into error, but it is important not to bind ourselves too closely to the more common forms of cycadean fronds in endeavouring to determine the leaves of extinct species. Seeing that the existing genera of cycads are obviously but a few remnants of a once vigorous and numerous family, we should not neglect the less known and more aberrant forms of fronds in our comparisons of fossil and recent specimens.

We are accustomed to include in the *Cycadaceæ* a large number of Jurassic and Lower Cretaceous fronds which possess some more or less close external resemblance to those of living species. That such determinations are correct we have no absolute proof, but can only trust to the distinctly cycadean form which the leaves present. It is possible that among such Mesozoic genera there are included some which should rather come under the head of *Bennettiteæ*, a group of plants nearly allied to the true cycads, but which possess certain peculiarities of structure of sufficient importance to exclude them from the *Cycadaceæ* as at present defined. Silicified stems from the Upper Jurassic and Lower Cretaceous rocks of England, France, Italy, America, and other places, agree in anatomical structure with the stems of recent cycads, but in organic connection with some of these fossil forms there has been found a special type of inflorescence, showing a more highly organized and specialized structure than is afforded by the flowers of existing *Cycadeæ* or *Zamieæ*. Our knowledge of the vegetative and reproductive structures of *Bennettites* is mainly due to the researches of Carruthers,[1] Solms-Laubach,[2] and more recently Lignier.[3] The *Bennettiteæ* inflorescence presents certain points of contact with the *Coniferæ*, and the characters it possesses in common with and distinct from those of cycadean flowers suggest that "the *Bennettiteæ* are posterior to the *Cycadaceæ*, at least as regards the reproductive structures." As Lignier has said in his recent paper, we may perhaps regard the *Bennettiteæ* as a family which has been derived with the cycads from common ancestors. We have still to learn what forms of frond were possessed by these stems. Carruthers[4] speaks of a "remarkable

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[1] Carruthers (1).
[2] Solms-Laubach (1 and 2).
[3] Lignier. (For abstract of this paper see Nature, October 18, 1894, p. 594.)
[4] *Loc. cit.* p. 697 (footnote).

cycadean leaf" from the Lower Greensand, which he suggests may possibly represent a frond of *Bennettites*; the specimen referred to is not in organic connection, nor in any close association, with a stem, and therefore no satisfactory conclusion can be drawn as to its real nature. As yet we can only reply to the question as to what was the precise form of *Bennettites* leaves by mere guesses, founded on no surer basis than a vague suspicion of probability. The leaf-scars on the surface of the stems suggest a frond of cycadean habit; and in all probability many of the Mesozoic leaves which we are accustomed to connect with true cycadean stems should be referred to *Bennettites*. To include all cycad-like fronds in the *Cycadaceæ* as defined for existing species, would almost certainly result in assigning many fossil leaves to a wrong position. Possibly the better plan would be to assign such fossil fronds as may reasonably be referred to cycadean plants, to some more comprehensive Natural Order than that of the *Cycadaceæ*.

This brings us to the question of intermediate forms, and the association of cycadean structure with several of these synthetic types lends an increased interest to the past history of cycads, and at the same time enhances the difficulty of systematic treatment. The Upper Carboniferous genus *Myeloxylon* (*Stenzelia*, Göppert, *Myelopteris*, Renault), found in England, France, and Germany, has been assigned by several writers to the *Filicinæ*, and placed in the *Marattiaceæ* or *Ophioglossaceæ*; others prefer to include it with the cycads. The structure of the vascular bundles of *Myeloxylon* petioles[1] is in some respects typical of recent cycads; the spiral protoxylem elements being on that side of the xylem facing the phlœm. The bundles are collateral in form, and often accompanied by mechanical or stereome elements. The fundamental tissue contains numerous secretory canals, and in some cases strands of stereome. One of the most readily recognized features is the hypodermal tissue, made up of alternating bands of thick walled fibres and thin parenchymatous cells. Occasionally the petiolar axis is found to be branched, and small *Pecopteris*-like pinnules have been observed attached to a slender *Myeloxylon* midrib. This discovery by Renault of pinnules in connection with *Myeloxylon*

[1] Seward (1). References given to other papers; see also Zeiller (1), p. 290, pl. xxvii. fig. 1.

appears to be confirmed by some specimens in the Binney Collection[1] of Coal-Measure plants. In one instance this form of petiole has been found inserted on a stem of *Medullosa Leuckarti*, Göpp. and Stenz., a plant with distinctly cycadean characteristics. Probably we may regard *Myeloxylon* as a synthetic or intermediate form exhibiting cycadean and fern characters, but more nearly allied to existing *Cycadeæ* than to the *Filicinæ*. In the Coal-Measure genus *Lyginodendron*,[2] originally described in detail by Williamson in 1873, we have another important link in the chain of cycadean phylogeny. A revision of the English specimens of this plant, and an examination of fresh material by Williamson and Scott, has brought into greater prominence the clearly defined cycadean features exhibited by the *Lyginodendron* stems. It has recently been shown by these observers that Williamson's genus *Kaloxylon* represents the root of *Lyginodendron*, and we have previously learned that *Rachiopteris aspera*, Will., with its sphenopteroid pinnules, is a branch of the same plant.[3] This is, again, an instance of cycadean and pteridophytic characters combined in a synthetic genus. The presence of secondary vascular tissue in *Lyginodendron* lends additional interest to this instance of fern-cycad alliance. In speaking of the occurrence of diploxyloid structure in this genus, Bertrand and Renault[4] regard the existence of such a type of vascular bundle in the petioles of recent cycads as a remnant of an ancestral structure.

The same diploxyloid arrangement occurs on an extended scale in the Permo-Carboniferous genus *Poroxylon*,[5] and must be looked upon as an important aid in any attempt to trace the lines of development of the *Cycadaceæ*. Renault has founded the genus *Cycadoxylon*[6] on a fragment of a silicified branch from Autun, in which the structure of the wood and fundamental tissue bears a distinct resemblance to a young cycadean stem. He suggests that this type may find its true position between cycads and

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[1] Now in the Woodwardian Museum, Cambridge.

[2] Williamson (1, part iv.). The name was proposed by Gourlie in 1843. (Williamson, p. 393.) See also Solms-Laubach (A.), Fossil Botany, p. 358.

[3] Williamson (1, pt. vi.), p. 684; also (1, pt. xiii.), p. 298.

[4] (1), p. 237.

[5] Bertrand and Renault (2).

[6] Renault (1), p. 283.

Cordaiteæ. Unger's genus *Cordaites*,[1] with its large parallel veined leaves and tall woody stem, affords another example of the occurrence of cycadean structures in association with anatomical features suggestive of another set of plants; in this case it is with the *Coniferæ* that cycadean characters appear to be combined. In the Mesozoic floras we have Carruthers' genus *Bennettites*, to which reference has already been made, with its combination of cycadean and coniferous characters. Another and less accurately known plant, *Williamsonia*,[2] offers a difficult problem to the palæobotanist; but here, again, we have probably to deal with a synthetic type closely allied to *Bennettites*.

Enough has been said to show the promising character of the study of the geological history of cycads, and we may not unreasonably entertain the hope, that we are within a measurable distance of deciphering some of the earlier chapters in the records of cycadean development.

Before considering the questions of terminology and the details of generic and specific determination of fossil cycadean fronds, we may briefly pass in review the recorded facts as to the past history of the *Cycadaceæ*, and especially such as have reference to the representatives of this order in Palæozoic times. In 1868 Carruthers[3] expressed the opinion that "no satisfactory evidence exists of the occurrence of *Cycadeæ* in any Palæozoic formation." It is true that the facts we at present possess do not allow us to affirm that the Palæozoic strata contain examples of plants which exhibit typical cycadean structure, and of such a kind as to warrant their inclusion in the *Cycadaceæ* as at present defined.

It has already been shown that certain typical features of cycad structure are met with in various Permo-Carboniferous genera, but these are associated with other morphological characters which are unknown among recent representatives of this class of gymnosperms. It would, indeed, be a matter of surprise if we found in Palæozoic strata a perfectly typical cycadean genus. In the case of Jurassic plants we speak unhesitatingly of cycad leaves, although we cannot as a rule support such assertions with facts of anatomical details or floral structure If external resem-

[1] Renault (1), p. 323.

[2] See *Bennettites*.

[3] (1), p. 676.

blance of leaf form is to be trusted at all, we must admit the existence in Upper Palæozoic rocks of a few fossil fronds, which have as much claim as those from Jurassic strata to be classed among the *Cycadaceæ.* In reviewing the evidence in favour of Palæozoic cycads, we may for convenience sake consider Permian and Carboniferous specimens together.

In 1848 Gutbier[1] figured and described a Rothliegende plant from Rheinsdorf, near Zwickau, which he designated *Pterophyllum Cottæanum.* The figure reminds one to some extent of *Ctenis falcate*, L. and H., but the pinnæ show no trace of any anastomosing venation; the specimen cannot well be excluded from the provisional cycadean genus *Pterophyllum.* Eichwald[2] has figured a portion of a frond from the Carboniferous rocks of Konznetzk in the Altai Hills, under the name of *Pterophyllum inflexum*; this also seems to conform to the recognized characters of *Pterophyllum.* Carruthers[3] has referred to some stems described by Eichwald from Russian Permian rocks, but is of opinion that they cannot be accepted as satisfactory examples of Palæozoic cycads; the same author also calls attention to the specimens described by Presl and Guillard as cycadean stems, and shows that they have no claim to be placed among fossil cycads. Schmalhausen[4] has more recently figured a stem fragment from the Permian of Kargala in Orenburg, which he refers to Schimper's species *Clathraria strigata*, but regards the specimen as a stem of *Cordaites lancifolius*, Schmalh. In 1864 Sandberger[5] recorded a species of *Pterophyllum*, *P. blechniodes*, from the Upper Coal-Measures of Holzplatze, near Oppenau; the specimen seems to have been reasonably placed among cycadean fronds. Göppert,[6] in 1843, described what he considered to be the oldest known cycadean frond; this imperfect fragment from Konigshütte, in Silesia, he named *Pterophyllum gonorrachis.* Two other specimens were recorded by the same author from Palæozoic strata as *Cycadites gyrosus* and *Cycadites taxodinus*;[7] the former is a small and imperfect specimen which

[1] (A.) Verstein. Roth. Sachsen, p. 21, pl. viii. fig. 7.
[2] Vol. i. p. 215, pl. xv. figs. 5, 6.
[3] (1), p. 675.
[4] (1), p. 37, pl. v. figs. 4 and 5.
[5] (1), p. 34, pl. ii. figs. 1–4.
[6] (1), p. 50, pl. i. fig. 6.
[7] (2), p. 131, pl. ii. figs. 1–34.

it is hardly possible to definitely refer to either cycads or ferns; the latter specimen, from the Culm beds, is more distinct, but still by no means a satisfactory proof of the existence of a cycadean species in the Culm flora. Solms-Laubach[1] considers that Göppert was probably justified in referring the last-named species to the *Cycadeæ*. An examination of the type specimens in the Breslau Museum of these two species of *Cycadites* led me to regard *C. gyrosus* as too imperfect for identification, and suggested the possibility that *C. taxodinus* might perhaps be regarded as a fragment of a coniferous branch. If the evidence for Carboniferous cycads rested simply on Göppert's specimens it would be of little value; but there have been many more perfect examples recorded from this formation. From the Permo-Carboniferous rocks of France we have several records of cycadean fronds. The genus *Pterophyllum* has been discovered in the Upper Carboniferous beds of Montchanin (Saône-et-Loire), and the fragment is figured by Saporta and Marion as *Pterophyllum Grand'Euryanum*, Sap. et Mar.[2]; the form of the pinnæ and their manner of attachment to the rachis support this determination. Another species is recorded by Renault, under the name of *Sphenozamites Rochei*,[3] from the Permian of Autun; the figure of this plant, given by Saporta and Marion,[4] suggests a strong likeness to *Noeggerathia*, and it may be that if, as some believe, the latter genus must be assigned to the *Filicinæ*, the same position should be given to Renault's species. *Noeggerathia* may be left for the present as one of those doubtful forms which cannot be definitely assigned to any clearly defined position. From the Commentry coal-field, from which so many interesting additions have been made by Renault and Zeiller to the Coal-Measures flora, we have several new species of cycadean leaves. *Zamites carbonarius*, Ren. and Zeill.,[5] is the name given to the largest of a set of frond fragments from a particular locality in this coal-field; the type specimen consists of a portion of a stiff rachis bearing a few alternately placed oval pinnæ, and the form of the segments is not unlike that of *Noeggerathia*. In addition to

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1 Fossil Botany, p. 86.
2 Saporta and Marion, vol. i. p. 109.
3 Renault (2).
4 *Loc. cit.* p. 109.
5 Flor. Commentry, p. 614, pl. lxvii. fig. 7. See also Renault and Zeiller (1).

this species, the same authors institute five other specific names[1] for isolated pinnæ which do not appear to afford any distinct indication of specific difference. Potonié,[2] in his recent work on the Permian flora of Thüringen, includes all these five species under *Zamites carbonarius*, and an examination of the figured pinnæ certainly lends support to this view. Zeiller[3] has defended Renault's determination, on the ground that there are certain differences in the venation and form of the pinnæ which are hardly consistent with the suggested inclusion under a single species; he is, however, willing to admit that possibly *Zamites regularis* may be identical with *Z. Planchardi*. Whatever may be the specific value of these Commentry specimens, Zeiller regards them as undoubtedly fragments of the same generic form, and the discovery of more perfect specimens leads him to found a new genus, *Plagiozamites*, as more suitable for their reception than *Zamites*. In speaking of the resemblance between *Plagiozamites* and *Noeggerathia*, Zeiller expresses an opinion in favour of including the latter genus among cycads, using the term cycads[4] in a wide sense. This opinion is partly based on the close similarity between *Noeggerathia* and *Plagiozamites* on the one hand, and on the marked resemblance between the latter genus and *Zamites* on the other. The form of the fronds certainly favours this view, but such reasoning from external resemblance cannot be accepted as conclusive when we are dealing with cycads and ferns. In all these cases we must be prepared to find a combination of pteridophytic and cycadean characters, and if we were in possession of the facts of anatomical structure, we should possibly be quite unable to decide definitely for one or other of these two groups of plants.

The Commentry flora has furnished an exceedingly fine specimen of the genus *Pterophyllum*[5]—*P. Fayoli*, Ren. and Zeill. This example is unusually large and well preserved, and there can be little or no hesitation in accepting it as a Palæozoic cycadean frond, having an equally strong claim to be described as such as

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[1] Flor. Commentry, pp. 615–617, pl. lxvii. figs. 8–19.

[2] (1), p. 210.

[3] (2), p. 177.

[4] *Ibid.* p. 179.

[5] Renault and Zeiller (2), p. 619, pl. lxviii. fig. 1.

the Mesozoic representatives of the same genus. The genus itself is merely a provisional one, and rests on external characters of vegetative structures, but the cycadean habit is sufficiently obvious to lend confidence to the generally accepted botanical position assigned to this and other cycad-like leaves. Portions of gigantic leaves are figured by Renault and Zeiller from the Commentry coal-field under the generic name *Titanophyllum*,[1] and it is suggested that possibly these may belong to *Calpoxylon* stems, which have been referred on anatomical grounds to the *Cycadaceæ*, but these and many other leaf forms must remain in the list of *plantæ incertæ sedis* until additional facts are available. Renault has recently described another species of Permian cycad, *Pterophyllum Combrayi*,[2] which shows a fairly close resemblance to *P. Jaegeri*, Brong. Enough has been said to show that in Permo-Carboniferous times there existed certain forms of leaf structures, which must be assigned with the numerous Mesozoic fronds to the provisional genera of extinct cycads. The large number of seeds from this geological horizon, with their well-preserved structure and variety of external form, are naturally a source of difficulty as regards systematic position. There are distinct indications of cycadean affinity in many of the silicified gymnospermous seeds; some belong, no doubt, to *Cordaites*, whilst others may be more correctly placed in the *Coniferæ*. The seeds of the recent genus *Ginkgo* show some points of contact with those of cycads, and among the seeds of Palæozoic plants it would not surprise us to find cycadean and coniferous characteristics represented in the same species. We cannot well do more than speak of these doubtful fossils as examples of Palæozoic gymnospermous seeds, many of which distinctly resemble the seeds of recent cycads.. Grand'Eury[3] includes many such fossils in the family *Noeggerattiaceæ*, a subsection of gymnosperms; the choice of this name is not a very happy one, seeing that we know so little as to the actual position of Sternberg's genus *Noeggerathia*.

Ascending the geologic series from the Permian to the Upper Jurassic strata, we find a gradual increase in the number and variety of cycadean fronds, and in the Wealden vegetation the

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[1] Renault and Zeiller, p. 622, pl. lxix.
[2] (3), p. 672.
[3] (1), p. 301.

Cycadaceæ were represented by many large and striking species. Further reference will be made to the Lower Cretaceous cycads in the general review of the Wealden flora at the end of this volume. Throughout the Cretaceous and Tertiary series we have evidence of a decline in the relative importance and numerical proportion of the *Cycadaceæ*. It has been suggested that possibly the paucity of species may in some measure be explained by our very imperfect acquaintance with tropical and subtropical Cretaceous and Tertiary plant-bearing strata;[1] it may be that the rocks of these eras were deposited under climatal conditions which were not favourable to a rich development of cycads. Heer[2] has described various frond fragments from Tertiary beds which are not particularly satisfactory as records of cycadean species. The two species *Nilssonia Serotina*, Heer, and *N. pygmæa*, Heer, from the Miocene flora of Sachalin Island, are both founded on fragments which may possibly belong to that doubtful genus in which they have been placed. From the Upper Fresh-water Molasse of Schaffhausen, the same author describes a structureless stem as *Cycadites Escheri*, Heer;[3] the appearance of the scale-covered surface lends some support to this determination, but the specimen is too imperfect to be of any particular importance. Heer figures a fragment of a frond from Lausanne under the name *Zamites* (*Dioon*?) *tertiarius*,[3] founded on a poor and fragmentary specimen. Three species of Tertiary cycads are figured by Saporta and Marion in their *l'Évolution du règne végétal*:[4] one of these is assigned to *Zamiostrobus*—*Z. Saportanus*, Schimp., and may possibly be rightly described as a cycadean cone, but its precise nature cannot be definitely ascertained. The other two species, *Zamites epibius*, Sap., and *Encephalartos Gorceixianus*, Sap., are most probably true cycads. Ettingshausen's New Zealand specimen, described as *Zamites* sp.? cannot be accepted as trustworthy evidence of a Tertiary cycad.[5] From Australia the same author records *Anomozamites Muelleri*,[6] Ett., a species based on small fragments of what may be a

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1 Solms-Laubach, p. 85.

2 Flor. foss. Arct. vol. v. (Flor. Sachalin), pp. 19 and 21, pl. ii. figs. 1–6.

3 (A.) Fl. Tert. Helvet. p. 46, pl. xv. and pl. xvi. fig. 1.

4 Les Phanérogames, vol. i. p. 116.

5 Ettingshausen (1), p. 13, pl. i. fig. 10.

6 (2), p. 9, pl. viii. figs. 19–22.

cycadean leaf. Another possible Tertiary cycad is described by Ettingshausen from the Miocene beds of Leoben; to this the name *Ceratozamia Hoffmanni*, Ett., has been assigned.[1] The single imperfect pinna which is figured by the author of the species, does not afford sufficient evidence that it belongs to this particular recent genus. Granting its cycadean nature, and even this entails a considerable amount of faith, there is surely no reason why the fragment should not be referred to some other genus than the one chosen; one might suggest "cycadean pinna?" as a more fitting term than *C. Hoffmanni*. Göppert's Tertiary species of a Greenland cycad, *Zamites arcticus*,[2] is founded on a fairly good specimen, and certainly appears to be correctly included among the *Cycadaceæ*. These few examples of fragments described by various writers as cycadean fronds, sufficiently demonstrate the meagre relics of this order of gymnosperms in Tertiary rocks.

In his Monograph on the Jurassic cycads, Saporta[3] has given a useful and critical summary of the history of the literature on fossil *Cycadaceæ*, to which is added a series of definitions of the chief characters by which the several genera of fronds may be recognized. Certain suggested emendations of some of these diagnoses will be found under the head of the respective genera in the descriptive part of this Catalogue.

Without following the gradual additions to our knowledge of fossil cycadean fronds during the last sixty or seventy years, or attempting to discuss the numerous classifications proposed by various writers, it may serve a useful purpose to draw attention to some of the difficulties and possible sources of error associated with the investigation of the past history of cycads.

The characters generally made use of in the separation of distinct genera of fossil cycadean leaves may be enumerated as follows: (i.) The method of attachment of the pinnæ to the rachis, and whether persistent or deciduous. (ii.) The nature of the base of the pinnæ, auriculate or gradually tapered, etc., the presence or absence of a distinct basal callosity. (iii.) The pinna apex, whether truncate, acuminate, etc. (iv.) Venation. (v.) The angle of insertion of the pinnæ on the rachis; the alternate

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[1] (3), p. 272, pl. iii. fig. 10.

[2] Göppert (2), p. 134, pl. ii. figs. 9 and 10.

[3] (A. 2), Pal. Franç. [2] vol. ii. 1875, pp. 26–45.

or opposite arrangement of the pinnæ. (vi.) The form of the epidermal cell-walls. (vii.) Presence of spines on the segment margin. In addition to these more detailed characters, the form of the frond as a whole, whether simple, pinnate, or bipinnate, and the shape of the individual pinnæ, long, narrow, broadly oval, etc., are important characters to be kept in view.

In Göppert's valuable paper on fossil cycads,[1] the wholesome warning is given that to define generic characters within such narrow limits as are often adopted, results in an unnecessary multiplication of genera, and tends to confusion and to increase the difficulties of determination. Allusion has already been made to the numerous leaves, the affinities of which cannot be definitely settled until further data are forthcoming. As regards the genus *Nilssonia*, some writers have argued for its inclusion among ferns, but others prefer to consider it an unusual form of cycadean frond. *Tæniopteris*, *Neuropteris*, *Noeggerathia*, and a host of other leaves must for the present be left in a somewhat doubtful position. The genus *Stangerites*, instituted by Bornemann,[2] has been used by a few authors as a convenient term for certain *Tæniopteris*-like leaves, but the name seems unnecessary, and may be ranked among those misleading titles which suggest a relationship to a living genus which is not supported by facts of any taxonomic value. Saporta, in speaking of this genus, remarks that the author of the term *Stangerites* "a ajouté à ce qui s'était fait avant lui une confusion réellement inextricable et périssé de difficultés la synonymie des principales espèces, decrites d'après leurs feuilles seulement."[3]

In the recent species *Stangeria paradoxa* (Moore), it is worthy of note that we have pinnæ with entire margins, and others with deeply cut lobes extending to the midrib; some of the deeply divided laminæ suggest in a slight measure a *Nilssonia* form of leaf. In a small plant of *Cycas circinalis*, L., in the Royal Gardens, Kew, I noticed an abnormal form of leaf structure at the base of a young frond, suggesting another example of an approach to the *Nilssonia* type of leaf. Instead of the ordinary uninerved and separate pinnæ characteristic of *Cycas*, this

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[1] (1), p. 116.

[2] p. 58, misspelt "*Strangerites*, nov. gen."

[3] *Loc. cit.* p. 39.

particular specimen showed a lamina on either side of the basal part of the rachis, having the appearance of several pinnæ fused together laterally, the position of each segment being indicated by a strong vein.

In every classification which is based on artificial characters, and which gives us provisional genera, there must necessarily be inconsistencies, and in all probability plants possessing no close relationship will often be included in the same genus. Among fossil ferns this is especially the case; as regards cycads, although not perhaps to an equal extent, there are the same difficulties to be encountered owing to the isolated and fragmentary nature of the specimens on which determinations are based. It may, perhaps, be possible to add to the convenience of classification, or to minimise the danger of conveying wrong impressions by ill-chosen names, by adopting some more admittedly provisional classification than is at present employed. An attempt to modify our present system, which is too often inadequate and unsatisfactory, will be more appropriately undertaken after the Wealden and Jurassic genera have been subjected to a detailed treatment. For the present, attention may be drawn to some of the obstacles in the way of accurate determination of fossil fronds.

As regards the manner of attachment of pinnæ to the rachis: among recent genera there are some in which the pinnæ are readily detached from the rachis by a well-marked line of articulation; *e.g.* in such forms as *Zamia furfuracea*, Ait., with broad oval pinnæ, and other species of the same genus. In species of *Encephalartos*, *Ceratozamia*, *Dioon*, etc., there are distinct and sharply defined scars left on the axis of the frond on the fall of the pinnæ; in others, again, the pinnæ are persistent. Among fossil forms, the rachis scars and detached pinnæ with clearly cut bases evidently point to a deciduous habit; but it is often a matter of great difficulty to decide definitely as to the existence of such a character, and it is quite unsafe to trust to a feature of this kind as an essential character in generic classification. It is by no means easy in some cases to distinguish the true auriculate base of a pinna, from a cordate form produced by the crushing and flattening of a thick and leathery segment. Bornemann has called attention to this possible source of error, and points to the absence of any true auriculate base in the pinnæ of recent fronds. In examining herbaria specimens of some *Encephalartos* fronds, such as *E. Caffer*, Miq., and other species with broad stout pinnæ, one frequently notices that the basal portions of the segments have been depressed in such a way as to present in surface view the appearance of a distinct auriculate base. In some of the examples of *Otozamites Klipsteinii* (Dunk.) var. *superba*, described in the present volume, this has probably been the case; but, thanks to the large number of excellent specimens in the Rufford Collection, it is perfectly clear that the pinnæ of this striking plant possessed auriculate bases. The absence or presence of a callosity is often a question of considerable uncertainty among fossil leaves, and the existence of a basal thickening, often none too distinct in the segments of recent species, can only be satisfactorily made out in exceedingly well-preserved specimens. In some cases there is a distinct wrinkling of the coaly surface layer in the position where a callosity would naturally occur, and this may no doubt have sometimes resulted from a callosity in the living pinna, but in others the same appearance may be due to mere bending of the frond segments in the process of fossilization.

It has been shown by more than one writer how easily the manner of attachment of the pinnæ to the rachis may be obscured by the frond being seen from its under side. In the case of *Dioon* a view of the upper face of the leaf would lead one to refer it to such a genus as *Dioonites*; but if the lower surface were exposed to view *Pterophyllum* would be the most appropriate genus. In a species like *Macrozamia Denisoni*, Moor and Meull., in which the pinnæ are attached along a median line on the upper face of the rachis, the same pinnæ seen from below are apparently inserted laterally on the axis, and show no signs of decurrent bases. Braun's figures of *Zamites* (= *Otozamites*) *brevifolius*, Braun,[1] as seen from above and below, bring out very clearly the striking contrast between the two views; the same kind of difference is well shown in Feistmantel's figures of *Ptilophyllum acutifolium* var. *maximum*, from the Rajmahal Hills of India.[2]

The comparative breadth of the pinna base is a character which varies considerably according to the position of the segment on

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[1] Pl. xiii. figs. 13–15.

[2] Feistmantel, Pal. Ind. pt. ii. pl. xl.

the rachis, whether towards the tip or the lower part of the leaf, or according to the age of the frond. The terminal pinnæ are often strongly decurrent at the base, whilst the lower segments have a uniform width; a young frond of *Cycas media*, Br., shows pinnæ with no indication of tapering towards the rachis, but the older and broader segments are distinctly narrowed.

Stress is often laid on the form of the pinna apex, whether truncate, acute, etc. In the typical form of *Pterophyllum* the pinnæ have truncated apices, but specimens are occasionally referred to this common provisional genus in which the apices of the segments are clearly not truncate. Bornemann defines the genus as possessing pinnæ which may be either straight at the tip or obliquely truncate, and this wider definition is probably the most satisfactory. In such a specimen as that of *Otozamites Göppertianus* (Dunk.), figured in Pl. I. Fig. 2, some of the pinnæ are more or less truncate at the tip, and others regularly acuminate. In the examples of *Zamites Buchianus* (Ett.) in the British Museum Collection, the variation in the apical terminations of the pinnæ has proved a difficulty, some specimens having gradually tapering segments, and others showing obtusely terminated apices, but the occurrence of some intermediate forms throws doubt on the value of such a feature as a leading specific characteristic.[1] In dried fronds of *Cycas revoluta*, Thunb., it is not uncommonly found that in many of the pinnæ the pointed spiny apex has been replaced by a rounded termination, with a slight median depression at the end of the single vein. As a rule, however, the pinnæ of recent fronds maintain a fairly uniform mode of termination in the same species. The venation is not always readily made out even in fairly good specimens; the thick coriaceous pinnæ of some recent species, with their indistinct veins, prepare us for a similar difficulty in dealing with fossil leaves. It is well known that the lower surface of a pinna often shows very distinct venation, while the veins on the upper surface are quite obscure. In *Cycas* we have a convenient venation character, which is taken as the essential feature of the fossil genus *Cycadites*; but in this case, as we shall see later in describing the genus, frequent mistakes have been made in the determination of specimens, which apparently rest on such a readily recognized character

[1] Pl. III.

as the presence or absence of a midrib. Schenk has pointed out Dunker's error with regard to the supposed Wealden species of *Cycadites*, *C. Morrisianus*, Dunk., and a careful examination of the English material confirms Schenk's correction. In some recent species of *Cycas* the midrib is by no means obvious on the upper surface of the pinnæ; *e.g.* in a dried specimen of *Cycas Cairnsiana* (Muell.), the upper convex surface of a pinna presents an appearance suggestive of a few parallel veins, no doubt due to wrinkling, rather than of a single midrib. In *C. Beddomei*, Dyer,[1] the margins of the pinnæ are strongly revolute, and a cast of the lower surface of a pinna would show too longitudinal ridges separated by a distinct groove, the latter being formed by the projecting central vein. On the other hand, the tendency to a revolute margin in the long, narrow, linear pinnæ of other genera than *Cycas*, often leads to an appearance which might easily be mistaken for a stout midrib in fossil specimens of such a leaf. The under surface of the pinnæ of *Encephalartos Ghellinckii*, Lem. (Pl. XIII. Fig. 3), *Zamia angustifolia*, Jacq., etc., shows a narrow median groove separating the revolute edges of the narrow segments, and this same folding might readily give rise to a midrib-like character in the segments of fossil fronds. In a few exceptional cases there is an anastomosis of the veins in cycadean leaves; among fossil fronds Lindley and Hutton established the genus *Ctenis*, for "all leaves having the general character of *Cycadeæ*, but with veins connected by forks or transverse bars."[2] As regards living genera, some authors refer to *Bowenia* and *Stangeria* as having anastomosing veins, but the occurrence of anastomosis in the segments of the former genus is denied by Engler[3] and others. The proximity and number of the veins in a pinna are characters of no little value in the separation of specific forms, but the difficulty of eliminating the effects of fossilization and the different appearances presented by the upper and lower faces, render it difficult to arrive at any very trustworthy conclusion as to venation characters. In speaking of cycadean venation, Bornemann[4] suggests that the characteristic veins of *Zamia* have

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[1] Dyer (1).

[2] (A.) Foss. Flor. vol. ii. p. 103.

[3] Engler and Prantl, p. 9.

[4] *Loc. cit.* p. 39.

usually been overlooked as a means of identification. The inclination of pinnæ to the rachis, and their alternate or opposite disposition are characters which have been used as the basis of specific determination, but such features as these are likely to prove misleading unless used with great caution. In one part of a frond the pinnæ may be distinctly opposite, and in another alternate. The same kind of variation in the angle of insertion of a segment to the rachis, is readily seen in the large fronds of such recent species as *Ceratozamia mexicana*, Brong., *Macrozamia Macleayi*, Miq., and many others; also among fossils in the larger specimens of *Zamites Buchianus* (Ett.), etc. A comparison of the young and old fronds of many cycads reveals the same striking difference as regards the inclination of the pinnæ. The open or closely set arrangement of pinnæ is another misleading character; *e.g.* in an old frond of *Encephalartos longifolius*, Lehm., the pinnæ are for the most part in contact with one another, but the young frond presents a distinctly open habit, with the pinnæ much more openly arranged. In *Otozamites Göppertianus* (Dunk.) there is the same difference in this respect between the upper and lower portions of the same specimen, *e.g.* Pl. I. Figs. 1 and 2.

The form of the epidermal cells is a character of doubtful value, and at the same time one which can only be made use of under favourable conditions of fossilization. The custom of associating spiny margins with the pinnæ of *Encephalartos* has led an American writer to adopt this feature as the leading characteristic of his genus *Encephalartopsis*.[1] Fontaine has founded this new genus on some very fragmentary and imperfect pinnæ with spinous margins and anastomosing veins. None of the figured fragments afford any clue as to the nature of the pinna base, or as to the manner of insertion on the rachis. The material is hopelessly inadequate for the institution of a new genus. The fact of the fragments possessing anastomosing veins deters Fontaine from including them in the recent genus *Encephalartos*; as it is, he prefers to institute a new term, and to consider the species as probably a "prototype" of the recent genus. It is true one is accustomed to associate spiny pinnæ with species of *Encephalartos*, but there are several forms of that genus in which no indication of such a character is found; and on the other hand, spiny pinnæ

[1] Fontaine (A. 2), Potomac Flora, p. 174.

are met with in *Dioon edule*, Lind., and to a certain extent in *Zamia Lindeni*, etc. Newberry [1] has doubtfully referred a small portion of a frond from the Rhætic beds of Honduras to the genus *Encephalartos*, but expresses his hesitation as to the true position of the specimen by adding a query to the generic name. It is suggested by Newberry that the Miocene cycad named by Saporta *Encephalartos Gorceixianus*, does not correspond so closely with any living member of the genus as does the Honduras specimen; he adds: "This correspondence in the form of the pinnules is so close that I felt warranted in placing our fossil provisionally in the genus *Encephalartos*. The fructification will of course be necessary for a demonstration of generic identity, and has not yet been obtained." In Lesquereux' posthumous monograph on the Dakota flora, there is a fragment figured and described as a new species, under the name *Encephalartos cretaceus*, Lesq.[2]; but this is another example of what we may regard as the utterly unwarrantable use of a recent generic name, and the institution of a new species on absolutely insufficient data. It does not seem to have been generally recognized that the living species of *Encephalartos* present a great variety of leaf form, from the long and narrow pinnæ of such species as *E. Ghellinckii*, Lem. (Pl. XIII. Fig. 3), and *E. cycadifolius*, Lehm. (Pl. XIII. Fig. 6), through *E. Lehmanni*, Lehm., etc., to *E. Caffer*, Miq., and *E. horridus*, Lehm. There is a very striking difference between the young and old fronds of *E. cycadifolius*: in the former the pinnæ are much more oblique to the rachis, and have not assumed the stiff and straight character which is so pronounced in the latter. Many of the Mesozoic cycadean fronds present a striking similarity to *Encephalartos* leaves, but it would be exceedingly rash to apply the name of the recent genus to even the best of these fronds, and still more unwise to make use of it for the merest fragments of isolated pinnæ.

It will be most convenient to consider the Wealden specimens referred to the *Cycadaceæ* under the headings *Frondes* and *Trunci*; and also to describe such seeds and reproductive structures as may possibly be included among cycadean fossils. Unfortunately the isolated mode of occurrence of leaves, stems, and seeds does not

[1] (1), p. 346, fig. 5.

[2] Lesquereux (A. 3), p. 29, pl. i. fig. 12.

allow, in the great majority of cases, of any certain conclusions as to the relation of the detached members one to another.

FRONDES.

Cycadites Römeri, Schenk.
Cycadites Saportæ, sp. nov.
Dioonites Dunkerianus (Göpp.).
Dioonites Brongniarti (Mant.).
Nilssonia Schaumburgensis (Dunk.).
Otozamites Klipsteinii (Dunk.).
Otozamites Klipsteinii (Dunk.), var. *superba* mihi.
Otozamites Klipsteinii (Dunk.), var. *longifolia* mihi.
Otozamites sp., cf. *O. Klipsteinii* (Dunk.).
Otozamites sp., cf. *O. Reibeiroanus*, Heer.
Otozamites Göppertianus (Dunk.).
Zamites Buchianus (Ett.).
Zamites Carruthersi, sp. nov.
Specimens of doubtful position.
Anomozamites Lyellianus (Dunk.).

Genus **CYCADITES**, Sternberg.

[Flor. Vorwelt, iv. p. xxxii. 1825.]

Sternberg proposed this name in 1825 for three fossil plants from the Lower Cretaceous of Hör in Scania, and one from Radnitz in Bohemia. He defined the genus as follows: "Folia pinnatifida seu pinnata, nervis validis simplicibus e rhachi horizontaliter exeuntibus."

Sternberg's species *Cycadites Nilssoni* had been previously figured by Nilsson in 1820,[1] but he left the plant unnamed; this species is now included in the genus *Nilssonia*. Another of Sternberg's species, *C. linearis*, is no doubt, as Presl first suggested,[2] a fragment of some fossil stem. *Cycadites palmatus*, Sternb., from Radnitz, is probably a fragment of *Cordaites*, and *C. zamiæfolius* suggests a coniferous twig. In 1824 Nilsson[3] figured a portion of a leaf from the Quadersandstein of Hör, with

[1] Nilsson (1), pl. iv. fig. 3.
[2] Sternberg (A.), Flor. Vorwelt, fasc. vii. p. 194.
[3] (2), p. 143, pl. ii. *bis*. figs. 4 and 6.

uninerved and apparently palmately-arranged segments; this he described as probably a Filicite. Brongniart[1] afterwards referred Nilsson's plant to *Cycadites*, on account of the resemblance of the leaf segments to the pinnæ of the recent genus *Cycas*. As Schenk[2] has pointed out, Nilsson's figure in all probability represents an *Aralia* leaf, and the fossil is certainly not a species of *Cycadites*. In Brongniart's *Prodrome*[3] we have the following definition of the genus *Cycadites*:—

"Feuilles pinnées, à pinnules linéaires, entières adhérentes par toute leur base, traversées par une seule nervure moyenne, épaisse; point de nervures secondaires."

He regards the single-veined linear pinnæ as the important feature, and in spite of the fact that the first specimen to be included under this generic name was incorrectly determined, this definition of *Cycadites* has been generally adhered to.

Schimper, Saporta, and other authors have, in the main, adopted Brongniart's diagnosis. We may perhaps most conveniently define *Cycadites* as follows:—

Frond pinnate, pinnæ alternate or opposite, linear, lanceolate, entire, with a single median vein; attached to the rachis by the entire base, the lower margin of which may be slightly decurrent on the frond axis, or slightly narrowed towards the point of attachment.

It is better to confine our definition to the frond characters, and thus frame it in such a manner that it practically includes those fossil fronds which have a cycadean habit, and resemble the recent *Cycas* in the possession of uninerved segments. In several cases *Cycadites* fronds have been found in close association with characteristic *Cycas*-like carpellary leaves; but in the majority of specimens we have only sterile fronds, and it is better, therefore, to have some definition which enables us to give such leaves a place in a convenient genus, which does not depend upon special characters of fertile leaves.

The genus *Cycadites*, as defined by most writers since the days of Brongniart, possesses easily recognized characters, and ought not to present any very serious difficulty in the way of

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[1] (A. 2), p. 93.
[2] (A. 1), Fl. foss. Grenz. Keup. p. 158.
[3] p. 93.

generic determination. When we come to examine the various plant fragments which have been figured as representatives of the genus at different geological horizons, it becomes apparent that the mere acceptance of a list of *Cycadites* species as an index of the past history of the genus would undoubtedly lead us into error. In any case it would be rash to maintain that a record of even the most perfectly preserved specimens of the *Cycadites* type of frond, affords an epitome of the geological history of the genus *Cycas*. The occurrence of fossil carpellary leaves very similar to, or practically identical with, those of *Cycas*, lends confirmation to the position assigned to many of the *Cycadites* fronds; but as regards other species we can only express the opinion that they are parts of a plant which closely resembles in habit, and probably in structure, the living genus. It has already been pointed out that the pinnæ of *Cycas circinalis*, L., may occasionally be united laterally and assume a form suggestive, in some degree, of *Nilssonia* or *Pterophyllum*. No great weight can be attached to this single instance of such lateral fusion, but it is worth noting as having a possible connection with some of the fossil leaf forms which present little resemblance to recent fronds. Saporta has called attention to the similarity between some *Cycadites* species and *Nilssonia*, and one of Heer's species, *C. Dicksoni* [1] from the Cretaceous of Greenland, seems to possess pinnæ which are either in contact with one another, or actually united by the margins.

Berger figured a fragment as *Cycadites alatus*, Berg.,[2] and compared it with *Nilssonia brevis*, Brong., the same plant being afterwards renamed by Göppert *Nilssonia Bergeri*.[3] As regards the first record of *Cycadites* in Palæozoic rocks, it cannot be said that there is any very decided evidence of the occurrence of this genus, but Göppert's *C. taxodinus* is by no means such a doubtful representative of the genus as several of the species described from newer beds. Göppert's *C. gyrosus* may perhaps be a portion of a young frond with its pinnæ circinately rolled, but it is not enough to establish the existence of *Cycadites* in Carboniferous times. Sterzel has recently figured an imperfectly preserved

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[1] Heer (A. 3.), Fl. foss. Arct. vol. iii. pt. ii. p. 99, pls. xxvii. and xxviii.
[2] Berger, p. 22, pl. iii. figs. 5 and 6.
[3] (1), p. 141.

impression from the Middle Rothliegende of Possendorf, Saxony,[1] which he speaks of as "*Cycadites?* or *Walchia* sp.," but does not consider it sufficiently distinct to allow of accurate identification. The figure entirely justifies Sterzel's doubtful attitude. In the Mesozoic beds *Cycadites* fronds become more abundant; a list of most of the species has been given by Solms-Laubach.[2]

A few of the so-called *Cycadites* species call for special mention. The Jurassic specimens described by Leckenby, from Cloughton, as *Cycadites zamioides*[3] are probably, as Nathorst suggests, fragments of a conifer. The type specimen of Leckenby's species in the Woodwardian Museum, Cambridge, bears a label on which Nathorst has written, "A conifer of the genus *Palissya*"; and Richards,[4] who examined the specimens a few years ago, adopts this view. In the case of some small indistinct impressions, it is often very difficult to decide between a twig of a conifer with its spirally arranged leaves extended in one plane, and a small cycadean frond with its uninerved pinnæ inserted on the two sides of a rachis. A branch of *Cephalotaxus Fortunei*, Hook, might very easily be mistaken for *Cycadites* if found in a fossil state with the details of structure imperfectly preserved. Heer has described several species of *Cycadites* from Arctic localities, but the figures do not inspire confidence in his determinations. *Cycadites Dicksoni*[5] may very probably be a true *Cycadites*; *C. sibiricus*, Heer,[6] and *C. gramineus*, Heer,[7] from the Jurassic rocks of Siberia, are both founded on the merest fragments of single pinnæ, and cannot be taken as trustworthy records. The institution of species on such minute fragments as the figures represent, is to be greatly deplored; the result can only be either to mislead those who are willing to accept all fossil species described by well-known authors, or to deter the more sceptical from attaching any importance to fossil plant

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[1] Sterzel, p. 140, pl. xii. fig. 12.

[2] (A.), Fossil Botany, p. 86.

[3] Leckenby (A.), Quart. Journ. Geol. Soc. vol. xx. 1864, p. 77, pl. viii. fig. 1.

[4] (1), p. 8.

[5] Heer, Fl. foss. Arct. vol. iii. pt. ii. p. 97, pls. xxvii. and xxviii.; and vol. vi. pl. xiv. fig. 10.

[6] *Ibid.* vol. v. pt. ii. p. 16, pl. iv. fig. 1.

[7] *Ibid.* fig. 2, etc.

determinations which do not rest on other characters than those of external form. Another species from the same beds, *C.? planicosta*, Heer,[1] is founded on imperfect pinnæ, but in this case Heer definitely admits the doubtful value of the name. The specimen described by the same authority from the Tertiary beds of Schaffhausen as *Cycadites Escheri*[2] is very likely a cycadean stem, but the genus *Cycadites* has been restricted to fossil fronds, and Heer's stem fragment should be referred to some other genus, in order to avoid the confusion likely to arise from using the name in a more comprehensive sense. Dawson has described some fronds from the Middle Cretaceous of the Rocky Mountains, which he names *Cycadites Unjuga*,[3] and compares with Heer's *Cycadites Dicksoni*. The two figures of the Canadian specimens do not appear to agree as regards the *Cycadites* form of pinna: in Fig. 2 each pinna appears to have several parallel veins, and the general habit seems different from that in Fig. 2*b*; if Fig. 2 be an accurate representation of the specimen, and the vein-like lines are not the draughtsman's shading, it could hardly be accepted as a true *Cycadites*. Feistmantel figures a fragment under the name of *Cycadites constrictus*, Feist.,[4] and speaks of a midrib in the basally constricted pinnæ; the figure does not show any distinct midrib, and leaves one in doubt as to the wisdom of choosing the genus *Cycadites*.

1.—Cycadites Römeri, Schenk.

[Fig. 1.]

1871. *Cycadites Römeri*, Schenk, Palæontographica, vol. xix. p. 229, pl. xxxii. figs. 1, 1*a*.
1874. *Cycadites Römeri*, Schimper, Trait. pal. vég. vol. iii. p. 552.

Type. Portion of a frond. Berlin Museum.

The following definition is given by Schenk for this species:—[5]

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[1] Heer, Fl. foss. Arct. vol. iv. pt. ii. pl. iv. fig. 16.
[2] Heer (A. 1), Fl. Tert. Helvet. p. 46, pl. xv.
[3] Dawson (1), p. 20, pl. i. fig. 2.
[4] Feistmantel, Gond. Flor. vol. i. pt. iv. p. 25, pl. vii. fig. 10.
[5] Schenk (A. 2), Palæontographica, vol. xix. p. 229.

"Folia petiolata pinnata, petiolus validus, segmenta linearia patentia integra alterna basi dilatata breviter decurrente sessilia, 8½ cent. longa, 2 mm. lata, uninervia, nervus medianus validus."

He refers to the recent species *Cycas Siamensis*, Miq., as most nearly allied to the fossil frond. This is the only example of *Cycadites* recognized by Schenk among the North German Wealden plants; the specimens referred by Dunker to that genus being without the characteristic single vein in the pinnæ. The English specimens, for which the name *Cycadites Saportæ*, sp. nov., is proposed, differ from the present species in their narrower and more approximately disposed pinnæ, inclined almost at right angles to the rachis. The scanty material in the Rufford Collection referred to *Cycadites Römeri* enables us, however, to add one or two points to the original diagnosis by Schenk:—

Frond pinnate, rachis strong, pinnæ linear and narrow, obliquely and laterally attracted to the rachis, entire, alternate, with slightly broadened and somewhat decurrent base, single median vein, apices acuminate and terminating in a sharp point.

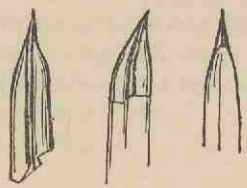

Fig. 1.—*Cycadites Römeri*, Schenk (V. 2738). Slightly enlarged.

V. 2738. Fig. 1.

An imperfect specimen, showing several partially preserved pinnæ, the largest of which has a length of 8½ cm., as in Schenk's specimen, and a breadth of 3 mm.

In the type specimen of *C. Römeri* the pinnæ are broken at the apices, but in the English example the sharply acuminate tips are clearly preserved, and correspond closely with those in *C. Saportæ*, *Cycas revoluta*, Thunb., etc. Each pinna is traversed by a median groove, which must probably be regarded as the midrib seen from the under side, but it should be noticed that there are in some of the pinnæ slight variations in the breadth of the groove, and it occasionally departs somewhat from a strictly median course. The appearance, indeed, is such as to suggest a folding over of the pinnæ margins. It has already been pointed out in the introductory remarks on fossil cycadean fronds, how the pinnæ of such recent species as *Encephalartos Ghellinckii*, Lem., may become folded over until a narrow median groove is left in the middle of the lower surface of the segment, representing the line of separation of the recurved edges (Pl. XIII. Fig. 3). On the other hand, we may have a similar curling over in the pinnæ of a true *Cycas*; but in the present specimen the narrow line is for the most part perfectly median and of uniform breadth, and cannot well be attributed to any other cause than the presence of a central vein. At one corner of the specimen there are three pinnæ, which clearly demonstrate a folding over of the margins, but this is in itself no proof of the absence of a single vein. These pinna fragments are in oblique contact with what appears to be a portion of the rachis, and if we may regard the two as organically connected, the segments exhibit the same characters as regards the form and attachment of the base as Schenk has described in the German examples. Ecclesbourne. *Rufford Coll.*

2.—Cycadites Saportæ, sp. nov.

[Pl. III. Fig. 7; Pl. VI. Fig. 5; Pl. VIII. Fig. 2.]

Type. Large and well-preserved fronds. British Museum.

The difficulty of recognizing the essential character of *Cycadites* in the pinnæ of fossil fronds has made itself felt in no small degree in dealing with the present series of specimens. The figures and descriptions given by Römer and Dunker of the *Cycadites*-like leaves have to be viewed in the light of Schenk's more recent statements,[1] based on an examination of Dunker's type specimens. If we leave out of consideration those portions of cycadean fronds which are figured by Dunker as *Cycadites*

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[1] Schenk (A. 2), Palæontographica, vol. xix. p. 233.

Morrisianus, Dunk.,[1] and which present a close agreement in habit with the English specimens, we have only *C. Römeri*, Schenk, among Wealden fronds with which to compare *C. Saportæ*. The differences between *C. Römeri* and the present species are, I believe, too well marked to admit of a single specific designation.

In view of the exceptionally large size of the Ecclesbourne fronds, and the satisfactory manner of preservation, it is better to adopt a new specific term, and I have ventured to identify the name of the Marquis of Saporta with this new form of Lower Cretaceous cycad.

Since the above was written the Marquis of Saporta's promised Monograph on the *Flore fossile du Portugal* has been published. A review of this valuable contribution to Mesozoic palæobotany is given in the latter part of the present volume. Among the very few remains of cycadean fronds described by Saporta, one form of *Cycadites* appears under the name of *C. tenuisectus*,[2] Sap., and the figures of the frond fragments show a very distinct resemblance to the English specimens which I have referred to the new species, *C. Saportæ*. Possibly the Portuguese and British plants should be placed in one species, but for the present at least, there are certain differences to be noticed which hardly justify this adoption of Saporta's specific name. In the English fronds the pinnæ are somewhat stouter, the tips more sharply acuminate, and the general habit of the leaf appears to be rather stiffer than in *C. tenuisectus*.

Frond pinnate, linear, of uniform breadth; rachis broad and flattened, marked with obliquely placed lines, terminating proximally in a broadened and swollen base. Pinnæ of uniform breadth, alternate or subopposite, attached to the upper surface of the rachis, and inserted at right angles or slightly oblique to the frond axis, the bases of the two rows of the pinnæ almost in contact; average length of the pinnæ 6–7 cm., and 1–15 mm. in breadth; bases slightly broadened and contiguous, apices of the long linear pinnæ terminating in a sharp point; single median vein in each segment.

In 1839 Römer instituted the species *Cycadites Brongniarti*

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[1] Dunker (A. 2), Wealdenbildung, p. 16, pl. vii. fig. 1.

[2] (1), p. 171, pl. xxxii. figs. 1–4 and 6.

for a specimen from the North German Wealden beds, and thus defined it[1]: "C. foliis pinnatis sublinearibus, pinnis numerosis linearibus approximatis apice obtusiusculis medio costatis basi sub dilatatis."

He speaks of the pinnæ as possessing a strong midrib, and his figure shows this character very clearly. Dunker has refigured Römer's original specimen, and here again the pinnæ appear to have a distinct median vein; he points out that Mantell's *Cycadites Brongniarti*[2] should be placed in the genus *Nilssonia*, as it does not conform to the accepted definition of *Cycadites*. This Tilgate fossil[3] is now referred to as *Dioonites Brongniarti* (Mant.).

In 1852 Ettingshausen[4] obtained a portion of a cycadean frond from near Teschen, in Silesia, and referred it to Römer's species, but at the same time expressing the opinion that it represented a form intermediate between *C. Brongniarti*, Röm., and *C. Morrisianus*, Dunk. This is certainly not the same species as Römer's type, and should, as Schenk suggests, be placed in another species; he speaks of it as *C. Heerii*, Schenk, and expresses the opinion that possibly *C. Brongniarti*, Röm., may be simply a partially developed frond of *C. Morrisianus*.[5] Subsequently the same author includes both *C. Brongniarti* and *C. Morrisianus* as synonyms of *Dioonites Dunkerianus* (Göpp.). He states that the type specimen of *C. Morrisianus*, Dunk., shows no indication of a midrib, and must therefore be referred to *Pterophyllum* or *Dioonites* instead of to *Cycadites*. There is the same absence of a median vein, according to Schenk, in the segments of *C. Brongniarti*, Röm., and this must, therefore, be also excluded from the genus *Cycadites*.[6] It is not quite clear if Schenk is here speaking of Römer's original specimen; if he refers to the figured specimen as it appears in the illustrations of Römer and Dunker, the figures are certainly at variance with Schenk's description. There is the same apparent contradiction between figure and

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[1] Römer, F. A. (A.), Verstein. Ool. Geb. p. 9, pl. xvii. fig. 1.

[2] Dunker, *loc. cit.* p. 16, pl. ii. fig. 4.

[3] Mantell (A. 4), Geol. S.E. England, p. 238.

[4] (A. 4), Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, 1852, p. 20, pl. i. fig. 9.

[5] (A. 3), Palæontographica, vol. xix. p. 7.

[6] (A. 2), p. 233.

diagnosis in *Dioonites abietinus*[1] (Göpp.), as represented in pl. xxxvii. fig. 1 of Schenk's monograph. Schimper retains Römer's species, and unites with it *Pterophyllum Dunkerianum*, Göpp., as figured by Dunker,[2] but in this case the figure shows very clearly that the venation is not of the *Cycadites* type. In the face of Schenk's statements, we cannot, then, accept any of Dunker's figures of what he describes as species of *Cycadites* as really examples of that genus; and, as Saporta[3] points out, the only representatives of *Cycadites* so far known for beds of approximately Wealden age are *C. Römeri*, Schenk, and *C. Heerii*, Schenk. In the English specimens referred to the new species *C. Saportæ* the preservation is fortunately good, and leaves no doubt as to the existence of a true midrib in the pinnæ. *C. Römeri* agrees to some extent with this species, but differs in its broader pinnæ and their disposition on the frond axis. The specimens of *C. Saportæ* are unusually large, and hence enable us to obtain a good idea as to the general habit of the frond; if it were not for this fact one might be inclined to include them under Schenk's species. The plant described by Braun from the Jurassic sandstones of Steinstedt as *C. rectangularis*[4] differs in its shorter and broader pinnæ, and in the fact that they are more distinctly at right angles to the rachis. Some of Saporta's figures of what he regards as *C. rectangularis*, are much more like *C. Saportæ* than the type specimen figured by Braun; *cf.* especially pl. xiii. figs. 1 and 3 of the *Flore Jurassique*. Saporta includes *C. pectinatus*, Berg., as a synonym of Braun's species, and adopts the term *rectangularis* in preference to the older name *pectinatus*, because of the use of the latter term by Lindley and Hutton in connection with the genus *Zamites*;[5] perhaps hardly a sufficiently sound argument to overrule the priority of Berger's term.

Berger's small fragment as figured in his pl. iii. fig. 4,

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[1] (A. 2), p. 234. Göppert, and not Miquel, appears to be author of the two specific names *abietinus* and *Dunkerianus*; Schenk refers both these species to Miquel.

[2] Schimper (A.), Trait. pal. vég. vol. ii. p. 180.

[3] *Loc. cit.* p. 72.

[4] Braun (A.), Palæontographica, vol. ix. p. 56, pl. xiv. fig. 7.

[5] Saporta, *loc. cit.* p. 70.

evidently belongs to a plant of very similar habit to that of *C. Saportæ*; it differs mainly in the greater breadth of the pinnæ, so far at least as it is possible to judge from Berger's figure.

Another species which bears a still closer resemblance to *C. Saportæ*, is *C. Rajmahalensis*, Old., described by Oldham, from India.[1] The figures and description of this plant are in close agreement with the Ecclesbourne Wealden species; the segments of the Indian frond seem to be rather more closely arranged and somewhat shorter than in the English form. It would, however, be somewhat unwise to refer the Wealden specimens to Oldham's species, considering the geological age of the two plants, and the less perfect preservation of *Cycadites Rajmahalensis*. In this, as in many other cases of fossil plants, we have to speak cautiously as to the relationship of individual members of different floras, and must trust rather to the comparative study of the floras as a whole, than to the apparent identity of isolated elements.

Trautschold's specimen of *Cycadites acinaciformis*, Traut.,[2] is similar to the present species, but probably not identical with it. Schenk suggests that the Russian species is probably identical with *Pecopteris decipiens*, Traut., and must be placed with the ferns. It is difficult to speak with much confidence as to the nature of the specimen figured as *C. acinaciformis*, but it certainly bears a strong likeness to the cycadean genus.[3]

V. 2777. Pl. VIII. Fig. 2 (¼ natural size).

This exceptionally fine specimen shows one frond 60 cm. in length, and a second 38 cm. long, the latter being inclined to the former in such a way as to suggest but little displacement from their original position of growth on the parent stem. The larger frond, as represented on a small scale in the photograph, shows a striking uniformity in the length and breadth of the numerous closely set pinnæ. In several of the segments the sharp apices are clearly preserved. Judging by other specimens, in which the pinnæ are longer and more nearly at right angles

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[1] Oldham and Morris (A.), Foss. Fl. Gond. p. 15, pl. viii.

[2] Trautschold (A. 3), Nouv. Mém. Soc. Nat. Moscou, vol. xiii. 1876, p. 34, pl. xxi. fig. 1.

[3] Schenk (A. 2), Palæontographica, vol. xix. p. 261.

to the rachis, it is probable that this large example may represent a frond not quite fully developed. The stout rachis, about 1·4 cm. in breadth, and especially that of the smaller frond, shows numerous obliquely running longitudinal lines. The contiguous and slightly broadened bases of the pinnæ are very distinct on portions of the larger frond. In some places the segments, adhering together by their contiguous bases, have been torn *en masse* from the axis of the leaf.

The stout and distinct median vein is well marked throughout. Near Hastings. *Rufford Coll.*

V. 2797. Pl. VI. Figs 5 and 5*a*.

Frond 13·5 cm. in length; rachis 1 cm. broad. The long and contiguous pinnæ are attached at right angles to one edge of the flattened axes. Midrib distinctly preserved, as in Fig. 5*a*; also the sharply acuminate tips of the segments. Longest pinna 11 cm. The general appearance of this specimen is indicative of an older frond than **V. 2777.** Ecclesbourne. *Rufford Coll.*

V. 2124*a*. Pl. III. Fig. 7.

24 cm. long. At the two extreme ends only one row of pinnæ has been preserved, and the impression of the broad rachis is shown on the surface of the rock. In other places the two rows of pinnæ are almost in contact, as in the portion represented in Pl. IV. Fig. 5, and there is very little of the rachis visible between the bases of the two sets of pinnæ. The arrangement and general appearance of the segments bear a marked resemblance to *Dioonites Dunkerianus* (Göpp.). Ecclesbourne. *Rufford Coll.*

V. 1069. A more terminal portion of a frond. Pinnæ smaller and more obliquely inclined to the rachis than in most of the other specimens. *Cf.* the terminal portion with the specimen of *Dioonites Dunkerianus* (**V. 2823**) figured in Pl. II. Fig. 3. Ecclesbourne. *Presented by P. Rufford, Esq.*, 1885.

V. 2124. Narrow pinnæ attached to one side of the flat rachis.

V. 2124*b*. Several portions of fronds. In one there appears to be the broad and thick basal termination of the petiole fairly clearly preserved. The midrib and pointed apex well seen in several of the pinnæ. Ecclesbourne. *Rufford Coll.*

V. 2924. 25 cm. long. A single row of pinnæ attached to one margin of the broad flat rachis; midrib distinct. Ecclesbourne. *Rufford Coll.*

Genus **DIOONITES**, Miquel.

[Tijdsch Wis. Nat. Wet. vol. iv. 1851, p. 205.]

In dealing with such fronds as those figured by Dunker as *Cycadites Morrisianus*, Dunk., and *C. Brongniarti*, Röm., and afterwards described by Schenk as species of *Pterophyllum* or *Dioonites*, we have to face the difficulty of deciding upon the most suitable generic term. The fronds in the Rufford Collection show well-marked characters, and leave no doubt as to the form and manner of attachment of the pinnæ; we have long, narrow, linear and parallel-veined segments, with acutely pointed tips attached by broad and non-auriculate bases to the upper surface of the rachis. Must these be included in *Pterophyllum* or *Dioonites*, or do the generally received definitions of these genera not admit of the application of either name to the Wealden fronds? Let us briefly summarize some of the various definitions of these genera, and note how far they coincide with the characteristic features of the present series of specimens. *Pterophyllum* was defined by Brongniart in 1828 [1] as a genus characterized by—"Feuilles pinnées, à pinnules d'une largeur à peu près égale, s'insérant sur le pétiole par toute la largeur de leur base, tronquées au sommet; nervures fines, égales, simple, peu marquées, toutes parallèles." He speaks of the truncate apices of the pinnæ as an essential character, but does not insist on a lateral or surface insertion on the frond axis. *Pterophyllum Jaegeri*, Brong., is spoken of as one of the species of this genus, and in this instance the attachment of the segments is apparently lateral. In the *Tableau* [2]

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[1] (A. 2), Prodrome, p. 95.

[2] (A. 4), p. 63.

Brongniart points out that subsequent writers have applied his generic name to plants which do not conform to the original definition. He considers the essential characters to be (i.) a slight union of the bases of the pinnæ; (ii.) the quadrilateral, oblong, or linear form of the segments; (iii.) *truncately terminated* segments; and (iv.) the presence of fine parallel veins *not convergent* at the apex. Morris[1] speaks of *Pterophyllum* as including plants with pinnate fronds and sublinear pinnæ, inserted by the whole base, with the apices truncate or sometimes acute, etc. Miquel[2] keeps closely to Brongniart's original definition. Göppert[3] adopts a wider definition, and includes in this genus plants with obtusely and acutely terminated pinnæ, etc. Bornemann,[4] in 1856, defined the genus as follows: "Frond pinnate or deeply pinnatisect, pinnæ approximate, and with the whole base attached to the rachis, short, broad, quadrate, or elongate, straight at the tip or obliquely truncate, horizontal or oblique to the rachis; veins parallel."

Leckenby[5] assigns the name *Pterophyllum* to the species *P. medianum*, Leck., with its *Nilssonia*-like lamina, which is apparently not attached to the side of the frond axis. Schenk, in his *Fossile Flora der Grenzschichten*[6] . . . , adopts a very comprehensive definition, and defines the pinnæ of *Pterophyllum* as distichous, elongate, or adherent, narrow or broad, apex acute or truncate; but he says nothing as to the manner of attachment to the rachis. He includes *P. incrustans*, Göpp., and *P. Braunii*, Göpp., in the same genus. Heer[7] prefers the genus *Zamites*, used in an unusually wide sense, for such fronds as his *Z. borealis*, Heer, *Z. acutipennis*, Heer, etc., which resemble in general form the leaves of the Wealden species originally described by Dunker as *Cycadites Morrisianus*. Schimper separates the fronds with irregularly pinnatifid leaves from the true *Pterophyllum* type, and institutes for their reception the genus *Anomozamites*.[8] In the

[1] (1), p. 118.
[2] (1), p. 73.
[3] (1), p. 129.
[4] p. 58.
[5] *Loc. cit.* p. 77, pl. viii. fig. 2.
[6] (A. 1), Fl. foss. Grenz. Keup. Lias, p. 163.
[7] Fl. foss. Arct. vol. iii. p. 66, pl. xv.
[8] Trait. pal. vég. vol. ii. p. 140.

genus *Pterophyllum* he includes fronds with pinnæ vertically attached to the side of the rachis, and having truncate apices. His genus *Ctenophyllum*,[1] which includes certain forms often referred to *Pterophyllum*, is defined as follows: "Folia linealia, gracilia; foliolis lateri rachis superiori oblique adfixis, sæpius oppositis, linealibus, obtusis, basi retro folium infrapositum defleuntibus, coriaceis, tenuiter et parallele nervosis."

Saporta departs somewhat from the definitions given by other authors,[2] and restricts *Pterophyllum* to fronds with pinnæ attached to the side of the rachis, and which are distinct one from another, not fused laterally at the base, and having truncate apices. Feistmantel,[3] on the other hand, in speaking of *Zamites proximus*, Feist., points to the separate pinnæ, which are not connected at the base, as a feature inconsistent with the inclusion of the plant in the genus *Pterophyllum*. Nathorst[4] has described certain plants from Bjuf as possibly species of *Pterophyllum*; but to express the absence of perfectly satisfactory evidence, he prefixes a query to the generic name. More recently, this author has called attention to the lateral insertion of the pinnæ as an essential character of *Pterophyllum*, and a convenient distinguishing feature from *Nilssonia*.[5] In Zittel's *Handbuch*,[6] the lateral attachment of the pinnæ, which may or may not be distinct at the base, and their rounded or truncate apices are given as important generic marks. It is suggested that possibly such a frond as *Pterophyllum Dunkerianum*, Göpp., ought not to be included in the genus *Pterophyllum*, because of the insertion of the segments on the upper surface of the frond axis. Solms-Laubach[7] refers to *P. Jaegeri*, Brong., as an example of one form of *Pterophyllum* frond, and in another place[8] calls attention to the *Nilssonia*-like form of some species of the same genus, which agree with other examples of *Pterophyllum* in the lateral insertion of the leaf lamina.

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[1] Trait. pal. vég. vol. ii. p. 127.
[2] *Loc. cit.* p. 43.
[3] Foss. Fl. Gond. vol. i. ser. ii. 2, p. 115.
[4] (A. 1), pt. ii. pp. 69–72.
[5] (A. 3), Denkschr. k. Ak. Wiss. math.-nat. Cl. vol. lvii. p. 6.
[6] (A.), p. 224.
[7] Fossil Botany, p. 88.
[8] *Ibid.* p. 139.

On the whole, then, the characters generally insisted on seem to be the lateral attachment of the pinnæ to the rachis, and by many, but by no means all authors, the truncately terminated segments. The confusion which has arisen from constant alterations by various writers, and from the not uncommon practice of including certain fronds in a particular genus, in spite of obvious discrepancies between the specimens and the generic diagnosis, is sufficiently obvious if we glance at some of the better known *Pterophyllum* species as figured by different authors. We have such forms as *P. inconstans*, Göpp., *P. Dunkerianum*, Göpp., *P. Jaegeri*, Brong., *P. Braunii*, Göpp., etc., included in the same genus. It is true that in examining fossil fronds we are often unable to decide as to the actual manner of attachment of the pinnæ, and are thus driven to leave the specimen as doubtful, or to decide as best we may in the face of difficulties inseparable from the determination of isolated leaf fragments. We cannot always be sure whether we have the frond preserved with its lower or upper side uppermost. It is, however, clear that we cannot consistently make use of Brongniart's genus for such specimens as those before us.

The genus *Dioonites* of Miquel has been adopted by some authors for these narrowly segmented Wealden fronds. This again is a generic name which has been made to do duty for forms of leaves, which it is difficult to regard as correctly included in the same genus, even if the genus be admittedly a provisional and artificial one. Miquel is responsible for the proposal of this name, and for the following definition:[1] "Frondes pinnatæ, rigidæ, crassæ. Foliola densa patentissima suprema nunc subimbricata, lanceolata, vel lineari-lanceolata, recta vel subfalcata, acuta vel acutiuscula, basi tota latitudine inserta, inferne retrorsum subdecurrentia, nervis cum margine parallelis æqualibus subtus distinctioribus (cum sulculis stomatiferis alternantibus)." He included under this name several species previously described as examples of *Pterophyllum* and other genera. Bornemann adopts Miquel's genus and extends its use to some additional species, but does not make any important alteration in the original diagnosis. Schimper retains the term

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[1] (2), p. 7.

Dioonites, and gives the essential characters as follows:[1] "Folia pinnata, pinnis pro more angustis, lanceolatis, acutis, obliquis, tota latitudine insertis, basique leniter pro- et decurrentibus, nervis parallelis." In Zittel's *Handbuch*[2] the genus is quoted, and *Pterophyllum Buchianum*, Ett., and *P. Brongniarti*, Schenk, are given as two typical species. The former of these has since been transferred by Nathorst to a new genus, *Zamiophyllum*,[3] on the ground that the pinnæ are slightly narrowed towards the base. Saporta repeats the character of *Dioonites*[4] as given by previous writers, and figures *D. Brongniarti* as a typical example; but the species referred to by this writer at the end of his definition as the typical form of the genus is *D. Kurrii*, Schimp. In Fontaine's *Potomac Flora* we find numerous forms included under Miquel's genus, but it must be noted that this author, while giving what he refers to as Schimper's definition of the genus, speaks of the pinnæ as "sometimes expanded at base so as to extend up and down the rachis."[5] This is an important alteration, as Schimper describes the pinnæ as distinctly decurrent, and it is this characteristic which is repeated by the majority of writers as one of the essential generic features. In his definition of *Dioonites Buchianus* (Ett.) Fontaine refers to the pinnæ as slightly narrowed at the base, but does not regard this character as opposed to the adoption of Miquel's genus. The attachment of the pinnæ by the whole of a more or less decurrent base appears to be the chief characteristic generally insisted on. In several definitions of *Dioonites* no mention is made of the place of attachment of the frond segments, whether on the surface or sides of the rachis; in several of the figured specimens referred to this genus the pinnæ are inserted laterally. Some authors have emphasized the fact that the segments must be attached to the upper surface of the rachis, as in *D. Brongniarti*. This position of the pinnæ affords one point of difference from *Pterophyllum*, and in the decurrent and separate leaves we have other features characteristic of *Dioonites*. Nathorst, in discussing

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[1] (A.), Trait. pal. vég. vol. ii. p. 128.
[2] p. 223.
[3] (A. 3), p. 46.
[4] (A. 2), vol. ii. p. 44.
[5] p. 181.

the generic characters of the plant, to which he applies the name *Zamiophyllum Buchianum* (Ett.), refers to Miquel's genus *Dioonites* as characterized by the attachment of the pinnæ to the upper surface of the rachis, and by the insertion of the segments almost at right angles to the axis; he says nothing as to the decurrent bases of the pinnæ. If we accept this definition, and depart from the usually accepted feature of a decurrent pinna base, we may well include the Wealden plants under this genus. It is certainly not an easy matter to draw a definite line between pinnæ attached to the rachis by the entire base, which is not decurrent, and those which are similarly attached, but with their bases more or less decurrent. In the English examples of the species *D. Dunkerianus* (Göpp), the pinnæ towards the upper end of the frond are distinctly decurrent, but those occupying a lower position cannot be described as possessing decurrent bases. *Cf.* Pl. II. Fig. 3, and Pl. III. Fig. 6. There are two other genera to which reference should be made, which to a certain extent agree in their definitions with such fronds as *D. Dunkerianus*, etc., viz. *Ctenophyllum* and *Ptilophyllum*. The former genus was instituted by Schimper[1] to include certain forms of fronds which do not in all essentials comply with the definitions of *Otozamites* on the one hand, and *Dioonites* on the other, *Pterophyllum pecten*, L. and H., being taken as the type species. The author of the genus afterwards somewhat modified his original diagnosis, and pointed out that *Pterophyllum Braunianum*, Göpp., had been erroneously described as a species of *Ctenophyllum*. The genus *Ptilophyllum*, proposed by Morris in 1840[2] for certain Indian fronds, can with difficulty be distinguished from *Ctenophyllum*. It is thus defined:—

"Fronds pinnate; pinnæ linear, closely approximated, more or less elongate; base variable in form, oblique, round, imbricate, sometimes auricled in the upper and sometimes in the lower part. Veins slender, equal, parallel."[3]

Göppert long ago expressed the opinion that Morris' term was a needless addition to the list of cycadean genera.[4] It

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[1] *Loc. cit.* vol. ii. p. 143.
[2] Morris (2), p. 21.
[3] Morris (1), p. 116.
[4] (1), p. 117.

has been found useful by several writers as a convenient name to apply to Indian fronds, but as at present used it does not appear to be wholly satisfactory. The genus *Ptilophyllum* seems to have been almost confined to Asiatic fronds, and the locality of a specimen has probably had too great a share in the selection of *Ptilophyllum* in preference to *Ctenophyllum* as the most suitable name. Nathorst[1] figures and describes a leaf fragment from Japan as *Ptilophyllum* cf. *cutchense*, Morr., but it would seem practically impossible to separate such a form as this from some English Jurassic fronds usually placed in the genus *Ctenophyllum*.

On the whole perhaps the better course is to retain, at least for the present, the name *Dioonites* as the most suitable generic designation for the Wealden species *D. Dunkerianus* (Göpp.). We must slightly modify the definition of the genus, and no longer insist on the decurrent pinna base as an essential characteristic. The implied relationship to the recent *Dioon* is the least satisfactory feature of *Dioonites*, but possibly we shall be able, on a future occasion, to suggest some further alteration in the existing nomenclature of fossil cycadean fronds. We may define this genus, using the term *Dioonites* in a wide and provisional sense, as follows:—

Frond pinnate, pinnæ at right angles, or more or less obliquely inclined to the rachis, attached to the upper surface of the frond axis, bases separate, may or may not be decurrent, not narrowed towards the point of attachment, apices acuminate, straight or slightly truncate, veins parallel.

In dealing with *Dioonites*, as with many other genera, we may easily fall into the error of excluding or including certain forms owing to our imperfect knowledge as to the manner of attachment of the pinnæ; but it is obviously impossible to devise a perfectly satisfactory system, so long as we are limited by the exigencies of fossilization and the imperfection of the frond fragments.

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[1] Nathorst (A. 3), p. 52, pl. iv. fig. 8.

Dioonites Dunkerianus (Göppert).

[Pl. II. Fig. 3; Pl. III. Fig. 6.]

1843. *Nilssonia pecten*, Dunker, Progr. p. 7.
Pterophyllum Dunkerianum, Göppert, Foss. Cycad. p. 52.
1846. *Pterophyllum Dunkerianum*, Dunker, Wealdenbildung, p. 14, pl. ii. fig. 3, pl. vi. fig. 4.
Cycadites Morrisianus, Dunker, *ibid.* p. 16, pl. vii. fig. 1.
? *Pterophyllum abietinum*, Dunker, *ibid.* p. 15, pl. vii. fig. 2.
1848. *Pterophyllum Dunkerianum*, Bronn, Index pal. nomencl. p. 1055.
Cycadites Morrisianus, Bronn, *ibid.* p. 371.
1849. *Zamites Dunkerianus*, Brongniart, Tableau, p. 107.
Cycadites Morrisianus, Brongniart, *ibid.* p. 107.
1850. *Pterophyllum Dunkerianum*, Unger, Gen. spec. plant. foss. p. 290.
Cycadites Morrisianus, Unger, *ibid.* p. 280.
1851. *Dioonites Dunkerianus*, Miquel, Rangschik. foss. Cycad. p. 212.
? *Dioonites abietinus*, Miquel, *ibid.* p. 205.
1852. *Pterophyllum Dunkerianum*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 20.
1856. *Dioonites Dunkerianus*, Bornemann, Organ. Rest. Lettenkohl. p. 56.
Cycadites Morrisianus, Bornemann, *ibid.* p. 51.
1869. *Dioonites Dunkerianus*, Schimper, Trait. pal. vég. vol. ii. p. 150.
Cycadites Morrisianus, Schimper, *ibid.* p. 180.
1871. *Dioonites Dunkerianus*, Schenk, Palæontographica, vol. xix. p. 232, pl. xxxvi. figs. 1–5.
Cycadites Morrisianus, Schenk, *ibid.* p. 233.
? *Dioonites abietinus*, Schenk, *ibid.* p. 234, pl. xxxvii. fig. 1.
1874. *Dioonites Dunkerianus*, Schimper, *loc. cit.* vol. iii. p. 550.

Type. Portions of fronds. Berlin Museum.

Göppert[1] thus defines the species: "Pt. fronde pinnata, pinnis crassiusculis alternis lineari-acicularibus elongatis pectinato-patentissimis subremotis æque distantibus 4–5 nervis subacutis." Dunker originally named this plant *Nilssonia pecten*, but an inspection of drawings received from Dunker led Göppert to dissent from the original designation. Dunker, in his *Wealdenbildung*, makes one or two slight alterations in Göppert's diagnosis; he speaks of the venation as "nervis 3–4 instinctis," and adds "rhachi crassa compressa."[2] The specimen represented in Dunker's pl. v.

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[1] (1), p. 134.
[2] (A. 2), p. 14.

fig. 3 shows the pinnæ apparently attached rather to the side than to the middle of the upper surface of the rachis; the bases are slightly swollen, and the apices pointed. In pl. vi. fig. 4 of the same author part of the broad rachis is shown, and the approximate and narrowly linear pinnæ are inserted at right angles to the frond axis. The specimen figured by Dunker and named by Göppert *Pterophyllum abietinum*, bears such a strong resemblance to *Dioonites Dunkerianus* as seen from the under side of the frond, that I have ventured to insert this species as a possible synonym. Schenk has previously called attention to this resemblance, and suggests that possibly the similarity may amount to specific identity; Schenk's figure shows a distinct midrib in the pinnæ, but this must be an error in the sketch or some deceptive appearance in the fossil. The specimen referred to *Dioonites abietinus*, by Hosius and von Marck, is probably a fragment of *Zamites Buchianus* (Ett.).[1] Schenk adopts Miquel's generic term *Dioonites*, which the latter author proposed in 1851 for this and other species of *Pterophyllum*. In speaking of the genus *Cycadites*, reference was made to Schenk's substitution of *Dioonites* or *Pterophyllum* for *Cycadites*, in the case of certain specimens previously assigned by Dunker to the latter genus; an examination of the type specimens having convinced Schenk of the absence of a single median vein in the leaf segments, and therefore of the erroneous adoption of the same *Cycadites*. Schenk's figure 1, pl. xxxvi.[2] shows a portion of one side of a frond with closely placed long and narrow pinnæ, which in their manner of attachment suggest a spirally twisted frond axis, such as we have in the recent cycad *Macrozamia spiralis*, Miq.; but this may well be an accident of fossilization. Fig. 5 of Schenk shows the same kind of rachis as in Dunker's fig. 4, pl. vi. The figures of the epidermal cells given by this writer show a distinctly undulating outline in the walls, and the presence of numerous stomata.

It does not seem quite clear whether Schenk has correctly included *C. Brongniarti*, Röm., as a synonym of the present species;[3] he speaks of Römer's species as probably the upper

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[1] (A. 1), Palæontographica, vol. xxvi. p. 213, pl. xliv. fig. 199.
[2] (A. 2), Palæontographica, vol. xix.
[3] *Loc. cit.* p. 233.

portion of a frond of *Dioonites Dunkerianus*. The evidence of the figures of Römer and Dunker does not, however, sufficiently support this view to justify our following Schenk's example without having examined the type specimen. In the case of *Cycadites Morrisianus*, Dunk., there can be little doubt that the specimens referred by Dunker to *Cycadites* must be transferred to the genus *Dioonites*.

It should be pointed out that Ettingshausen had previously suggested the specific identity of *Cycadites Morrisianus*, Dunk., and *Pterophyllum Dunkerianum*, Göpp.; he considered it possible that *P. Göppertianum* ought to be included with these two species.[1]

The specimen figured by Ettingshausen as *Cycadites Brongniarti*, Röm.,[2] has since been placed by Schenk in a new species—*Cycadites Heerii*.[3]

Among the Ecclesbourne specimens there are several good examples which must be included in Göppert's species. At first sight many of them would be referred to *Cycadites*, and the general habit of the frond shows a striking resemblance to that of *Cycadites Saportæ*, sp. nov., but a closer examination demonstrates that no true midrib can be detected, and that the ridge in some of the pinnæ which closely simulates such a central vein, is merely the strongly marked convexity of the upper surface of the leaf segments. Among recent cycads the genus *Encephalartos* affords examples of fronds in which the general habit is strikingly similar to that of *Dioonites Dunkerianus*: *E. Ghellinckii*, Lem., as shown in Pl. XIII. Figs. 3–5, possesses pinnæ of about the same size, and with a very similar mode of attachment, at least as regards their almost horizontal position, but in the lateral insertion to the rachis the segments of the recent species differ from those of the fossil frond. In *E. Ghellinckii* the convex upper surface of the pinnæ presents a very similar appearance to that in the Wealden frond segments, and the sharply acuminate tips of the pinnæ is practically identical in the two cases. In Pl. XIII. Fig. 3 a portion of a frond of this species is represented, natural size; in Fig. 4 the median groove on the under side of a single

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1 (A. 4), p. 21.

2 Ettingshausen, *loc. cit.* p. 20, pl. i. fig. 9.

3 Schenk (A. 3), Palæontographica, vol. xix. p. 7, pl. iii. fig. 4.

pinna is clearly shown; and in Fig. 5 a section of a pinna illustrates the strongly revolute form of the margins. Lemaire's figure of this species is very poor, and gives an imperfect idea of the habit of the leaf.[1]

Another species of this recent genus, *E. cycadifolius*, Lehm. (Pl. XIII. Fig. 6), also illustrates a point of contact between existing and extinct fronds; it differs from *E. Ghellinckii* in its somewhat broader pinnæ. It would, however, tend to a misconception of the true nature of the Wealden fronds, if the generic term *Encephalartos* were adopted on the strength of the striking similarity as regards the character of the fronds; we unfortunately know nothing as to the flowers and stems of *Dioonites Dunkerianus*. We may adopt a slightly emended form of Schenk's definition for the present species:—

Frond pinnate, rachis strong, pinnæ approximate, thick, linear, entire, alternate or subopposite; 2–3 mm. broad at the widest part, with a length of 11 cm. or more, gradually but slightly narrowed towards the distal ends; the two rows of pinnæ attached close together to the upper surface of the rachis; the lower margin of the basal end of the pinnæ either slightly decurrent, especially towards the tip of the frond, or somewhat broadened and bluntly rounded; towards the apex of the frond the segments are obliquely inclined, and in the lower portion almost at right angles, to the axis. Veins usually indistinct, 5–6 parallel equal veins in each pinna.

V. 3218. Pl. III. Fig. 6.

23 cm. in length. The upper surface of the pinnæ strongly convex; pinnæ slightly and gradually tapered towards a pointed apex. The arrangement of the segments and their somewhat broadened bases are very similar to those in *Cycadites Saportæ*. Schenk speaks of the pinnæ as 4–4½ cm. long, but his figure represents some with a length of 8 or 9 cm. In the present specimen the longest pinna has a length of 11 cm., and this does not include the actual apex. In nearly all the segments it is impossible to make out the venation, but in one or two cases the parallel veins are visible. Ecclesbourne. *Rufford Coll.*

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[1] Lemaire, pl. DLXVII.

V. 2823. Pl. II. Fig. 3.

Cf. **V. 1069.** *Cycadites Saportæ.* Small specimen, evidently close to the frond apex. The pinnæ are much more oblique and decurrent than in the previous example. Ecclesbourne. *Rufford Coll.*

V. 2821. Fig. 2.

Imperfectly preserved piece of rachis with portions of pinnæ on one side; some of the pinnæ have well-marked venation and acute tips. The figure shows some of the more perfect apices. The pinnæ have a breadth of about 2 mm., and each is traversed by numerous veins, in some of the segments as many as ten may be counted. A comparison of this specimen with **V. 3218** (Pl. II. Fig. 6) shows some fairly striking differences, and it is not improbable that we have to deal with two specific forms; in **V. 2821** the veins are more numerous, and the pinnæ are shorter and proportionately broader than in the other examples referred to this species. Ecclesbourne. *Rufford Coll.*

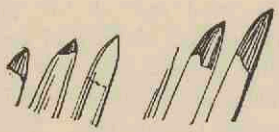

FIG. 2.—? *Dioonites Dunkerianus* (Göpp.).
Distal terminations of pinnæ (V. 2821).

V. 2124c. Broad and flat rachis very like that of *Cycadites Saportæ.* On one side the long and narrow pinnæ are fairly well preserved, showing occasional signs of venation and a strong convex upper surface. Ecclesbourne. *Rufford Coll.*

V. 2127. Probably a portion of a frond near the apex. The broad bases of the pinnæ and their manner of attachment to the rachis clearly seen. Ecclesbourne. *Rufford Coll.*

V. 2361. Probably a fragment of this species; broad pinnæ. Ecclesbourne. *Rufford Coll.*

V. 2822. Here the pinnæ are more oblique to the axis of the frond, and the lower edges of the bases more decurrent, as in the terminal fragment shown in Pl. II. Fig. 3 (**V. 2823**). Ecclesbourne. *Rufford Coll.*

V. 2824. Similar terminal portion to preceding specimen. Ecclesbourne. *Rufford Coll.*

V. 2916. Two specimens. Rachis 16 cm. long, apparently twisted, showing in the lower portion two alternate or sub-opposite pinnæ attached to its upper surface; in the upper part the segments are separated by 6 mm. of rachis, suggesting a view of the under side of the frond. Pinnæ slightly convex, presenting the appearance of a broad midrib. Ecclesbourne. *Rufford Coll.*

Dioonites Brongniarti (Mant.).

1833. *Cycadites Brongniarti*, Mantell, Geol. S.E. England, p. 238.
1841. *Pterophyllum Brongniarti*, Morris, Annals, p. 119.
1842. *Hisingera Mantellii*, Miquel, Mon. Cycad. p. 62.
1844. *Nilssonia Brongniarti*, Göppert, Foss. Cycad. p. 57.
1848. *Cycadites Brongniarti*, Bronn, Index pal. nomencl. p. 371.
1849. *Zamites Brongniarti*, Brongniart, Tableau, p. 107.
1850. *Nilssonia Brongniarti*, Unger, Gen. spec. plant. foss. p. 295.
1851. *Nilssonia Brongniarti*, Bronn and Römer, Leth. geog. vol. ii. p. 61, pl. xxviii. fig. 14.
1852. *Nilssonia Brongniarti*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 23.
1854. *Pterophyllum Brongniarti*, Morris, Brit. foss. p. 19.
1856. *Nilssonia Brongniarti*, Bornemann, Organ. Rest. Lettenkohl. p. 59.
1871. *Dioonites Brongniarti*, Schenk, Palæontographica, vol. xix. p. 236, pl. xxxii. fig. 2.
1874. *Dioonites Brongniarti*, Schimper, Trait. pal. vég. vol. iii. p. 551.
1875. *Pterophyllum Brongniarti*, Topley, Weald. p. 409.
1881. *Dioonites Brongniarti*, Renault, Cours. bot. foss. vol. i. p. 51, pl. iv. figs. 13 and 14.
1889. *Dioonites Kotoei*, Yokoyama, Journ. Coll. Sci. Japan, vol. iii. p. 44, pl. vii. fig. 1, and pl. xiv. fig. 14.

Type. Imperfect fragment of frond.

In 1833 Mantell described a badly preserved frond fragment from the Tilgate beds of Sussex, which he named *Cycadites Brongniarti*, using the term *Cycadites* rather as a general designation indicative of cycadean affinity, and not in accordance with the narrow sense in which Brongniart defined the genus. Morris substituted *Pterophyllum* for *Cycadites*, and Dunker called attention to the plant figured by Römer as *C. Brongniarti*, which should not be confounded with Mantell's type described under the same name; the latter he suggested should be referred to *Nilssonia*. Göppert adopts *Nilssonia* as the generic term, and Miquel, Ettingshausen, and others follow his example. Schenk, on the other hand, points out certain discrepancies between the characters of Mantell's species, as further illustrated by subsequently described examples of the same type from the Wealden of North Germany, and the genus *Nilssonia*; he substitutes Miquel's term *Dioonites* for Dunker's *Nilssonia*.[1] Schenk's specimen is in a better state of preservation than the English example, and shows more clearly the manner of attachment of the pinnæ. This species differs from *Otozamites Göppertianus* (Dunk.), in the absence of an auriculate base to the segments, in its coarser veins, and in the segments being more nearly at right angles to the axis of the frond. We may adopt Schenk's definition: "Folia pinnata, segmenta e basi latiore apicem versus attenuata acuminata lineari-lanceolata integra approximata alterna vel opposita, in petioli latere antico sessilia, 3 mm. usque ad 2·5 cm. longa, 3·5–5 mm. lata, superiora breviora, summa brevissima ovata, superiora oblique patentia, media patentissima, nervi tenues quinque vel sex tenues æquales paralleli."

The plant figured by Leckenby[2] as *Pterophyllum angustifolium*, Leck., from the Oolite of Gristhorpe, shows a marked similarity in general appearance to *Dioonites Brongniarti*.

Yokoyama's Japanese species, *D. Kotoei*,[3] may probably be included as a synonym of Mantell's plant; the former author mentions the greater number of veins in the pinnæ of his plant as a distinguishing feature from *D. Brongniarti*, and speaks of the

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[1] Schenk (A. 2), p. 34.

[2] (A.), pl. viii. fig. 3.

[3] Yokoyama (A. 2), p. 44.

latter form as having 5–6 veins in each leaf segment, whereas in *D. Kotoei* there are 7–14. In Schenk's figure of Mantell's species there are eight or nine veins shown, and in the solitary specimen in the Rufford Collection there appear to be at least eight veins. The greater length of the segments is another point referred to by Yokoyama as a specific character of his plant; but it is difficult on comparing the published figures of the two species to detect any distinct difference in this respect. On the whole, I am unable to discover any sufficient difference between the two plants to warrant the retention of Yokoyama's specific name. *Ptilophyllum oligoneurum*, Ten.-Woods,[1] also agrees closely with the English species. In speaking of *Pterophyllum Richthofeni*, Schenk, from China, Schenk[2] suggests that probably some of the fragments so named may be identical with *Dioonites Brongniarti*; there is certainly a close correspondence between the two forms, but perhaps hardly a sufficiently strong resemblance to justify the inclusion of the Chinese specimens in the synonomy of Mantell's species. The plant figured by Schenk[3] as *Pterophyllum æquale*, Brong., from Persia, resembles *Dioonites Brongniarti*. In Schenk's specimen the pinnæ appear to be inserted on the upper surface of the rachis, and not laterally as the generic term *Pterophyllum* implies.

V. 2748. 26 cm. long. The alternately disposed pinnæ are attached to the middle of the upper face of the frond axis. Venation clearly marked. The lower margin of the pinnæ is curved gradually upwards, cutting off the veins obliquely, and the upper margin is practically horizontal. The segments are somewhat less than those in Mantell's figure, but there can be little doubt as to the specific identity of the specimens. Eccles-bourne. *Rufford Coll.*

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[1] Jack and Etheridge (A.), pl. xviii. fig. 11.

[2] Richthofen (A.), China, vol. iv. p. 247, pl. xlvii. fig. 7, and pl. xlviii. figs. 5, 6, and 8.

[3] Schenk (A. 7), Bibl. bot. vi. pl. v. fig. 23.

Genus **NILSSONIA**, Brongniart.

[Ann. Sci. Nat. vol. iv. 1825. p. 200.]

In 1820 Nilsson[1] described and figured certain plant remains from Hör, a small village north of Lund in Scania, and regarded them as probably fern fronds, but he made no attempt to define them specifically. In 1825 Brongniart refigured and described some of Nilsson's specimens under the following specific names: *Nilssonia elongata*, *N. brevis*, *N.* (?) *æqualis*, *Pterophyllum majus*, and *P. minus*. It was on one of Nilsson's specimens that Brongniart founded his genus *Nilssonia*, and also *Pterophyllum*; the two Hör species referred by Brongniart to this latter genus have since been transferred by Nathorst[2] to Schimper's genus *Anomozamites*. We have the first complete diagnosis of *Nilssonia* in the *Prodrome*,[3] where it is thus defined: "Feuilles pinnées; pinnules rapprochées, oblongues, plus ou moins alongées, arrondies au sommet, adhérentes au rachis par toute la largeur de leur base, à nervures parallèles dont quelques-unes sont beaucoup plus marquées." In his later work,[4] Brongniart retains this name and speaks of *Nilssonia* as closely allied to *Pterophyllum*. Miquel[5] substituted a new generic term, *Hisingera*, for some of the species of *Nilssonia*, and as an example of the new genus he cites *Cycadites Brongniarti*, Mant. Göppert[6] accepts Brongniart's genus in its wide sense, and does not suggest the institution of any sub-genera. In 1856 Bornemann adopted the following definition of *Nilssonia*:[7] "Frondes coriaceæ, pinnatæ, vernatione circinatæ, foliola contigua continue tota latitudine inserta, patentia, abbreviata, basi passim cohærentia, apice obtusa vel truncata, nervis parallelis arcuatis apice confluentibus nonnullis validioribus." This writer points out the difficulty of recognizing the

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[1] Nilsson, p. 108.
[2] (A. 1), Flor. Bjuf. p. 66.
[3] p. 95.
[4] (A. 4), Tableau, p. 63.
[5] (1), p. 61.
[6] (1), p. 139.
[7] Bornemann, p. 58.

two different kinds of veins in the leaf divisions. Schenk, in his *Flora der Grenzschichten*[1] includes *Nilssonia* among the ferns, and refers to certain specimens in which the leaves show numerous round projecting structures between the veins, and which he regards as sporangia or sori; and it is on the strength of these appearances, suggestive of fern fructification, that the genus is excluded from the *Cycadaceæ*. Schenk speaks of the veins as equal and simple, and refers to the epidermal cells as having the straight walls characteristic of cycads. No great importance should be attached to any argument based on the form of the cell walls, as Schenk himself has admitted; but the fructification is a much more important feature. Saporta[2] places *Nilssonia* in the *Cycadaceæ*, and considers that Schenk was probably deceived by certain leaf parasites, which might well present an appearance closely simulating fern sori. Nathorst[3] follows a similar course, and speaks of our ignorance as to the actual nature of Schenk's sori, seeing that no traces of structure have been preserved; he suggests stomata and parasitic fungi as two possible explanations of these sorus-like appearances. Solms-Laubach[4] does not accept the proposed explanation as satisfactory, and inclines to follow Schenk in classing *Nilssonia* among the ferns, on the strength of the sorus-like bodies on the leaf lamina. Nathorst draws special attention to the insertion of the leaf segments on the upper surface of the rachis as an essential character of the genus; he speaks of the veins as equal and simple. Various authors have spoken of two kinds of veins in the leaves of *Nilssonia*, stouter and finer veins, but Nathorst remarks that Schenk has recognized his mistake with regard to the supposed two sets of veins; he mistook folds in the leaf lamina for well-marked simple veins.[5] Schimper,[6] in the first volume of the *Trait. pal. vég.*, classes *Nilssonia* with the *Filicinæ*, and accepts Schenk's interpretation of the apparently

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[1] (A. 1), p. 124.
[2] (A. 2), Pal. Franç. vol. ii. p. 41.
[3] (A. 2), Foss. Fl. Schwedens, p. 20.
[4] Fossil Botany, p. 139.
[5] Nathorst (A. 2), p. 18.
[6] p. 488.

fertile specimens; but in a later work[1] by this author we find *Nilssonia* placed close to *Pterophyllum* in the *Cycadaceæ*.

Without following in further detail the various descriptions or definitions of this genus, we may thus sum up the chief characters by which the species may best be recognized:—

Frond coriaceous, the lamina more or less deeply pinnatifid, the lines of division generally extending almost to the rachis; segments attached to the upper surface of the axis by the entire base, contiguous, usually broad and truncate, but varying considerably in size and shape; apices obtuse or truncate. Veins simple and equal.

In connection with *Nilssonia*, which may best be considered as a genus of doubtful affinity, but probably cycadean, there are three other genera of which some mention must be made,—*Anomozamites*, *Ptilozamites*, and *Pterophyllum*. As regards the last, Nathorst has on several occasions emphasized the distinct difference as regards the manner of attachment of the leaf segments; in *Pterophyllum* they are inserted laterally on the rachis; in *Nilssonia*, as in *Dioonites*, they are attached to the upper face of the leaf axis.[2] The genus *Anomozamites* was instituted by Schimper[3] for certain species of *Pterophyllum* with irregularly pinnatifid leaves, and this term has been generally adopted; the veins are described as simple and parallel, and the segments as laterally attached. Nathorst, however, has instituted a genus, *Ptilozamites*,[4] in which are included pinnate and bipinnate fronds, which in habit correspond fairly closely with *Anomozamites*, but differ in the possession of forked veins which dichotomize at the base, and occasionally branch a second time before reaching the margin of the leaf segment. The plant originally described by Leckenby as *Ctenis Leckenbyi*,[5] the specific name having been suggested by Bean, shows very clearly the characters of the venation and the branching habit of the frond; this must now be included in Nathorst's *Ptilozamites*[6] as suggested by the author

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[1] (A.), Zittel, Handbuch, p. 225.

[2] Nathorst (2), p. 61, and (A. 3), Denkschr. k. Ak. Wiss. vol. lvii. p. 45.

[3] (A.) Trait pal. vég. vol. ii. p. 140.

[4] (A. 1), Flor. Höganäs och Helsingborg, p. 21.

[5] (A.), Quart. Journ. Geol. Soc. vol. xx. p. 78, pl. x. fig. 1.

[6] Nathorst (A. 1), Flor. Höganäs, p. 21.

of the genus himself. An inspection of Nathorst's figures of *Anomozamites* and *Ptilozamites* species suggests a difficulty in certain cases in deciding between the two genera. In such a form as *Anomozamites gracilis*, Nath.,[1] we have well-marked branching in some of the veins, and a close approximation in general appearance to other species included in *Ptilozamites*, cf. *e.g.* *P. Heeri*, Nath.,[2] and *A. minor*[3] (Brong.).

Fontaine[4] figures a few small fragments of leaves from the Potomac flora under the name *Anomozamites*, but there is hardly enough material to justify even a generic determination, and still less to warrant the institution of two new species.

Nilssonia Schaumburgensis (Dunk.).

[Figs. 3*a*, *b*, and *c*.]

1843. *Pterophyllum Schaumburgense*, Dunker, Progr. p. 6.
1844. *Pterophyllum Schaumburgense*, Göppert, Foss. Cycad. p. 54.
1846. *Pterophyllum Schaumburgense*, Dunker, Wealdenbildung, p. 15, pl. i. fig. 7; pl. ii. fig. 1; pl. vi. figs. 5-10.
1848. *Pterophyllum Schaumburgense*, Bronn, Index pal. nomencl. p. 1056.
1849. *Pterophyllum Schaumburgense*, Brongniart, Tableau, p. 107.
1850. *Pterophyllum Schaumburgense*, Unger, Gen. spec. plant. foss. p. 292.
1851. *Pterophyllum Schaumburgense*, Miquel, Rangschik. foss. Cycad. p. 213.
1852. *Pterophyllum Schaumburgense*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 22.
1856. *Pterophyllum Schaumburgense*, Bornemann, Organ. Rest. Lettenkohl. p. 58.
1869. *Anomozamites Schaumburgensis*, Schimper, Trait. pal. vég. vol. ii. p. 141.
1871. *Anomozamites Schaumburgensis*, Schenk, Palæontographica, vol. xix. p. 231, pl. xxxiii.
1883. *Pterophyllum Schaumburgense*, Peyton, Quart. Journ. Geol. Soc. vol. xxxix. Proc. p. 3.
1890. *Nilssonia* cf. *Schaumburgensis*, Nathorst, Denkschr. k. Ak. Wiss. math.-nat. Cl. vol. lvii. pp. 45, 49, and 53, pl. i. figs. 6-9.
1894. *Nilssonia Schaumburgensis*, Yokoyama, Journ. Coll. Sci. Japan, vol. vii. pt. iii. p. 227, pl. xx. figs. 12 and 14; pl. xxi. fig. 14; pl. xxii. figs. 5–7.

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[1] (A. 1), Flor. Bjuf. p. 65, pl. xv. fig. 15.
[2] *Ibid.* p. 60, pl. xii. figs. 1 and 7.
[3] *Ibid.* p. 66, pl. xiv. figs. 5–7, and pl. xviii. fig. 4.
[4] (A. 2), Potomac Flora, p. 167, pl. xxx.

Type. Several specimens of leaves.

Dunker defined the species as follows:—

"Pterophyllum fronde pinnate vel, rarissime quidem, profunde pinnatifida, pinnis alternis approximatis sub-obliquis irregularibus, oblongo-ovatis, vel quadratis vel rotundatis, infimis subdecurrentibus, nervis crebris tenuibus instructris, rhachi (suptereti?) longitudine striata."

The specimens figured by Dunker from the North German Wealden beds show a considerable variation in size and form; this variable character is also well brought out in the later and more perfect figures in Schenk's monograph. Such a specimen as that represented by Dunker in pl. i. fig. 7[1] must probably be regarded as a leaf seen from the under side, thus showing a *Pterophyllum*-like appearance. Schenk draws attention to the apparent lateral attachment of the segments in some of the specimens which are seen from the under surface, but notes that there can be no doubt as to their actual insertion on the upper surface of the axis. Schimper includes this variable Wealden species in his genus *Anomozamites*, and Schenk accepts this determination. Peyton has previously recorded the species in the English Wealden beds, but no detailed descriptions or figures accompany his note. Nathorst records from Japan specimens of what is most probably the same species as the English and North German forms; he refers to a previous paper[2] in which he pointed out the true *Nilssonia* character of Dunker's species, the segments being attached to the upper face of the rachis, and not laterally as in *Pterophyllum* or *Anomozamites*. A leaf fragment closely resembling the present species is figured by Schenk[3] from Persia as *Anomozamites minor*, Schimp. In Yokoyama's recent contribution on Mesozoic plants from Kōzuke, etc., several specimens are referred to this species on the authority of Nathorst; the figures suggest a lateral attachment of the unequal segments, but possibly the leaves are shown with the under side uppermost. Nathorst's figures of this species from Japan represent typical *Nilssonia* fronds.

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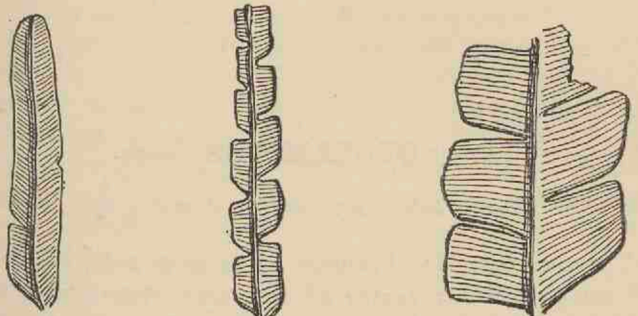
[1] (A. 2), Wealdenbildung.

[2] (2), p. 82.

[3] (A. 7), Bibl. bot. vi. pl. v. fig. 21.

V. 2171.** Figs. 3*a* and *b*. The two figured specimens are examples of the narrower form of the species: in *a* the almost entire lamina resembles a small example of *Tæniopteris*; in *b* the truncate segments are well shown; and in both cases the venation is distinct. Both specimens are represented twice the natural size. *Rufford Coll.*

V. 2171*a*. Fig. 3*c*. Broader specimen, 1·1 cm. in breadth. The median groove on the upper surface and the veins are very distinct. This example serves as a connecting link between the larger forms of the plant as described by Schenk, and the smaller English specimens.



a. *b.* *c.*

Nilssonia Schaumburgensis (Dunk.).
Fig. 3*a* and *b* (V. 2171**). } (Twice nat. size.)
Fig. 3*c* (V. 2171*a*).

V. 2171. Several specimens. The variation in the size and division of the lamina is well illustrated in these examples. Generally speaking, Schenk's figures represent leaves with more regular lobes than are found in the English specimens. In some cases the segments are numerous and very narrow, in others the lamina is almost entire.

V. 2171*b*. A specimen with the lamina entire for a length of 4·2 cm.

V. 2171*c*. This specimen of one of the narrower forms of the species shows a depression at the distal end of the lamina, and presents a very similar appearance to that of *Tæniopteris Beyrichii* (Schenk) as figured by Schenk. Ecclesbourne. *Rufford Coll.*

V. 2172. This specimen was erroneously included under *Tænio-pteris Beyrichii* in Vol. I. (p. 126).

V. 2234*a*. 5 mm. broad. In a length of 4·2 cm. there are about 23 divisions in the lamina; in the same length of **V. 2171***b*, the lamina shows no divisions. At one end the segments gradually decrease in size until they almost disappear. Ecclesbourne.

Rufford Coll.

Other specimens: **V. 716.** Hastings. *Dawson Coll.* **V. 1436.** Ecclesbourne. *Presented by P. Rufford, Esq.*, 1886. **V. 2234.** Ecclesbourne. *Rufford Coll.*

Genus **OTOZAMITES**, Braun.

[Münster, Beiträg. Petrefact. Heft vi. 1843, p. 36.]

The name *Otozamites*, instituted by Braun in 1843, was defined by him as follows: Leaves pinnate, pinnæ alternate and approximate, auriculate, and attached by a portion of the base; veins radiating from the point of attachment to the margins of the segments.

This author includes *Zamites falcatus* (Sternb.), *Z. Bucklandi* (Brong.), and *Z. brevifolius* (Braun, etc.) as species of his new genus; *Z. falcatus* was first figured by Sternberg[1] as *Odontopteris falcata*, and *O. Bucklandi* was described by Brongniart in 1825 as *Filicites Bucklandi* var. *Britannica*[2]; both of these species were assigned by Morris[3] to his genus *Ptilophyllum*. Brongniart adopts Braun's generic name, and points out that *Otopteris*, Lindley and Hutton, corresponds to *Otozamites* of Braun. This genus affords another example of confusion in nomenclature arising from a difference of opinion as to the botanical relationship of the fossil

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[1] (A.), Flor. Vorwelt, pl. xxiii. fig. 1, fasc. 5 and 6, p. 78.

[2] Brongniart (4), p. 422.

[3] (1), p. 117.

fronds. Brongniart[1] says that *Otozamites Bucklandi*, Brong., was figured by De la Beche[2] as a fern from the Lias of Axminster, and by Lindley and Hutton as *Otopteris obtusa*,[3] the typical species of the genus. The same writer suggests the advisability of distinguishing certain leaf forms under another genus, *Sphenozamites*, of which the chief characteristic is the absence of an auriculate base in the pinnæ; this genus has come into general use, and serves a useful purpose as a convenient provisional term. Bornemann[4] has suggested that probably some of the plants referred to *Otozamites* are without true auriculate pinnæ, the apparently eared form being merely a result of pressure on the upper surface of the thick pinnæ. He removes some of Braun's species from the genus, and speaks of *Otozamites brevifolius* (Sternb.) and *O. gramineus* (Morr.) (=*Zamites gramineus*, Morris) as typical species. The following is Bornemann's emended version of Braun's diagnosis:[5] "Leaves pinnate; pinnæ approximate, alternate, or subopposite, lanceolate, pointed or more or less blunt, auriculate at the base, and attached to the rachis only by the lower part, the upper corner of the auriculate base prolonged and partly covering the rachis. Veins radiate from the point of attachment towards the margin of the pinnæ, and are for the most part dichotomous." This definition appears to be on the whole satisfactory, but Bornemann unfortunately errs in describing the pinnæ as attached to the rachis by the lower portion; the manner of insertion of some auriculate pinnæ cannot correctly be described according to his definition. Schenk has discussed at some length the botanical position of the genus *Otopteris* in his *Flora der Grenzschichten*;[6] he draws attention to a specimen of which the segments exhibit a peculiar marginal structure, suggestive of a *Pteris*-like fertile leaf. The structure of the epidermal cells is also referred to in support of the inclusion of this genus among the *Filicinæ*; but in his later writings Schenk speaks of *Otozamites* as a member of the *Cycadaceæ*.

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[1] Tableau, p. 61.
[2] Pl. vii. fig. 2.
[3] (A.), Foss. Flor. pl. cxxviii.
[4] p. 49.
[5] p. 52.
[6] p. 135.

Schimper, in the first volume of his *Trait. pal. vég*,[1] adopts the genus *Otopteris*, L. and H., but afterwards (vol. ii.)[2] accepts Braun's generic name *Otozamites*; he institutes a sub-genus *Rhombozamites* for *Otozamites Beanii* and other species, and makes use of one of Pomel's terms, *Cyclozamites*, for *Otozamites Bunburyanus* and other forms. This subdivision seems quite unnecessary, and tends rather to confusion than to useful classification. Saporta[3] retains *Otozamites Bucklandi* (Brong.) as the type of the genus, but in his diagnosis mention is made of certain features which set rather narrow limits to the generic characters; the basal callosity of the pinnæ and the auriculate upper angle of the base, are features which do not always appear in fronds which must be referred on general grounds to the genus *Otozamites*. It is true we frequently find that the upper lobe of the pinna base is more decidedly auriculate than the lower, but this is not universal. Saporta's figures of some of the species of *Otozamites* show this quite clearly; *e.g.*, *O. Reglei*, Sap.,[4] *O. Brongniarti*, Schimp.,[5] etc. In describing the characteristics of the various examples of the genus, Saporta points out the numerous variations from the normal type. In discussing the geological history of the genus, this author refers to the absence of *Otozamites* from Wealden and Neocomian strata; since these words were written several examples of Wealden forms have been discovered, and the material acquired in recent years shows that the small plant figured by Dunker as *Cyclopteris Klipsteinii*[6] is most probably a species of *Otozamites*. The groups into which Saporta divides this genus have been adopted by Schimper in Zittel's *Handbuch*.[7] The recognition of certain typical species as representatives of different forms of a genus may in some cases be a convenient aid to classification, but there is always the danger of unduly emphasizing slight and unimportant differences for the sake of such purely arbitrary grouping. In the case of a genus such as

[1] p. 483.
[2] p. 167.
[3] p. 45.
[4] Pl. cix.
[5] Pl. ciii.
[6] (A. 2), Wealdenbildung, pl. ix. figs. 6 and 7.
[7] p. 221.

Otozamites we know very little indeed as to its exact botanical position, and for the present, at least, it will probably be better not to bind ourselves to any of these subdivisions of the genus. We may adopt a definition of *Otozamites* very similar to that previously quoted from Bornemann, but which gives a more definite expression to the variable character of the numerous forms and fronds included in Braun's genus:—

Frond pinnate; pinnæ attached to the upper surface of the rachis by a portion of the auriculate base, base more or less distinctly auriculate, the upper lobe often more prominent than the lower; segments may be approximate, imbricate, or distinct. Veins numerous and branched, radiating from the point of attachment and cut off obliquely by the margin of the pinna; in the longer and narrower form of pinna the veins are practically parallel to the edges of the segment; pinnæ vary from long, narrow, and linear-lanceolate, with acute tips, to broadly oval or almost orbicular in form, with bluntly rounded apices.

Solms-Laubach,[1] after speaking of the flabelliform venation of *Otozamites*, goes on to say that in some forms of this genus the veins of the pinnæ conform much less distinctly to that type than in others. If we examine the narrower and longer forms of *Otozamites* pinnæ, the veins become more or less parallel to the segment margins soon after leaving the auriculate basal portion. In the longer segments of *Otozamites gramineus* and other species this is the case, so that the flabelliform character of the venation cannot by any means be relied upon as a constant and easily recognized characteristic of the genus. It is often a difficult matter to decide whether the pinnæ bases are actually auriculate; in dealing with some fronds we find it almost impossible to draw a well-marked line between *Otozamites*, *Ctenophyllum*, and *Ptilophyllum*, etc.

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[1] Fossil Botany, p. 89.

Otozamites Klipsteinii (Dunk.).

[Pl. I. Figs. 3 and 4; Pl. VII.]

1846. *Cyclopteris Klipsteinii*, Dunker, Wealdenbildung, p. 11, pl. ix. figs. 6 and 7.
1848. *Cyclopteris Klipsteinii*, Bronn, Index pal. nomencl. p. 377.
1849. *Adiantites? Klipsteinii*, Brongniart, Tableau, p. 107.
1850. *Cyclopteris Klipsteinii*, Unger, Gen. spec. plant. foss. p. 95.
1869. *Aneimidium Klipsteinii*, Schimper, Trait. pal. vég. vol. i. p. 486.
1871. *Aneimidium Klipsteinii*, Schenk, Palæontographica, vol. xix. p. 213, pl. xxxi. fig. 6.

Type. Detached pinna and fragment of frond.

Dunker defines the species as follows: "Cyclopteris fronde pinnata, pinnulis alternis sessilibus? ovato-oblongis æqualibus, nervis creberrimis flabellatis tenerrimis." He points out that the veins are exceedingly delicate, and apparently dichotomous in the upper portions, the venation shown in his figures being coarser than it actually is in the specimens. Ettingshausen figures four detached leaflets which he describes as intermediate in character between *Cyclopteris Mantelli* and *C. Klipsteinii*; in his drawings there appears to be a distinct suggestion of a midrib, but nothing is said in the definition of the species as to the existence of a median vein. It has already been pointed out (Wealden Catalogue, vol. i. p. 131) that these leaflets are certainly not typical examples of *Sagenopteris Mantelli* (Dunk.), as Ettingshausen erroneously states. It will be better to leave them out of consideration as doubtful fragments.

Schenk figures a single pinna of this species, which shows very clearly an auriculate base and dichotomously spreading veins. The Rufford Collection contains a large number of well-preserved fronds with pinnæ of various sizes, and which in some cases are clearly identical with the species figured by Dunker and Schenk as *Cyclopteris* or *Aneimidium Klipsteinii*. The number and variety of the specimens present a difficulty as regards specific determination. A casual inspection of the fronds with large and broadly oval segments would probably lead one to institute a new specific name for their reception, but on carefully examining and comparing all the examples, it appears to be impossible to determine definite specific limitations. The frond figured in Pl. I. Fig. 3 must certainly be referred to Dunker's species; the pinnæ agree closely with that figured by Schenk, and with the inferior figure by Dunker. We have a pinnate frond, with segments attached by an auriculate base; the venation agrees with that of *Otozamites*, and the general character of the leaf points to that genus as the most convenient designation for the specimens. Another specimen, Pl. II. Fig. 4, possesses pinnæ of the same form as those in **V. 2236**, but differs in its much stouter rachis and in the imbricate disposition of the segments. It is difficult to speak confidently as to the relation of the several specimens one to another, but probably we have in Pl. II. Fig. 4 the lower portion of a young frond of the same form of which Pl. I. Fig. 3 represents a terminal fragment. Leaving a more detailed notice of these specimens until later, we must turn to the extremely fine examples of the larger fronds, such as those represented in Pl. VII. Fig. 9, etc. It is possible there may be two or three species represented by this splendid series of fronds, which I have referred to the genus *Otozamites*; in some the pinnæ are longer and narrower than in others, and in some we have a shorter and broader form of segment. On the whole, in the absence of any constant and well-marked differences consistent with separate species, I prefer to include nearly all these various forms under one species, *Otozamites Klipsteinii* (Dunk.), and resort to descriptive terms for the designation of one or two varieties. We may thus define this comprehensive species: Frond pinnate, rachis fairly stout, tapering to a slender axis in the terminal portion; pinnæ attached to the upper surface of the rachis, in the young frond probably imbricate, with a more or less well-marked auriculate base; veins numerous, radiating from the point of attachment towards the margin of the pinnæ; apices obtuse, pinnæ alternate or subopposite, in the mature fronds almost at right angles to the axis, or more or less obliquely inclined.

Before describing the individual specimens referred to this species and its varieties, we may notice some other forms of the genus *Otozamites*, and other plants with which the present example may be compared. *Otozamites Beanii* (L. and H.) [1] corresponds

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[1] Fossil Flora, pl. xliv.

with *O. Klipsteinii* in having auriculate pinnæ, broader and stouter than the majority of species of the genus. In describing the type specimen, Lindley and Hutton ask if the plant may be a pinnated leaf of the *Cycadeoideæ*, but reply with a decided negative; in the second volume of the *Fossil Flora* the generic name *Otopteris* is substituted by the authors of the species for *Cyclopteris*, under which the plant was originally described. In the Leckenby Collection in the Woodwardian Museum, Cambridge, there are several very fine specimens of *Otozamites Beanii*, which in some instances show a terminal portion with small pinnæ very similar to such an apical tip as is represented in Pl. I. Fig. 3. In the Yorkshire plant the species are, however, very distinctly auriculate, and have the upper portion of the base more prominently lobed than is the case in *O. Klipsteinii* (Dunk.). In one of Leckenby's specimens, which possesses a rachis 43·5 cm. long, the largest pinna has a length of 3 cm. and a breadth of 1·9 cm., the smallest measuring 1 cm. by 7 mm. Some of Zigno's figures of his species *Otozamites Molinianus*[1] present a striking likeness to *O. Beanii*, and ought most likely to be referred to that species. Kurr's figure of what he calls *Zamites Mandelslohi*[2] agrees very closely with the specimen represented in Pl. IV. Fig. 4; the genus *Otozamites* has been rightly substituted by Schimper for Kurr's species. The larger pinnæ of *O. Klipsteinii* show a certain resemblance to those of some few previously described plants; but in no case does the similarity appear sufficiently pronounced to justify a reference to the same species. In the third volume of the *Gondwana Flora of India*,[3] Feistmantel figures some isolated pinnæ under the name *Glossozamites Stoliczkanus*, Feist., and describes them as probably constituting the largest representatives of Schimper's genus. The form of these large segments is not at all unlike that of the Wealden pinnæ, but in the latter case the auriculate base favours the adoption of the genus *Otozamites*. The plant described many years ago by Göppert, from a much lower geological horizon, under the name of *Cyclopteris frondosa*[4] (Göpp.), may be compared, as regards the form of its leaf segments,

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[1] (A.), Flor. foss. Oolit. vol. ii. pl. xxxv.

[2] Pl. i. fig. 3.

[3] Vol. iii. pt. i. pl. xx. figs. 4 and 5.

[4] Schimper (A.), Trait. pal. vég. vol. i. p. 453, pl. xxxv.

with the larger specimens of the present species. Schimper places this Culm species in his genus *Cardiopteris*, and describes it as an unusually large-leaved neuropteroid fern. The venation of the large pinnæ of the Wealden fronds suggests that of certain fern pinnules; and it must be borne in mind in dealing with such leaves as those of a neuropteroid or otozamitean type, that we are unable to speak dogmatically as to the botanical position of the species.

Among the Jurassic plants figured by Saporta[1] there occur a few examples of fronds with leaf segments comparable to those of *O. Klipsteinii*; e.g., *O. decorus*, Sap., and *O. lagotis*, Brong. A detached segment named by Saporta *Sphenozamites Brongniarti*, agrees fairly closely with some of the larger pinnæ of the English Wealden specimens, but the French fragments are too small to allow of any precise comparison, and hardly worthy of a special specific name. The frond fragments described by Hosius and von Marck as *Pterophyllum blechniforme*[2] have a certain resemblance to some of the English specimens, but are clearly not specifically identical; the generic name *Otozamites* would seem to be more applicable to this species of Hosius and von Marck than that of *Pterophyllum*. The pinnæ of Fontaine's species *Zamites tenuinervis*[3] may be compared with some of the longer segments of *Otozamites Klipsteinii*, but there is not sufficient evidence to justify the inclusion of the Potomac and English forms in the same species.

Finally, we have a somewhat similar form of leaf in some examples of the Palæozoic genus *Cordaites*[4] recently figured by Grand'Eury from the Coal-field of Gard. Whilst drawing attention to some of the plants previously described, in which a greater or less resemblance may be traced to the present species, it must be definitely stated, that we are without any satisfactory evidence as to the exact position in the plant kingdom to which these large-leaved forms should be referred. Having regard to the general habit of the fossil fronds, the apparently stiff nature of the pinnæ, etc., the cycads appear to be the more likely plants with which to

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[1] Pl. xl.

[2] (A. 1), Palæontographica, vol. xxvi. pl. xliv. fig. 197.

[3] Potomac Flora, pl. lxvii. fig. 1, etc.

[4] Grand'Eury, pl. vi. figs. 14 and 16.

compare *Otozamites Klipsteinii.* Among recent cycadean species we do not meet with fronds possessing pinnæ with a well-defined auriculate base, but we are not without instances of fronds which in other respects bear a decided resemblance to the Wealden plant. *Zamia purpuracea*, Ait., may be cited as one recent species with large pinnæ comparable to those of the Wealden plant; the young pinnæ of this living cycad are very similar in form to the more terminal segments of *Otozamites Beanii.* In this species of *Zamia*, as also in *Z. pygmæa*, Sims, and in some other forms, etc., the pinnæ are distinctly narrowed towards the point of attachment to the rachis, from which they are readily detached, leaving a well-marked scar. The recent fronds correspond rather more closely with such fossil forms as *Podozamites Reinii*, Geyl., etc., described by Geyler[1] and others. In *Otozamites latifolius* (Phill.)[2] we have another large-leaved form which may to some extent be compared with the present species: the specimens of Phillips' species are imperfectly preserved, and do not give any decided indication of an auriculate base; the venation appears to agree fairly closely with that of Nathorst's genus *Ptilozamites*, and the prominence of the veins reminds one of some of the large and boldly veined segments of such recent species as *Zamia picta*, *Z. Skinneri*, Warsz., etc.

V. 2336. Pl. I. Fig. 3. This terminal portion of a frond must no doubt be referred to the same species in which the detached segments figured by Dunker and Schenk have been included. In Dunker's specimens there is not the same distinctly auriculated base as in this example, but this may be put down to less perfect preservation and possibly inaccurate drawing; in Schenk's leaflet of the same species the auriculate base is distinct, and agrees exactly with that in the English frond. The veins appear to be rather fewer and farther apart in this terminal portion than in the pinnæ of the larger fronds. Largest pinna 2 cm. by 9 mm. Ecclesbourne. *Rufford Coll.*

V. 2170*a*. Two detached pinnæ; the venation finer, and exactly like that in Schenk's example. Ecclesbourne. *Rufford Coll.*

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[1] (A.), Palæontographica, vol. xxiv. pl. xxxiv.

[2] Phillips, p. 171, fig. 6.

O. Klipsteinii (Dunk.), var. superba mihi.

V. 2745*a*. Pl. I. Fig. 4.

Rachis 12·5 cm. in length. Largest pinna 4·2 cm. by 1·6 cm.; smallest 3·8 by 1·2. The largest pinnæ of **V. 2336** has a length of 2 cm. and a breadth of 9 mm. Some of the pinnæ are very clearly preserved, and show excellent venation. The rachis appears to be slender, as in **V. 2336.** The upper pinnæ have very slightly auriculate bases, which are attached by their central portion to the surface of the frond axis. In the lower pinnæ the base is more distinctly lobed. Cf. *Pterophyllum oblongifolium*, Kurr [= *Glossozamites oblongifolius* (Kurr)].[1] There is not, I am inclined to think, sufficient proof of any important difference between **V. 2336** (Pl. I. Fig. 3) and **V. 2745*a*** (Pl. I. Fig. 4) to warrant a specific separation; but as we shall find a gradual transition from such specimens as **V. 2745*a*** to the fronds with much larger pinnæ, *e.g.* Pl. VII., it will be convenient to institute a variety of Dunker's species under the name *superba*. Ecclesbourne. *Rufford Coll.*

V. 2170. Pl. VII. Fig. 9. It may be, as suggested in the introductory account of the species, that we have two or three species included under *O. Klipsteinii* (Dunk.), but thanks to the numerous and well-preserved specimens it is possible to examine an unusually fine series, and so escape to some extent from the dangers of fragmentary and imperfect portions of fronds, which often lead to unnecessary multiplication of specific names. In the present instance we can trace a gradual transition from the short and broad segments, such as those represented in Pl. VII. Fig. 5 (**V. 2745**), to the large forms such as Pl. VII. Figs. 1 and 6 (**V. 2122**). The leaves with the broader and more or less imbricating obliquely set pinnæ come very near to *O. Beanii*, and those with more separate, longer, and narrower segments closely resemble the pinnæ figured by Fontaine as *Zamites tenuinervis*, Font. In fragments of young fronds or in the lower part of older fronds the pinnæ may have a length of 2 cm. and a breadth of 1·4 cm., in the larger segments 8·2 × 2·4 cm. In this specimen (**V. 2170**) the rachis is 23 cm. in length; it has left a hollow mould in the rock, roofed over by the basal ends

[1] Kurr, pl. i. fig. 5.

of the pinnæ; on one side there are nine pinnæ, and on the other seven. These show the broad, obtusely terminated form of the segments very clearly; they are attached to the upper surface of the rachis by the central portion of the distinctly auriculate base. Most of the pinnæ overlap, the upper edge of each projecting over the lower margin of the pinna next above it; very similar in habit to some of the larger specimens of *O. Beanii* in the Leckenby Collection. On the under side of the same slab there occur portions of pinnæ of another frond, and a section of a rachis mould, about 6 mm. broad and 8 mm. in depth; also a specimen of *Cycadites Saportæ*, sp. nov. Ecclesbourne.

Rufford Coll.

V. 2122*a*. Pl. VII. Fig. 2. Rachis imperfectly preserved; portions of six pinnæ, the uppermost having the same form as the largest of **V. 2745** (Pl. I. Fig. 4), the lowest and largest, 6·4 × 3 cm. (Pl. VII. Fig. 2), showing a slight lobe in the middle of the upper margin. In some of the segments the point of attachment is well shown, and the numerous fine spreading veins are well marked in the carbonaceous surface layer.

V. 2126*a*. Pl. VII. Figs. 4 and 8. Frond 28 cm. long.; 11 pinnæ on one side. Hollow round mould of rachis, about 4–5 mm. in diameter. Short and broad overlapping pinnæ, 4·8 × 2·5 cm., and very like those of **V. 2740***a*, **V. 2740**, etc. The upper and smaller pinnæ, as shown in the figure, are narrower and longer and not overlapping; these agree exactly with the segments in **V. 2745***a* (Pl. I. Fig. 4). Uppermost pinnæ about 3 cm. × 1·8 cm.; a segment separated from this by 11 cm. and attached to about the middle of the specimen, measures 4·5 × 2·5 cm. The two larger pinnæ (Pl. VII. Fig. 8) agree very closely with those of **V. 2170** (Pl. VII. Fig. 9); they have a strongly convex upper surface, and show a sharp bending down of the lamina near the point of insertion to the rachis. This bending of the pinna base is exactly similar to the appearance frequently presented by the stiff leathery pinnæ of recent species of *Encephalartos*, to which allusion has been made in the introductory remarks on fossil *Cycadaceæ*.

V. 2126. 32 cm. long. Rachis about 4 mm. broad, in the form of a round hollow mould. Compare the largest pinna of this specimen with the smallest of **V. 2122**.

V. 2740. Pl. VII. Fig. 7. Specimen 37 cm. long; 13 pinnæ on one side. The marked variation in length of pinnæ at the upper and lower end of the rachis is well seen. Several segments show the manner of insertion on the frond axis; venation fairly distinct. The pinnæ present a strongly convex surface, and are slightly inclined to the horizontal plane of the rachis, as in *Weichselia Mantelli* (Brong.), (Vol. i. p. 116). At the upper end of the axis the pinnæ bases are 2·7 cm. apart, towards the lower end 2–2·5 cm. apart. The upper pinnæ are practically identical with those of **V. 2170** (Pl. VII. Fig. 9), but the shorter, broader, and closer pinnæ of **V. 2170** are somewhat broader and closer than any in **V. 2740.**

V. 2740*a*. 30 cm. long. The venation exceedingly well marked. Rachis 5 mm. broad, flattened. Pinnæ vary considerably in size at the two ends of the frond, 4·8 × 2·5 to 3·5 × 2·1 cm. The auriculate base of many of the segments clearly shown. For the most part the segments overlap one another, oblique to the rachis, and apparently of a thick and leathery nature. Cf. *O. Beanii.* Ecclesbourne. *Rufford Coll.*

V. 2912*a*. Pl. VII. Fig. 3. Rachis 33 cm. in length. Lowest pinna 5·7 × 2·7 cm.; uppermost 6·5 × 3. Venation in excellent preservation. Apices bluntly rounded; the lower edge of the base appears to be more distinctly lobed than the upper. Smaller pinnæ like the larger ones in **V. 2740**, and the larger like those of **V. 2912**, etc.

V. 2912. This specimen shows six pinnæ attached to the rachis, three on each side; pinnæ 7 × 2·7 cm. broad, do not overlap, inclined to the horizontal plane of the rock surface. Rachis striated longitudinally, and shows cross lines at intervals, but the latter are no doubt simply minute transversely running cracks in a mineral substance. *Cf.* **V. 2090, V. 2122**, etc. Ecclesbourne. *Rufford Coll.*

V. 2745. Pl. VII. Fig. 5. Rachis 12 cm. long, with six pinnæ. Pinnæ short and broad. Compare this specimen with **V. 2336** (Pl. I. Fig. 3) and **V. 2745***a* (Pl. I. Fig. 4). Largest pinnæ 2·8 × 1·6 cm., lowest and smallest 1·8 × 1·4 cm. Venation distinct. *Cf.* upper end of **V. 2740***a*.

V. 2745*b*. 12·5 cm. long. Seven pinnæ on one side: largest 4·2 × 16 cm., smallest 3·8 × 1·2 cm. Rachis appears to be 2·5 mm. Venation good, upper pinnæ slightly auriculate, in the lower segments the ariculate base is more distinct. Cf. *Pterophyllum oblongifolium*, Kurr. Ecclesbourne. *Rufford Coll.*

V. 2090. Part of a rachis and four pinnæ. Pinnæ long, not overlapping, about 3 cm. apart, of similar form to those of **V. 2912.** Ecclesbourne. *Presented by P. Rufford, Esq.*, 1889.

V. 2364*a*. Portion of a single pinna; compare with some of the lower pinnæ in **V. 2740*a***; broad and short, 5 × 3·8 cm. Very different in appearance from **V. 2364**, but probably the same species; in **V. 2122** we have the same kind of divergence in the form of the segments as between the two specimens **V. 2364** and **V. 2364*a***. Ecclesbourne. *Rufford Coll.*

O. Klipsteinii var. longifolia, mihi.

V. 2122. Pl. VII. Figs. 1 and 6. Rachis 43 cm. long; 15 pinnæ on one side. The pinnæ in this specimen are of the longer and narrower form. The smallest and lowest segment measures 7·5 × 2·5 cm.; the uppermost and longest 8·4 × 2 cm. The lowest pinna connects such an example as this with **V. 2912, V. 2090, V. 2740,** etc. Pinnæ separate, bases in the lower part of the frond 3·5 cm. apart, the two uppermost separated by 2·5 cm. Venation not quite so distinctly seen as in some other specimens; the lower pinnæ show very clearly the auriculate form of base.

V. 2122*b*. This specimen, 20 cm. in length, is very imperfectly preserved. The pinnæ are of the longer and narrower type, and agree fairly well with those of *Zamites tenuinervis*, Font., but the distinctly auriculate form of the base and the manner of insertion on the rachis seem to sufficiently distinguish the specimen from the Potomac species, and to connect it with the other forms of *Otozamites Klipsteinii* var. *superba*. Possibly it would be better to designate such forms as **V. 2122, V. 2122*b*, V. 2123*a*,** etc., *O. Klipsteinii* var. *longifolia*. Between this specimen and **V. 2122** there is the closest similarity. Ecclesbourne. *Rufford Coll.*

V. 2123*a*. Here again we have a specimen, imperfectly preserved, which it is difficult to assign to a perfectly satisfactory position. The pinnæ are long and narrow, and agree with those of **V. 2122*b***, etc.; but on the other hand this form is nearer to that of *Zamites tenuinervis*, Font. The bases of the pinnæ are less distinctly auriculate, and in some there is a wrinkling of the leaf substance near the point of attachment to the frond axis. Cf. *Encephalartos Lehmanni*. Ecclesbourne. *Rufford Coll.*

Other specimens referred to this species: **V. 1069, V. 2126, V. 2364, V. 2912*b*, V. 3160** (a good example of *O. Klipsteinii* var. *longifolia*).

Otozamites sp. *Cf.* **O. Klipsteinii** (Dunk.).

V. 2734. Pl. II. Fig. 4.

In Pl. II. Fig. 4 is represented one of two specimens, of which one is the counterpart of the other. The rachis has a length of 12·5 cm., and bears at its upper end six imbricate and obliquely attached pinnæ. The base of the rachis is swollen, and shows a clean cut surface by which it was attached to the parent stem; just above the base there are traces of filiform appendages, possibly scale or hair structures, such as occur on the lower portions of many recent cycadean fronds. The bases of the alternately placed pinnæ fit in between one another, and are attached to the upper surface of the rachis. Saporta[1] has figured a very similar specimen as *Otozamites* sp., in which the base of the petiole shows two fairly large leaf-like or stipular (?) structures. The French Jurassic specimen closely resembles *O. Beanii* (L. and H.), but it is no doubt better to follow Saporta, and retain it as a fragment too small to be accurately determined. Another somewhat analogous form is figured by the same author as *Otozamites marginatus*[2]; but in dealing with portions of such partially developed fronds, any attempt to assign them to specific forms founded on nature fronds must be attended with no little difficulty and risk. Possibly this

[1] (A. 2), Pal. Franç. vol. ii. pl. vi. figs. 3 and 4.
[2] *Ibid.* pl. cix. fig. 1.

specimen (**V. 2734**) may be the basal portion of a young partially expanded frond of the same species (*O. Klipsteinii*), of which **V. 2336** (Pl. I. Fig. 3) is the apical termination of a young frond, but it would hardly be wise to do more than offer the suggestion. In **V. 2336** the rachis appears to be very slender; here, on the other hand, it is distinctly strong and broad: how far this constitutes an important difference, and how far it is due to one specimen being the terminal portion and the other the basal portion, or to differences in the manner of preservation, is difficult to decide. The individual pinnæ are very similar to, and possibly identical with, the isolated segment figured by Dunker[1] and Schenk[2] and now classed with **V. 2336**. Ecclesbourne. *Rufford Coll.*

Otozamites sp. *Cf.* O. Reibeiroanus, Heer.

V. 2926. This small specimen shows ? pinnæ attached to the upper surface of a rachis. It may belong to the same species as **V. 2734** (Pl. II. Fig. 4), but of this there is no obvious proof. It agrees very closely with Heer's Portuguese species *O. Reibeiroanus*.[3] The upper lobes of the pinnæ are more prominent than the lower. Ecclesbourne. *Rufford Coll.*

Otozamites Göppertianus (Dunk.).

[Pl. I. Figs. 1 and 2; Fig. 4.]

1846. *Pterophyllum Göppertianum*, Dunker, Wealdenbildung, p. 14, pl. ii. fig. 5.
1848. *Pterophyllum Göppertianum*, Bronn, Index pal. nomencl. p. 1055.
1849. *Zamites Göppertianus*, Brongniart, Tableau, p. 107.
1850. *Pterophyllum Göppertianum*, Unger, Gen. spec. plant. foss. p. 290.
1851. *Dioonites Göppertianus*, Miquel, Tijdsch. Wis. Nat. Wet. iv. p. 7.
1852. *Pterophyllum Göppertianum*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 21.
1856. *Dioonites Göppertianus*, Bornemann, Organ. Rest. Lettenkohl. p. 56.
1870. *Dioonites Göppertianus*, Schimper, Trait. pal. vég. vol. ii. p. 151.
1871. *Dioonites Göppertianus*, Schenk, Palæontographica, vol. xix. p. 235, pl. xxxiv. figs. 3 and 4.

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[1] Wealdenbildung, pl. ix. figs. 6 and 7.
[2] Palæontographica, vol. xix. pl. xxxi. fig. 6.
[3] Heer (A. 6), Secc. Trab. Geol. Portugal, 1881, pl. ix. figs. 1–9.

Type. Specimen of frond. Berlin Museum.

Dunker thus defined the species in 1846: "Pterophyllum fronde impari-pinnata, pinnis oppositis subrectis elongatis linearibus acuminatis subremotis, æque distantibus angulo acuto adnatis, nervis obsoletis quinis vel senis, rhachi crassa subtereti lævi."

He speaks of each pinna having five or six equal and thin veins, and shows this venation in the slightly magnified portion represented in fig. 5*a*, pl. ii. Dunker's figures certainly appear to justify his choice of the genus *Pterophyllum* as regards the manner of attachment and distal terminations of the segments. Reference has already been made, in speaking of the various sources of error connected with fossil cycads, to the very different appearance presented by a frond when viewed from the upper and lower surface. In the present instance it is quite possible, and, indeed, considering all the facts before us, I believe very probable, that we have in Dunker's fig. 5 a view of the under surface of the frond. The rachis is seen to project considerably above the level of the pinnæ, and the latter are either attached by broad bases to its margin, or pass underneath and are united to the face of the rachis which is pressed against the rock surface. The venation, as Dunker describes and figures it, does not accurately correspond with that of the English specimens which I have ventured to refer to this species. If, however, Dunker's drawing represents an imperfect fragment seen from below, it is very likely that we should find a somewhat different appearance presented by the veins to that which is seen in the more perfect pinnæ of the English fronds. If specimen **V. 2360** (Pl. I. Fig. 2) be compared with Dunker's pl. ii. fig. 5, the striking resemblance between them in the form and arrangement of the pinnæ cannot fail to be noticed. The English specimen seen from the under side would present an appearance very similar to that of Dunker's frond. Turning to Schenk's account of the same species, we find he follows Miquel in adopting the generic name *Dioonites* in preference to *Pterophyllum.* Schenk includes in this species the specimen figured by Dunker as *Pecopteris linearis*, which the former regards as a badly preserved fragment of *Dioonites Göppertianus*; this does not seem probable, so far as the figures enable us to form an opinion. This author extends the original diagnosis of the species, and points out that the pinnæ are attached to the upper surface of the frond axis; his figure shows a median groove in the upper surface of the rachis between the two rows of segments. The veins, apparently not very distinctly shown, are described as parallel, uniform, and delicate. Schenk's fig. 3, pl. xxxiv. probably represents, as in Dunker's fig. 5, the under surface of a frond, but in fig. 4 of Schenk's plate we have a small piece of leaf seen from above, and here the median groove and manner of insertion of the segments are indistinctly seen. A comparison of **V. 2123** (Pl. I. Fig. 1) with Schenk's figs. 4 and 4*a* reveals a fairly close resemblance; the correspondence in the general form of the fronds and pinnæ suggests the same species. In the German specimens we have only small and imperfect fragments, but in the Sussex examples the preservation is particularly good, and the details well marked. The pinnæ of the English specimens do not in every case show a distinctly auriculate base; it is only here and there that this feature can be seen. Considering the difference in the manner of preservation in the two sets of specimens, it is not much to be wondered at if no trace of the lobed base can be detected in the more imperfect specimens. Another important point is the probability, that Schenk's fig. 4 is the only specimen from the German Wealden in which we have a view of the upper surface of the rachis.

A plant from the Lower Cretaceous rocks of Portugal, originally figured by Morris[1] as *Zamites gramineus* var. *mundæ*, and afterwards by Heer[2] as *Otozamites angustifolius*, shows a certain amount of resemblance to the present forms; compare especially Heer, pl. ix. fig. 10 and fig. 3*b*. It must be admitted that the English specimens have a broader rachis than is apparent in Dunker's figures, but this may easily be due to the different manner of fossilization, and cannot be relied upon as an essential difference, considering the nature of the material. Some of Saporta's figures of *Otozamites latior*, Sap., resemble in general characters the Wealden species, but differ in some points of detail which sufficiently separate the two forms.[3] A comparison of Saporta's pl. xcvii. figs. 1 and 3 with the present specimens shows very clearly the different appearance presented by an upper

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1 (3), pl. xxvi. fig. 7.

2 Heer, *loc. cit.* pl. ix.

3 Saporta, pls. xcvii. and xcviii.

and lower view of the same plant. I am inclined to regard some of the examples referred by Saporta to *O. latior* as identical with Heer's *O. angustifolius*, Heer; *cf.* Saporta, pl. xcvii. fig. 2, and Heer, pl. ix. fig. 12, etc. The plant figured by Bartholni,[1] as *Otozamites latior*, closely resembles the present species. A somewhat similar habit is also seen in Leckenby's *Otopteris lanceolata*: the type specimen of this species appears to be identical with some other examples which have been assigned to *Ctenophyllum pectinata*; the base of the pinnæ may be very slightly auriculate, but the specimens do not afford satisfactory evidence of this.

It will be seen from the two specimens (**V. 2123** and **V. 2360**) figured in Pl. I. Figs. 1 and 2, that the frond presents a very different appearance in the lower and upper portions. The graceful and tapering pinnæ, with their slightly but distinctly auriculate base (Fig. 4), and the grooved broad rachis are perhaps the most striking specific characteristics. The inclusion of these specimens in Dunker's species may, perhaps, be an error of judgment, but I have endeavoured to show on what grounds this course has been taken. The institution of a new species would have been in some respects more satisfactory than defining afresh an old species founded on specimens much less perfect than those now before us, but, having recognized the strong probability that the apparent differences between Dunker's type and the English examples is due to accidents of fossilization, the original name has been retained. We may thus define *Otozamites Göppertianus*:—

Frond pinnate, deciduous; rachis broad, with a surface marked by irregular longitudinal lines; pinnæ alternate, articulate, attached by a slightly auriculate base to the middle of the upper surface of the rachis; towards the base of the frond the pinnæ are very narrow and short, and farther apart than those attached to the middle and upper portion of the frond axis; in certain parts of a frond the pinnæ are approximate and almost imbricate. Lower pinnæ very obliquely attached to the rachis, the upper gradually becoming inclined at a greater angle to the axis in passing towards the apex of the frond. Pinnæ linear-lanceolate, very gradually tapering from the base to the apex, occasionally somewhat falcate, apices acute and slightly symmetrical, the lower margin of a segment being sometimes decidedly curved in an upward direction,

[1] Bartholni, pl. iii. fig. 1.

the upper edge in some cases almost straight. Narrow elliptical scars left on the surface of the rachis where the pinnæ have fallen off. Veins numerous, radiating outwards from the centre of the base, but parallel in the greater part of the length of each pinnæ.

V. 2360. Pl. I. Fig. 2. Rachis 35·5 cm. long; exceedingly well preserved at the base, which shows by its clearly cut outline the deciduous habit of the frond. Surface wrinklings or irregular striations very distinctly marked on the rachis. The figure represents only a portion of the specimen; the upper part, not shown in the drawing, is practically identical with the portion of **V. 2123** figured in Pl. I. Fig. 1. The specimen as a whole shows very clearly the great contrast between the loosely arranged, very narrow, and short basal pinnæ; the somewhat more approximate and much longer, gradually tapering, and slightly falcate pinnæ in the middle of the frond; and the stiffer, more approximate, and broader pinnæ towards the apex. The lowest pinna is about 1 mm. broad, the broadest about 5 mm. Some of the pinnæ have a distinctly auriculate base. *Cf.* Dunker, pl. ii. fig. 5. Ecclesbourne. *Rufford Coll.*

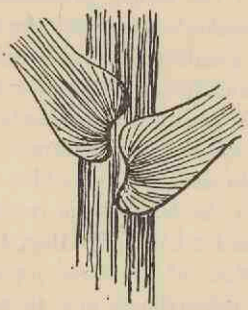

FIG. 4.—*Otozamites Göppertianus* (Dunk.), (V. 2741). Enlarged.

V. 2741. Fig. 4. Rachis 18 cm. in length. Part of the lower portion of a frond corresponding to **V. 2360** (Pl. I. Fig. 2). The gradual increase in the breadth of the pinnæ in passing from the lower to the upper part of the frond is well marked. Auriculate bases very distinct, and venation fairly clear. Ecclesbourne.

Rufford Coll.

V. 2123. Pl. I. Fig. 1. Rachis 10 cm. long; the pinnæ more closely arranged, and resemble on a rather larger scale Schenk's figures of this species. The auriculate character of the bases of the segments distinctly indicated, also the median groove in the axis of the frond. Numerous fine veins distinct. *Cf.* the upper unfigured portion of **V. 2360.**

There is an imperfect specimen of this species in the Museum of Practical Geology, Jermyn Street, in which the auriculate base and venation characters are fairly well shown.

Genus **ZAMITES,** Brongniart.

[Prodrome, 1828, p. 94.]

In describing some Japanese examples of the Wealden cycadean frond named by Ettingshausen [1] *Pterophyllum Buchianum,* Nathorst [2] draws attention to certain characters in the pinnæ which, he considers, exclude the species from *Pterophyllum* or *Dioonites,* in which it has generally been placed by other writers. He finds that the segments are somewhat narrower towards the point of insertion, and apparently laterally attached to the frond axis, thus differing in essential features from the above-named genera. The splendid series of specimens in the Rufford Collection confirms Nathorst's remarks with regard to the narrowing of the pinnæ towards the point of attachment to the rachis, but on the other hand, the English examples show a manner of attachment of the pinnæ more in accordance with the genus *Zamites,* the pinnæ being inserted on the upper surface of the rachis, and apparently along two more or less distinct lines. The new genus *Zamiophyllum,* proposed by Nathorst for this species as a substitute for *Pterophyllum* or *Dioonites,* on the ground that the characters do not conform in all essential respects with any existing genera, cannot well be retained in the light of the more recent facts afforded by the large series of English specimens. The genera *Dioonites* and *Pterophyllum* are quite unsuitable for this species,

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[1] (A. 4), Abh. k.-k. geol. Reichs. vol. i. 1852, p. 21, pl. i. fig. 1.
[2] (A. 3), Denkschr. k. Ak. Wiss. vol. lvii. p. 46.

and it would seem that Brongniart's genus *Zamites* corresponds most closely in general characters with these large Wealden fronds.

A brief review of some of the numerous definitions proposed for *Zamites* may suffice to emphasize the generally accepted characters, justifying at the same time Saporta's pertinent remarks as to the vague sense in which the name has frequently been applied. In 1828 Brongniart[1] proposed *Zamites* for a few fossil fronds showing some points of difference from his other genus *Zamia*; he mentions *Z. Bechii*, Brong., as an example of the former, and describes the pinnæ as: "Se recouvrant mutuellement et passant sur le pétiole commun; nervures divergentes arquées, souvent bifurquées."

The name *Zamia* is afterwards given up as likely to prove misleading as regards the relationship of fossil and recent leaves, and *Zamites* is described as characterized by the possession of entire pinnæ, not truncate at the apex, and not decurrent, but slightly constricted at the base. Brongniart includes Braun's two genera *Podozamites* and *Pterozamites* as two subsections of *Zamites*. Göppert[2] uses *Zamites* in a wide sense, and notes the resemblance of some species to the genus *Encephalartos* among recent cycads. The similarity between various fossil fronds and species of this living genus has not been sufficiently recognized by most palæobotanical authors. Göppert's definition does not restrict *Zamites* to fronds with basally constricted pinnæ, but includes those with a swollen and auriculate base. Pomel,[3] true to his unfortunate habit of founding new genera, proposes *Crossozamia* for certain species of *Zamites*, but the name has not come into general use. Bornemann[4] describes *Zamites* as comprising species with a greater or less resemblance to the recent Zamias, and defines the genus as follows: "Frond pinnate, leathery, pinnæ approximate or distant, from ovate to slender and linear in form, contracted at the base, entire or toothed on the upper margin, blunt at the top. Veins of uniform size, clearly seen on both sides of the pinnæ, dichotomous. Epidermal cells having the same structure as in recent Zamias." Schenk[5]

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[1] Prodrome, p. 94.

[2] (1), p. 122.

[3] Pomel, p. 342.

[4] Bornemann, p. 54.

[5] (A. 1), Fl. foss. Grenz. Keup. Lias, p. 158.

gives a diagnosis of *Zamites* in which the veins in the pinnæ are described as equal and parallel, and dichotomously converging towards the apex. He thus includes such forms as correspond to Braun's genus *Podozamites*. In Zittel's *Handbuch*[1] we find a closer approximation to the definition of *Zamites* as generally accepted: the pinnæ are described as attached to the upper surface of the rachis, and possessing a basal callosity, rounded or somewhat contracted at the base; the median veins parallel, and the outer veins diverging towards the apex of the pinna.

Solms-Laubach[2] notes the occurrence in the *Zamitæ* of pinnæ which articulate with and separate from the frond axis, pointed at the apex, abruptly rounded at the base, and attached obliquely to the rachis, which they overlap and cover. Solms pertinently remarks that isolated segments of species of *Zamites* may easily be mistaken for portions of other fossil genera. Before attempting to modify in any way the definitions of *Zamites*, it may be well to consider some of those special features which have been referred to by several writers, and to see how far such details of frond structure are likely to serve as trustworthy guides. As regards the basal callosity usually included in definitions of this genus, we must acknowledge the great difficulty to be experienced in deciding definitely as to its existence in many fossil leaves. In the process of fossilization the pinnæ of a cycadean frond are often flattened down against the rock, and closely adpressed to the surface of the rachis, and thus there may be produced transverse wrinklings just above the point of attachment of the segments; such wrinklings may easily suggest in a fossil specimen the original existence of a basal callosity. The venation may prove useful in determining certain species, but it is not very often that fossil specimens are sufficiently well preserved to admit of a complete diagnosis of the venation character. If, for example, we had neither the basal nor the apical portion of a pinna, it would be practically impossible to discriminate between some of the long narrow *Otozamites* pinnæ, and those of *Zamites* and other genera.

Nathorst's recently proposed genus *Zamiophyllum*, to which reference has already been made, was founded partly to include

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[1] Zittel (A.), p. 218.

[2] Fossil Botany, p. 88.

fronds of which the obliquely inclined pinnæ have a somewhat narrowed base. This decrease in breadth towards the point of attachment of a pinna is characteristic of numerous species of *Zamia*, *Ceratozamia*, and *Macrozamia*, and might well be included in a more extended definition of *Zamites*. The basal contraction of the segments is, as Nathorst points out, directly opposed to the accepted definitions of *Dioonites* and *Pterophyllum*; but there seems no good reason to regard such a feature as at variance with the genus *Zamites*. This name *Zamites* was proposed by Brongniart at a time when only two genera of living cycads had been recognized, *Cycas* and *Zamia*; and the present definition of the genus stamps it rather as a comprehensive and provisional designation for certain frond characters which are now shared by various members of the recent *Zamieæ*. If we retain *Zamites* as usually defined, or in a slightly modified form, it must be regarded merely as a convenient term to be applied to certain fossil fronds in which some of the characteristics of *Zamia*, *Macrozamia*, *Ceratozamia*, or even *Encephalartos* may be represented. In the recent *Zamia* the pinnæ are articulated to the rachis, and in many forms are readily detached, leaving a distinct circular or elliptical scar; this same character is also met with in other genera, such as *Ceratozamia*, *Encephalartos*, etc. The basal callosity often referred to as one of the important characteristics of *Zamites* is best seen in some forms of the genus *Macrozamia*, and the manner of insertion and position of the pinnæ on the rachis in species of *Zamites* find a parallel living in species of *Encephalartos*, *Ceratozamia*, *Macrozamia*, and *Zamia*.

The following general definition of *Zamites* may serve to indicate those characters which are most readily recognized in fossil fronds:—

Frond pinnate, pinnæ more or less obliquely inclined to the rachis and attached to the upper surface, apices acuminate and tapering, or obtusely rounded, the base may be abruptly rounded and marked with a callosity near the point of attachment, or the pinnæ may be slightly and gradually narrowed towards the base, margins entire; veins parallel, but slightly divergent in the apical portion of each pinna.

Such a definition is perhaps suggestive of a genus with characters expressed in too general terms, and not sufficiently limited, but a more complete examination of the different types of fossil leaves may possibly lead to the institution of other genera with more narrowly defined characters.

Zamites Buchianus[1] (Ett.).

[Pl. III. Figs. 1–5; Pl. IV.; Pl. VIII. A.]

1847. *Pterophyllum saxonicum*, Göppert, Nova Acta Ac. Cæs. Leop.-Car. vol. xxii. p. 362, pl. xxxviii. fig. 13.

1852. *Pterophyllum Buchianum*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 21, pl. i. fig. 1.

1856. ? *Dioonites Buchianus*, Bornemann, Organ. Rest. Lettenkohl. p. 57.

1867. *Pterophyllum saxonicum*, Ettingshausen, Sitz. k. Ak. Wiss. Wien. vol. lv. Abth. i. p. 11, pl. i. figs. 11 and 12.

1870. *Dioonites Buchianus*, Schimper, Trait. pal. vég. vol. ii. p. 149.

Dioonites saxonicus, Schimper, *ibid.* p. 211.

1871. *Zamites Göpperti*, Schenk, Palæontographica, vol. xix. p. 11, pl. iii. fig. 6.

1879–80. ? *Dioonites abietinus*, Hosius and von Marck, Palæontographica, vol. xxvi. p. 213, pl. xliv. fig. 199.

1889. *Dioonites Buchianus*, Fontaine, Potomac Flora, p. 182, pls. lxviii.–lxxiv.

Dioonites Buchianus var. *angustifolius*, Fontaine, *ibid.* p. 185, pls. lxvii., lxviii., and lxxi.

Dioonites Buchianus var. *obtusifolius*, Fontaine, *ibid.* p. 184, pl. clxviii. fig. 3.

1890. *Zamiophyllum Buchianum*, Nathorst, Denkschr. k. Ak. Wiss. Wien. vol. lvii. pp. 46 and 49, pl. ii. figs. 1 and 2; pl. iii.; pl. v. fig. 2.

Zamiophyllum Naumanni, Nathorst, *ibid.* p. 47, pl. v. fig. 1.

1894. *Zamiophyllum Buchianum*, Yokoyama, Journ. Coll. Sci. Japan, vol. vii. pt. iii. p. 223, pl. xx. fig. 1; pl. xxiii. fig. 6; pl. xxvii. fig. 5*a*, *b*; pl. xxviii. figs. 1 and 2.

Zamiophyllum Buchianum var. *angustifolia*, Yokoyama, *loc. cit.* p. 224, pl. xxii. fig. 4; pl. xxv. fig. 5; pl. xxviii. figs. 8 and 9.

Zamiophyllum Naumanni, *ibid.* p. 225, pl. xxii. fig. 3; pl. xxvi.

Type. Portion of frond. Collection of Herr Hohenegger, Teschen.[2] Ettingshausen defined the species as follows: "P. fronde pinnata, pinnis circa 1–2 dm. longis, 4–7 mm. latis, alternis, linearibus, subremotis, subangulo acuto adnatis, nervis creberrimis, tenuissimis instructis; rhachide crassiuscula."

The type specimen is described as the middle portion of a frond

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[1] Possibly *Zamites Milleri*, Zigno, may prove to be identical with this species (Zigno, Flor. foss. Oolit. vol. ii. p. 40, pl. xxx. fig. 6; Hugh Miller, Testimony of the Rocks, p. 434, fig. 136).

[2] Ettingshausen (A. 4), p. 32.

at least 3–4 ft. in length, and compared with *Pterophyllum Humboldti*, Dunk.; the latter species, however, appears to be a typical *Pterophyllum* species, and quite distinct generically from Ettingshausen's type. Schenk reproduces the figure given by Ettingshausen, and points out the fact that none of the pinna apices are shown in the specimens. Very probably we may regard *Zamites Göpperti*, Schenk, as *Z. Buchianus* (Ett.), seen from the lower surface; Schenk himself compared the former species with *Pterophyllum saxonicum*, Reich.,[1] from Niederschönen, and there seems good reason to follow Fontaine in including *P. saxonicum*, as figured by Ettingshausen, as synonymous with *Z. Buchianum*. Hosius and von Marck [2] have figured a small fragment of a frond, which they refer to *P. saxonicum*, but the specimen is too imperfect to admit of accurate identification. The same authors refer another specimen of cycadean frond to *Dioonites abietinus*, which shows a distinct resemblance to the smaller forms of *Zamites Buchianus* (*cf.* Hosius and Marck, pl. xliv. fig. 199, and Pl. III. Fig. 1 of the present volume), but perhaps the similarity is hardly sufficiently well marked to warrant the inclusion of the fossil in the synonym list of the present species, without the addition of a query. Some writers have preferred *Dioonites* to *Pterophyllum* for Ettingshausen's species; Schimper and Fontaine both adopt the former name. The Potomac flora has yielded numerous examples of fronds which Fontaine refers to *D. Buchianus*; he speaks of the species as "one of the most widely diffused and characteristic fossils of the Potomac flora." [3] This author institutes two varieties of Ettingshausen's species—*D. Buchianus*, var. *obtusifolius* and var. *angustifolius*. It might perhaps be advisable to adopt Fontaine's terms, and apply them to certain forms of the species represented in the numerous examples from the Wealden of Ecclesbourne, but there is the usual difficulty to be faced in drawing lines between one form and another. In looking at some specimens we find the pinna apices are very distinctly acutely tapered, and closely correspond with Fontaine's *D. Buchianus* var. *angustifolius*; but in such a frond as **V. 21737**, although on the whole the pinnæ are tapered, yet some of the segments terminate

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[1] Ettingshausen (A. 8), Sitz. k. Ak. Wiss. Wien. vol. lv. Abth. i. pl. i. figs. 11 and 12.

[2] (A. 1), Palæontographica, vol. xxvi. p. 213, pl. xliv. fig. 198.

[3] Potomac Flora, p. 182.

more obtusely, and lead us to specimens, such as **V. 2227**, in which we have no longer the form characterized by gradually tapered and pointed pinnæ. A similar variation in the apices and in the breadth of the pinnæ is pointed out by Yokoyama[1] in the Japanese examples. The frond figured by Göppert as *Pterophyllum Carnallianum*[2] shows a certain resemblance to some of the forms of the present species. Heer[3] has compared the present species with *Zamia globuliferus*, Heer, from the Kome beds of Greenland. Reference has already been made to Nathorst's substitution of the new genus *Zamiophyllum* for Miquel's name *Dioonites*. He points out that the species is from Urgonian strata, and not of Wealden age as Ettingshausen erroneously states. In referring to the basally narrowed pinnæ in the Japanese examples, Nathorst notes that the character is not apparent in the European specimens; we still find, however, in the examples described from the Rufford Collection abundant proof of this narrowing of the segments. The largest pinna mentioned by this author has a length of 260 mm. and a breadth of 4–6 mm.; in a pinna which is 3·5 mm. broad there are 12 veins, in one with a breadth of 6 mm. 17 veins, and 22 veins in pinnæ 8 mm. broad. Nathorst compares *Z. Buchianus* with the recent cycad *Zamia media*, Jacq. In describing a second Japanese form, which he refers to another species, *Z. Naumanni*, he expresses the opinion that it may possibly represent the lower part of a frond of *Z. Buchianus*[4]; it is compared with *Zamites Schenkii*, Schimp. (=*Z. Göpperti*, Schenk), from the Wernsdorf beds. Yokoyama also figures under Nathorst's species *Z. Naumanni* (pl. xxii. fig. 3, and pl. xxvi.) a portion of a frond with pinnæ having a breadth up to 20 mm., but suggests that it may be specifically identical with *Z. Buchianus*.

The English examples clearly demonstrate that the pinnæ are attached to the surface of the rachis, and not laterally as Nathorst inferred from his less perfect material. *Z. Naumanni*, Nath., is in all probability identical with *Z. Buchianus*; the specimens of the former figured by Nathorst seem in some cases, *e.g.* pl. iii. and pl. v. fig. 1, to show a surface attachment of the pinnæ.

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[1] Yokoyama, p. 223.

[2] (1), pl. i. fig. 4.

[3] (A. 3), Fl. foss. Arct. vol. vi. pt. i. p. 12, pl. i.

[4] (A. 3), Denkschr. k. Ak. Wiss. vol. lvii. p. 47.

In the specimen represented in pl. v. fig. 1 of Nathorst, there appear to be two elliptical scars about the middle of the frond fragment; these agree very closely with similar scars in several of the Rufford examples, and represent the points of detachment of pinnæ. The abundant examples in the National Collection enable us to extend and modify the existing definition of the species. Among recent species *Ceratozamia mexicana*, Brong., *Zamia cycadifolia*, Jacq., *Macrozamia Macleayi*, Miq., and *Encephalartos Lehmanni*, Lehm., may be mentioned as possessing fronds very similar in form to those of *Z. Buchianus* (Ett.).

We may define the species as follows :—

Frond large, pinnate; rachis longitudinally striated, with a fairly broad median groove on the upper surface. Pinnæ alternate, opposite or subopposite, varying in length from 3–4 cm. to 20 cm., and in breadth from 1·5 to 2 mm., attached obliquely to the rachis, and slightly thickened and somewhat broadened at the actual point of insertion; separated from the rachis by a distinct absciss line, leaving an elliptical scar; generally narrowed towards the base, but in the narrower pinnæ this reduction in breadth decreases and is not nearly so evident; usually inclined at about 45° to the rachis, they may be almost at right angles to the frond axis, and in the case of young fronds and the apical portions of larger ones, the pinnæ are attached at a much more acute angle. The distance between the pinnæ varies considerably in different parts of the same leaf, and in leaves of different ages; apices generally tapering to a point, or more or less obtusely rounded. Veins numerous, parallel, and as a rule not very prominent.

V. 2120. Pl. VIII.[1] Fig. 1 and Pl. III. Fig. 5. This splendid specimen has a length of 77·5 cm.; broken at one point, and somewhat displaced laterally. Breadth of pinnæ varies from 2 to 9 mm. Attachment of the pinnæ not shown in this example. The broader and lower pinnæ appear to taper towards the rachis more than in many specimens. Tips of some of the pinnæ clearly seen, as in Pl. III. Fig. 5; these agree very closely with the apices of pinnæ in **V. 2123** (Pl. III. Fig. 3). Certain parts of this frond agree exactly with **V. 2925**, etc. The apical portion appears to be identical with *Dioonites Buchianus* var. *angustifolia*, as figured by Fontaine in his pl. lxx. fig. 2.[2] The lower portion

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[1] Represented in Pl. VIII. $\frac{1}{6}$ nat. size.

[2] Potomac Flora.

corresponds to that of **V. 2123**a, etc. Veins numerous, but not well marked. Towards the upper end of the rachis there are elliptical scars marking the original places of insertion of detached segments. If **V. 2120** and **V. 2898** be compared, the most striking difference seems to be the less tapered and narrowed bases of the pinnæ in the latter specimen. Ecclesbourne. *Rufford Coll.*

V. 2227. Pl. III. Fig. 4. Large specimen, with unusually broad pinnæ; length of rachis 38 cm., width 1·2 cm. The oblique attachment of the segments distinctly shown, also the nature of the base and the position of the pinnæ on the axis. Surface of the rachis marked with longitudinal striæ; about 1 mm. from each margin of the rachis there is a distinct longitudinally running line. Pinnæ long, narrow, and slightly curved; one row attached obliquely by tapering bases to the upper surface of the frond axis, alternate in position. In the lower part of the frond the pinnæ have a length of about 19 cm., and a breadth of 1·3 cm.; their distal ends are bluntly acuminate, as shown in Pl. III. Fig. 4. Very little, if any, indication of a basal callosity on the segments. There is only a slight difference in size between the upper and lower pinnæ. *Cf.* **V. 2820.** Ecclesbourne. *Rufford Coll.*

V. 2820. A very similar specimen. Rachis 29 cm. long; the longest pinna between 17 and 18 cm. in length and 1 cm. broad. Towards the upper end of the frond the pinnæ are about 10 or 11 cm. long; the apices are not shown, and therefore the actual length can only be approximately measured; breadth of these pinnæ about 8 mm. Ecclesbourne. *Rufford Coll.*

V. 2125*a*. Rachis 21 cm. long. The upper portion closely resembles *Dioonites abietinus* as figured by Hosius and von Marck. Ecclesbourne. *Rufford Coll.*

V. 2128. Portion of a rachis of a large frond; the bases of detached pinnæ well preserved, also traces of scars on the rachis. Ecclesbourne. *Rufford Coll.*

V. 2363. Pl. III. Fig. 2. The chief feature in this specimen is the very distinctly and gradually tapering terminations of the few pinnæ which are preserved. Compare the apex of one of these pinnæ, with those of the two shown in Pl. III. Fig. 5

(**V. 2120**), and the less pointed form of **V. 2123***c* (Pl. III. Fig. 3). Ecclesbourne. *Rufford Coll.*

V. 2123*c*. Pl. III. Fig. 3. At the upper end of the specimen there is part of a rachis with five pinnæ attached; the rest of the slab shows several imperfect pinnæ with gradually tapered tips; the tips seem to be intermediate in form between those of **V. 2227** (Pl. III. Fig. 4) and **V. 2363** (Pl. III. Fig. 2), **V. 2123**, etc. Ecclesbourne. *Rufford Coll.*

V. 2125*b*. Pl. IV. Fig. 1. A young frond, 25 cm. long; *cf.* **V. 2123***b*, etc. Pinnæ approximate, very gradually tapering distally. The pinnæ are broadest in the middle of the specimen, and narrower towards either end; at the lower end the pinnæ are narrower and less closely arranged, agreeing with those of **V. 2262** (Pl. III. Fig. 1). Compare also **V. 2898** and Fontaine's pl. lxxi. fig. 2. Ecclesbourne. *Rufford Coll.*

V. 2125*c*. Pl. IV. Fig. 2. Rachis 33 cm. long. Pinnæ alternate and opposite, rachis depressed, the points of attachment of segments clearly shown, apical portions not preserved; broadest pinna 7 mm., narrowest 5 mm. Venation distinct. *Cf.* **V. 2123***a*, **V. 2125***a*, etc. Ecclesbourne. *Rufford Coll.*

V. 2123*a*. Pl. IV. Figs. 4 and 5. 35 cm. long. Rachis well shown, the longitudinal irregular striations distinct; these probably indicate strands of hypodermal sclerenchymatous tissue. Tips of pinnæ not seen, but bases very distinct; in Figs. 4 and 5 the surface and oblique insertion is easily recognized, also in some pinnæ the very slightly broadened base. In the lower part of the frond the pinnæ are nearly at right angles to the rachis, but more oblique towards the upper end. Veins numerous and fine, and in many pinnæ clearly shown. Ecclesbourne. *Rufford Coll.*

V. 2925. Pl. IV. Fig. 3. Specimen very similar to **V. 2125***a*; but pinnæ farther apart, and in this respect identical with the lower portion of **V. 2123***a*. In addition to the larger example, there is a very small fragment on one side of the slab, which is evidently the tip of a frond (Pl. IV. Fig. 3); in this the segments are closer together and more oblique to the rachis than in **V. 2125***b*, and more like **V. 2123***b* and **V. 2125***b*. Ecclesbourne. *Rufford Coll.*

V. 2262. (Pl. III. Fig. 1.) This agrees fairly closely with *Dioonites abietinus* (Göpp.) as figured by Hosius and von Marck[1]; probably their specimen is not a true example of Göppert's species. Small piece of rachis with long and narrow pinnæ; mode of insertion well seen. *Cf.* **2125*b***; breadth of pinnæ about the same, but in the present specimen the segments are farther apart and more spreading; this difference, however, only applies to the upper three-fourths of **2125*b***; in the lower fourth it is practically identical with **V. 2262**. This and some other specimens appear to be identical with *D. Buchianus* var. *angustifolia* as figured in the *Potomac Flora*, and with some of Yokoyama's specimens, *e.g.* pl. xxii. fig. 4, pl. xxv. fig. 5, and pl. xxviii. figs. 8 and 9.[2] *Cf.* **V. 2898**, **V. 1069**, and the upper part of **2125*a***. Longest pinna 7·5 cm., and 3 mm. broad. Ecclesbourne. *Rufford Coll.*

V. 720. Two specimens. Fragments of a young frond; pinnæ very obliquely set and approximate. Hastings. *Dawson Coll.*

V. 1069. Small specimen, probably the lower part of a frond, the pinnæ being much narrower in the lower than in the upper portion; manner of attachment of segments distinct. *Cf.* **V. 2262**, **V. 2125*a***, **V. 2123*b***, etc. Ecclesbourne. *Rufford Coll.*

V. 2123. Very imperfect example. Bases of several pinnæ show clearly the manner of attachment to the rachis; at the base of some of the pinnæ a wrinkled appearance suggests the existence of a callosity. There is not quite the same gradual narrowing of the pinnæ towards the frond axis as in **V. 2227** and many other specimens. Pinnæ long, and tapered to an acuminate tip, as in **V. 2363** (Pl. III. Fig. 2), etc.

V. 2123*b*. Rachis about 27 cm. long; pinnæ 4 mm. broad, alternate and approximate. *Cf.* **V. 2898**. The lower part of this specimen appears to be identical with the upper portion of **V. 2125**, also with **V. 720**. Evidently a young frond.

V. 2123*d*. Part of a single pinnæ, showing sharply pointed apex; venation not distinct. Ecclesbourne. *Rufford Coll.*

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[1] (A. 1), Palæontographica, vol. xxvi. pl. xliv. fig. 199.

[2] Yokoyama, *loc. cit.*

V. 2125. Rachis 19 cm. in length. Longest pinna 12 cm., gradually tapering towards the tip, which is not present. The long, narrow, and tapering segments of this specimen are exactly the same as those in the smaller examples, **V. 2262** and **V. 1069.** *Cf.* Fontaine,[1] pl. lxxiv. figs. 1–3, etc. Ecclesbourne.

Rufford Coll.

V. 2373*a*. Broad rachis, 1·2 mm. at the lowest end, but obviously flattened. Groove in the middle, and on each side of the groove there are two elliptical scars marking the places to which segments were attached; some of the segments appear to have a basal callosity; pinnæ opposite or subopposite. *Cf.* Nathorst's figure (Pl. V. Fig. 1*a*)[2] of the rachis of what he calls *Z. Naumanni.* Ecclesbourne. *Rufford Coll.*

V. 2698. Very large specimen, but the details not well preserved. Rachis 43 cm. long; pinnæ of the gradually tapered form, as in **V. 2363**, etc. The upper portion the same as **V. 2898**, **V. 2125*b***, etc. Breadth of uppermost pinna 1·5–2 mm.; that of the lowest 1 cm. This appears to be a frond seen from the lower surface, the pinnæ being, therefore, apparently laterally attached to the rachis. Ecclesbourne. *Rufford Coll.*

V. 2898. A fine example of what is probably a partially expanded frond. Rachis about 20 cm. long. Some pinnæ about 14 cm. in length and 3–4 mm. broad; towards the tip the pinnæ are crowded and imbricate, with a width of about 3 mm.; towards the base 6 mm. broad. Sussex. *Beckles Coll.*

Cf. the tip of this and **V. 2120**, **V. 2125*b***, etc. **V. 3153**, **V. 3154**, **V. 3156**, and **V. 3157.** Other specimens of this species. Ecclesbourne. *Rufford Coll.*

Zamites Carruthersi, sp. nov.

[Pl. VI. Figs. 2–4.]

Type. Portions of fronds. British Museum.

Frond pinnate; rachis longitudinally striate; pinnæ alternate, attached by an oblique base to the outer part of the upper surface of the axis, almost at right angles to the rachis in a fully

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[1] Fontaine, Potomac Flora.

[2] Denkschr. k. Ak. Wiss. vol. lvii.

developed frond, linear or linear-elliptical, somewhat abruptly narrowed towards the base, but slightly broadened at the actual base of attachment, separate from the rachis by a well-marked articulation. Veins divergent from the base, but for the most part parallel, and diverging at the tip of the segments, which is bluntly rounded.

In the examination of the fossil fronds in the National Collection, and the comparison of them with the leaves of existing species, I have often been struck with the close correspondence between certain forms of Wealden fronds and species of the genus *Encephalartos*. An inspection of a thoroughly representative collection of the different forms of *Encephalartos* fronds, such as are to be found in the exceptionally good collection of living and herbarium specimens at the Royal Gardens, Kew, tends to very considerably widen one's conception as to the characters of this recent genus of cycads. The species generally met with in collections are those in which the pinnæ are broad and more or less spiny; but the genus includes various other forms with pinnæ of quite a different form, which often bear a striking resemblance to various fossil fronds. As examples of the diversity of leaf form to be met with in this genus, the few following species may be cited as representatives of some of the forms assumed: *E. Caffer*, Miq., with its stout oval pinnæ, with or without marginal teeth, *E. pungens*, Lehm., with long, narrow, and acuminately terminated segments, *E. cycadifolius*, Lehm., and *E. Ghellinckii*, Lem. (Pl. XIII. Figs. 3–5), characterized by the long and narrow pinnæ, which form a striking contrast to the broader and better known segments of *E. horridus*, Lehm., and other species. Some of the species, *e.g. E. Lehmanni*, Lehm., *E. cycadifolius*, Lehm., and others have a close resemblance to some species of *Ceratozamia* and *Zamia*.

In the introductory remarks mention was made of the institution by Fontaine of a new genus, *Encephalartopsis*, for certain isolated pinnæ from the Potomac beds of North America; and such a genus might serve a useful purpose if founded on more satisfactory material, but as at present defined it can have but little value. Possibly the institution of such a genus, with a wide and modified definition, might prove a valuable addition to our list of fossil genera, but for the present it will perhaps be better to fall back on the old and comprehensive *Zamites*. I have ventured to connect the name of Mr. Carruthers with the present species of cycadean frond, as a slight recognition of his valuable contributions to our knowledge of the fossil *Cycadaceæ*.

Some of the large detached pinnæ figured by Fontaine as examples of his new species *Zamites tenuinervis*, agree fairly closely with those of the present form, but in the Potomac plant the venation appears to be coarser, and the bases of the segments usually "abruptly subcordate"; in the pinna shown in Fontaine's pl. lxxvi. fig. 7 the base seems much more like that in the English specimen. The paucity and imperfect character of the Potomac material, and the differences already alluded to, hardly warrant the adoption of Fontaine's name for the English forms. There is a close resemblance between the present specimens and some of those referred to *Z. Buchianus*, *e.g.* **V. 2123**, but in the latter species the longer and more gradually tapering pinnæ are sufficiently characteristic to distinguish the two forms. Among recent cycads, *Encephalartos longifolius*, Lehm., is one of those which resemble very closely in habit the fronds of *Z. Carruthersi*. As examples of other fossil fronds to be compared with this species, *Zamites affinis*, Schenk,[1] and *Palæozamia recta*, Tate,[2] may be mentioned.

V. 2123*d*. Pl. VI. Fig. 4.

In this specimen the manner of attachment of the pinnæ is clearly shown; the line of separation being particularly distinct at the base of the middle pinna of the portion of frond represented in Fig. 4, Pl. VI. Rachis at least 1 cm. broad, and marked with fine longitudinal lines. Venation very distinct, as in **V. 2123*c***. Only a portion of the specimen shown in the figure; rachis 21 cm. long. Ecclesbourne. *Rufford Coll.*

V. 2123*c*. Pl. VI. Figs. 2 and 3.

The pinnæ are very like those with blunt apices which have been included in *Z. Buchianus* (*e.g.* **V. 2227**), but in the present specimen the base and manner of attachment of the pinnæ constitute the special features. The form of base clearly seen in Fig. 3, and the blunt apex with the slightly divergent veins in Fig. 2. Rachis in this specimen 13 cm. in length, with portions of nine pinnæ on one side. Ecclesbourne. *Rufford Coll.*

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[1] Palæontographica, vol. xix. pl. iii. fig. 6.

[2] Tate (A.), Quart. Journ. Geol. Soc. vol. xxiii. pl. v.

The specimens referred to as *Otozamites Klipsteinii* var. *longifolia* should be compared with *Zamites Carruthersi*; *e.g.* **V. 2123***a*, **V. 2122**, and **V. 2122***b*; but in those and similar specimens the pinnæ have a more or less distinctly auriculate base. **V. 2123***b*. Single pinna. *Cf.* **V. 2123***d*. Ecclesbourne. *Rufford Coll.*

Specimens of Doubtful Position.

V. 2742. Pl. VI. Fig. 1. This may perhaps be the terminal portion of a frond of *Z. Carruthersi*, or possibly of *Otozamites Klipsteinii* var. *longifolia*, but it is very difficult to feel any great confidence in placing it in such a position. Ecclesbourne.

Rufford Coll.

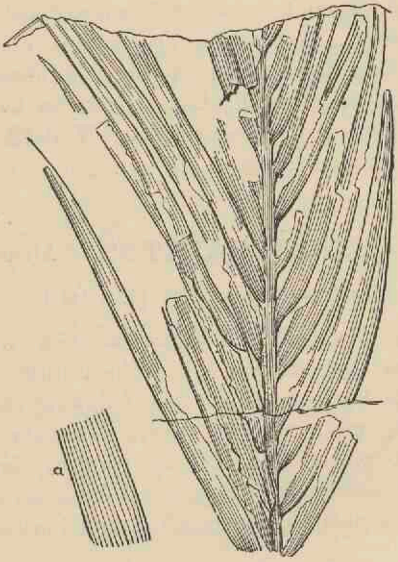

FIG. 5.—? *Zamites* sp. (V. 2744). ½ nat. size.

V. 2744. Fig. 5. This specimen and **V. 2743***a* suggest portions of a frond very similar to *Ctenis falcata*, L. and H., but no indication of anastomosing veins has been detected in the pinnæ of these Wealden examples. The portion of frond shown has a length of 13·5 cm.; one of the broadest pinnæ is 7 mm. in breadth, and is traversed by about ten veins (Fig. 5*a*). To some extent the specimen reminds one, as regards general habit, of

Zamites Buchianus, but the venation and decurrent pinnæ are distinctive features in the former, and the pinnæ are more oblique than in Ettingshausen's species. Ecclesbourne.
Rufford Coll.

V. 2275. Another terminal piece of frond, agreeing closely with **V. 2743**, and very possibly the same species, but the specimen shows no details, being merely a brown stain on the surface of a coarse grit. It is possible that these two specimens may belong to the terminal portion of a frond of which the older and larger segments are shown in Pl. VII. Figs. 1, 4, and 6 (**V. 2122**, **V. 2126***a*). Ecclesbourne. *Rufford Coll.*

V. 2743*a*. In some respects not unlike Nathorst's figure of *Zamiophyllum Naumanni*, a species of Japanese frond now referred to *Zamites Buchianus*. The present specimen is in all probability part of a frond seen from the under side. Cf. *Ctenophyllum latifolium*, Font., a plant which Fontaine[1] refers for no very obvious reason to Schimper's genus *Ctenophyllum*. **V. 3183.** Fragment of the same form. Ecclesbourne. *Rufford Coll.*

Genus **ANOMOZAMITES**, Schimper.

[Trait. pal. vég. vol. ii. 1870, p. 140.]

In discussing the genus *Nilssonia* mention was made of Schimper's genus *Anomozamites*, which he instituted for certain *Pterophyllum*-like leaves possessing the following characteristics: "Folia speciosa, mediocria, vel parva, elongata-oblonga vel elongato-linealia, pinnatisecta, hic illic (juniora) integra, nervis rhachi perpendicularibus, parallelis, simplicibus vel e basi dichotomis; pinnis inæqualibus, rectangulis, membranaceis vel tenuicoriaceis."

No mention is made in this definition of the place of insertion of the segments, whether lateral or on the upper surface of the leaf axis. Nathorst has since given special prominence to the manner of attachment of the segments as the chief distinguishing character between the present genus and *Nilssonia*;[2] the same author has also instituted a new genus for the reception of

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[1] Potomac Flora, p. 175, pl. lxviii. figs. 2 and 3.

[2] See *ante*, p. 52.

Anomozamites-like leaves with dichotomizing veins. We must, then, somewhat modify Schimper's original diagnosis, and the following may be adopted as a rough definition of this provisional genus *Anomozamites*; it is a slightly altered version of that in Zittel's *Handbuch*.[1]

Frond comparatively small, linear or tongue-shaped, and usually divided into segments which present a more or less obvious difference in size, separate or confluent at the base, attached laterally to the rachis, and never entirely covering the upper face of the frond axis; the segments bluntly rounded or truncate distally; veins simple and parallel, generally at right angles to the rachis.

The examples of this genus possess, as a rule, a characteristic habit which marks them off from the pinnate fronds of *Pterophyllum* with their equal and longer segments. It is difficult in some cases to distinguish between the genera *Anomozamites* and *Nilssonia*. In the former the segments are sometimes attached to the rachis in such a manner as to suggest the surface insertion of *Nilssonia*, but there is always some part of the frond axis exposed to view, whereas in *Nilssonia* the lamina appears to be continuous from one side to the other. It is not easy in the present instance to decide whether the genus *Pterophyllum* or *Anomozamites* is the more suitable; both are purely provisional genera, and it is not a matter of very great importance which term is adopted.

Anomozamites Lyellianus (Dunk.).

[Fig. 6.]

1846. *Pterophyllum Lyellianum*, Dunker, Wealdenbildung, p. 14, pl. vi. figs. 1 and 2.
1848. *Pterophyllum Lyellianum*, Bronn, Index. pal. nomencl. p. 1056.
1849. *Zamites Lyellianus*, Brongniart, Tableau, p. 107.
1850. *Pterophyllum Lyellianum*, Unger, Gen. spec. plant. foss. p. 290.
1851. *Dioonites Lyellianus*, Miquel, Tijdsch. Wis. nat. Wet. iv. p. 205.
1852. *Pterophyllum Lyellianum*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 22.
1856. *Dioonites Lyellianus*, Bornemann, Organ. Rest. Lettenkohl. p. 56.
1870. *Pterophyllum Lyellianum*, Schimper, Trait. pal. vég. vol. ii. p. 137.
1871. *Pterophyllum Lyellianum*, Schenk, Palæontographica, vol. xix. p. 230, pl. xxxiv. figs. 1 and 2.

[1] p. 224.

Type. Large specimens of frond. Berlin Museum.

Dunker thus defines the species in his *Wealdenbildung*:—

"Pterophyllum fronde pinnata, pectiniformi, pinnis oppositis linearibus æque distantibus, approximatis basi fere confluentibus, apice obtusis, angulo recto adnatis, nervis iv. vel v. tenerrimis, rhachi plana subsulcata."

The figure of Dunker's type specimen is very much more suggestive of the genus *Pterophyllum*, than are the drawings given by Schenk, or that of the solitary specimen in the Rufford Collection. Probably the original specimen is part of a frond seen from the under surface, thus showing a particularly prominent rachis. It may be that the English fossil should be placed in a new species, but the apparent differences which distinguish it from Dunker's specimen may be merely such as are the result of a more fully developed condition of frond in the latter case. Possibly *Zamites æqualis*, Dunk.,[1] should be included in this species. Schenk's figure agrees more closely with the English specimen: this author speaks of the segment as being attached to the upper surface of the rachis, and not laterally inserted; if this were really the case, the genus *Pterophyllum* as usually defined would be inapplicable. Schenk's example does not show the rachis sufficiently clearly to definitely settle this point, but in all probability, as in our specimen, there is a narrow line of axis separating the two rows of segments. A close inspection of Schenk's figure enables us to detect certain slight differences in the breadth of the pinnæ, similar to those in the Ecclesbourne specimen. It must be remarked, however, that there is very little difference in the breadth of the several segments. There is a striking agreement as regards general appearance and arrangement of the segments, between the Wealden specimen and the Jurassic species *Anomozamites Nilssoni*. Lindley and Hutton[2] figured this plant as *Pterophyllum Nilssoni* (Phill.): from their figure it is not easy to decide between *Nilssonia* or *Anomozamites* as the most suitable genus, but an examination of several specimens of this species from the Yorkshire coast, shows very clearly the characteristics of the latter genus. There are several examples of this form in

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[1] Wealdenbildung, pl. vi. fig. 3.

[2] Lindley and Hutton (A.), Fossil Flora, vol. i. pl. lxvii. fig. 2.

the Leckenby Collection, which have been examined by Nathorst and referred by him to *Anomozamites.*

In addition to the single specimen of *Anomozamites Lyellianus* in the British Museum, there is a somewhat larger example in the Museum of Practical Geology, Jermyn Street. In this latter specimen the pinnæ are broader and have a more open arrangement. The lateral attachment is very clearly shown, and the four or five veins in each segment are distinctly marked. Here and there may be noticed slight differences in the breadth of the segments, which are arranged alternately towards the upper and lower ends of the specimen, but in a few cases the pinnæ are opposite. The Jermyn Street specimen is from the Wealden of Ore near Hastings.

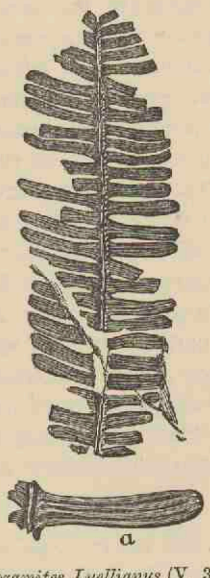

Fig. 6.—*Anomozamites Lyellianus* (V. 3251). Nat. size.

V. 3251. Fig. 6.

Probably a young leaf, showing clearly a gradual diminution in the length of the segments towards either end of the rachis. Manner of attachment and venations of the pinnæ clearly preserved; each segment appears to have four or five simple, parallel, and distinctly marked veins as shown in Fig. 6*a*. The segments appear to be much thicker than in the similar Jurassic form *A. Nilssoni*, and their breadth is much more uniform than in the latter species.

A species of a somewhat analogous habit has recently been described by Fontaine under the name of *Zamites Montanensis* from the Montana Coal-field.[1] Ecclesbourne. *Rufford Coll.*

Genus **CYCADOLEPIS**, Saporta.

[Pal. Franç. sér. ii. végétaux, vol. ii. 1875, p. 200.]

In 1875 Saporta proposed the term *Cycadolepis* as a convenient generic designation for detached bud scales of cycadean fronds. He defined it as follows: "Squamæ coriaceæ basi dilatatæ loco insertionis crassæ facie interiori plus minusve concavæ nudæque, facie autem dorsali convexiusculæ, sursum elongatæ lanceolato-acuminatæ, extus ad utrumque latus tomento piloso donatæ."

A small number of fronds have been recorded in which larger or smaller basal scaly structures are preserved; as a few examples of such, we have *Zamites gigas*, Morr., as figured by Saporta,[2] *Podozamites distans*, Presl,[3] *Otozamites* sp.,[4] *Podozamites lanceolatus minor*, Schenk,[5] etc. Among recent cycads we have, in addition to the ordinary pinnate fronds, various forms of smaller scale leaves; the latter are particularly well seen in *Cycas*, where an old stem shows a clearly marked alternation of the persistent basal portions of fronds alternating with the bases of scale leaves. These scale leaves are true leaf structures, in which the green assimilating portion of the phyllopodium has not been developed.

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[1] (A. 3), Proc. U.S. Nat. Mus. vol. xv. p. 494, pl. lxxxiv. fig. 4. Fontaine omits to mention that Dawson has described a fragment of cycadean frond from the Kootanie series of the Rocky Mountains as a new species, *Zamites Montana*, a name dangerously near to *Z. Montanensis* (see Dawson, Trans. Roy. Soc. Canada, 1885, section iv. p. 7, pl. i. fig. 6).

[2] *Loc. cit.* pl. lxxxi. fig. 1.

[3] *Ibid.* pl. lxxvi. fig. 2.

[4] *Ibid.* pl. lxxvi. figs. 3 and 4 [see also Zigno (A.), Flor. foss. Oolit. vol. ii. pls. xxxv. and xxxvi.].

[5] Nathorst (A. 1), Flor. Bjuf, i. pl. xvi. fig. 10.

In the genus *Ceratozamia* the expanded base of a frond shows two lateral stipule-like appendages, and these are also found in the same position on the margin of the smaller scale leaves.[1] In some forms of *Macrozamia*, the surface of an old stem is entirely enclosed in a thick armour of large persistent petiole bases without any accompanying scales. Many recent cycadean stems appear to be covered by numerous scale-like structures of identical form; it is by no means an easy task in many cases to distinguish between the bases of true fronds and those of scale leaves, even where both forms of leaf are present. The variation in form and size exhibited by the scale leaves of recent species, sufficiently demonstrates the futility of attempting any exact generic or specific discrimination in the case of the isolated fossil examples. It is true we have in *Dioon* and *Cycas* fairly characteristic lanceolate scales, often clothed in a dense woolly covering; but a close inspection of a tall stem of the latter genus reveals a marked difference in the scale leaves towards the apex of the stem, and those in the older portions, where there are only the persistent broad bases adhering to the plant stem. In dealing with fossil scale leaves it will probably be wise to extend the definitions of Saporta's genus and to include in it not merely the "elongate lanceolate-acuminate" forms of bud scales, but also other forms of true scale leaves, as well as those structures which may be regarded as the persistent bases of petioles. This genus, used in a much more comprehensive sense, should afford a convenient means of grouping together those detached leaf structures, which frequently cannot be definitely referred to any particular genus or species. Such isolated plant members, in themselves, perhaps, of little value, are worthy of record as contributions to the material from which to build up a more complete history of fossil cycadean plants. Some of the numerous scales in the Rufford Collection may, indeed, be referred to certain forms of stems, and no doubt as our material is increased others may be recognized as portions of some well-defined genus or species of cycad.

In the male and female flowers of some recent species the detached scales bear a close resemblance to the sterile leaf structures of the stem; it will be well, therefore, to include

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[1] Engler and Prantl, *Cycadaceæ*, p. 7.

in the genus *Cycadolepis* such scale leaves as afford no clear proof of their carpellary or antheriferous nature. As an example of such a resemblance, it may be noted that some of the smaller examples of the Ecclesbourne scales present a distinct agreement in shape and size with the detached carpellary scales of such a form as *Macrozamia Dyeri*. Similarly the isolated leaves of the "bulbils"[1] of *Cycas* and other genera, erroneously compared by some with the inflorescences known as *Bennettites* and *Williamsonia*, should be included under this comprehensive genus; also the narrow lanceolate-acuminate and short broad leaves of the two latter genera.

The only forms included by Saporta in *Cycadolepis*, e.g. *C. villosa* and *C. hirta*,[2] are narrow leaf-like structures similar to the scales of *Dioon* or *Cycas*. Fliche and Bleicher[3] have adopted Saporta's name for a very imperfect fragment which seems to be practically indeterminable. We may, perhaps, as a matter of convenience, and to avoid the obvious danger and inexpediency of instituting several more or less meaningless specific names, arrange the various detached scales under two main heads, basing the distinction of the two sections on the general form of the scales.

Cycadolepis.

Scale-like leaf structures of cycadean plants, varying considerably in form and including detached petiolar bases, bud scales, etc., also isolated carpellary or antheriferous scales which exhibit no trace of ovules or pollen-sacs.

1.—*Cycadolepis* (*Dory*[4]-*Cycadolepis*). Scales of a more or less linear-lanceolate form, broadest at the base and tapering gradually towards the apex.

2.—*C.* (*Eury*[5]-*Cycadolepis*). Broadly oval or orbicular scales, with the broadest portion frequently nearer the distal than proximal end; thick and fibrous structures.

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[1] Miquel (1), p. 7, pl. ii. figs. I and J.

[2] Saporta, *loc. cit.* pp. 201, 202, pl. cxiv. figs. 4–6.

[3] (A.), Bull. Soc. Sci. Nancy [2], vol. v. figs. 9–11, p. 76.

[4] *δόρυ* = spear.

[5] *εὐρὺς* = broad.

1.—Dory-Cycadolepis.

The forms included in this section of *Cycadolepis* are practically such as Saporta describes in his diagnosis of the genus. Saporta's examples are regarded as distinct species, but it is surely unnecessary to institute elaborate specific definitions for such isolated structures, and especially as the so-called species bear a distinct resemblance to one another. Both forms are from the Lower Kimmeridgian of the province Ain. *C. villosa* is compared with the scales of *Stangeria*, and *C. hirta* with those of *Cycas* and *Dioon*. It is by no means unlikely that both may belong to *Williamsonia*; similar scales figured by Fontaine in a specimen of *Williamsonia virginiensis*, Font.,[1] from the Potomac beds, and some of the Wealden *Williamsonia* scales both present a strong likeness to the French specimens, and suggest the possibility of generic identity. A specimen in the Rufford Collection (**V. 2830**), consisting of a collection of narrow acuminate hairy scales, which is probably part of a cycadean stem, shows some scales very similar to *C. hirta*, Sap. Feistmantel has figured a specimen of what he calls *C. pilosa*[2] from the Gondwana flora of India which agrees very closely with Saporta's examples, also with the leaves of *W. virginiensis*, Font. The same author figures another form as *Cycadolepis*,[3] which may perhaps be regarded as a cycadean scale. The specimen figured by Nathorst as *Cycadospadix integer angustior*, Nath.,[4] suggests a form which might be included in the present section of *Dory-Cycadolepis*.

V. 2802. Single leaf; linear-lanceolate in form; 7·5 cm. long, 9 mm. broad, delicate hairs on each margin. Appears to be identical with Saporta's "species" *C. villosa*. Compare **V. 2129**, in which there are several similar scales aggregated together. Very likely this specimen may be a detached leaf of *Williamsonia*. Further reference will be made to this form of scale in the descriptions of cycadean stems and some of the specimens of *Bennettites* (*Williamsonia*). Ecclesbourne. *Rufford Coll.*

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[1] Potomac Flora, pl. cxxxiii. figs. 6 and 7.

[2] Foss. Fl. Gond. vol. ii. pl. vii. fig. 5.

[3] *Ibid.* vol. i. pt. iv. pl. xiv. figs. 10–12.

[4] Nathorst, *loc. cit.* pl. xviii. fig. 6.

V. 2129*. A scale or possibly petiole base with numerous hair-like appendages; similar to **V. 2802**. *Cf.* also *Cycadolepis hirta*, Sap., and the *Otozamites* petiole of Pl. II. Fig. 4 of the present volume. **V. 2927**. Part of another woolly or hairy scale. Ecclesbourne. *Rufford Coll.*

2.—Eury-Cycadolepis.

In this section are included several detached scales varying in shape from an almost orbicular or somewhat pentagonal form, such as **V. 2699**, represented in Pl. VI. Fig. 6, to the larger and longer type as shown in Pl. V. Fig. 2. So far as I have been able to discover, these forms have not been previously figured; there cannot be much doubt as to their original connection with some form of cycadean stem, and indeed some of the specimens are identical with the stout curved scales on such stems as those of *Fittonia*. In some cases the scales occur in very close association with stems, but in none are they found actually in place. For the present, at any rate, it is better to describe some of the more characteristic forms, and to include them all under *Cycadolepis*, suggesting at the same time the very probable and indeed almost certain identity of some with the scales of *Fittonia* and other forms of stems. Hosius and von Marck have described a specimen from the Gault of Ahaus (Westphalia), which they regard as probably made up of a few large petiole bases belonging to some form of cycadean stem. One of these "petiole bases" has a length of 11 cm., a breadth of 4·7 cm., and is 4 cm. in thickness. The generic name *Megalozamia* is proposed for this doubtful fossil, and the following definition is given by these authors: "Rhachidum basibus incrassatis carnosis falciformibus, costis quatuor longitudinalibus præditis; costis marginalibus acutioribus, costa et dorsali et ventrali obtusiori."[1] Structures such as this diagnosis describes would be legitimately included in the genus *Cycadolepis*, used in the more comprehensive sense as suggested above.

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[1] (A. 1), Palæontographica, vol. xxvi. p. 203, pl. xliii. figs. 181–183.

V. 2929. Pl. V. Fig. 2.

The figure of this large example shows very well the general appearance of the longer forms; the surface shown in the drawing is strongly convex, and at the distal end somewhat suddenly incurved. Some of the dark curved lines seen in the figure are irregularly placed grooves suggesting the tracks of some small animal, which has slightly eaten into the hard fibrous substance of the scale. Very similar markings or grooves have been noticed by Grand'Eury [1] on a leaf of *Cordaites*, and described by him as "galeries d'insecte." Other lines and striations on the convex surface of the scale are probably due to a wrinkling of the leaf substance. The large petiole bases on an old stem of *Macrozamia Douglasi*, Hill, in the Botanical Department of the British Museum, bear a striking resemblance to this form of *Cycadolepis*. In the recent scales there is the same tendency to terminate in the pointed angular fashion as seen in the figured specimen, and in both there is a distinct narrowing towards the base of attachment. The convex under surface of the recent scales is covered with a thick down of hairs, and there is a similar wrinkled appearance to that of many of the fossil examples. Ecclesbourne. *Rufford Coll.*

V. 2699. Pl. VI. Figs. 6 and 6*a*.

This specimen is a good example of the stouter and more pentagonal form of scale, the distal edge is strongly recurved as seen in Fig. 6*a*, and the narrower basal end shows the surface of attachment. A comparison of this form of scale with those on the stems of *Fittonia squamata*, Carr.,[2] *Bucklandia* sp., *Fittonia Rigauxi*, Sap.,[3] etc., shows a very close agreement in size and shape. Ecclesbourne. *Rufford Coll.*

V. 2799. Another very large specimen, similar to **V. 2929** (Pl. V. Fig. 2), 13·5 cm. in length, 7·5 cm. wide at the broadest part. The convex surface is marked in places by reticulated lines and wrinklings; towards the distal end the surface is curved gradually

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[1] p. 338, pl. xxii. fig. 7.

[2] Carruthers (1), pl. lvi. fig. 1. (The original specimen is in the Museum of Practical Geology, Jermyn Street.)

[3] Saporta, *loc. cit.* pl. cxxvii.

inwards. At the base there is a well-defined semicircular area bounded by a distinct line; this is probably an attachment scar. Very similar to *Macrozamia Douglasi*, Hill. Another specimen with the same registered number has a similar form, and shows surface wrinklings. Ecclesbourne. *Rufford Coll.*

V. 2131. Several specimens: in some the curvature of the distal end is very pronounced.

V. 2131*a*. Smaller scales, about 5 cm. by 4 cm., closely resembling those of *Fittonia* and *Bucklandia*; *cf.*, *e.g.*, Carruthers,[1] pl. lvi. fig. 1, and Saporta,[2] pl. lvii. fig. 1.

V. 2131*b*. Scale of medium size; shows similarly convex surface and recurved apical portion, also distinct basal scar. Ecclesbourne. *Rufford Coll.*

V. 2699*a*. Part of a very large scale; reticulately marked surface.

V. 2699*b*. 6·5 cm. long, and about 5·5 cm. broad; here the narrower basal end is bent sharply back, the opposite end shows a well-defined angular margin.

V. 2699*c*. 7·5 cm. in length; similar in form to the large scale.

V. 2799. Shows the same kind of attachment surface at the base; the surface is marked by numerous dots and irregular lines suggestive of insect ravages. Ecclesbourne. *Rufford Coll.*

V. 2749. Small scale showing distinct rectulate markings on the surface. On the same piece of rock there is an impression of a cycadean stem showing what appear to be the outlines of petiole bases; possibly this may be a badly preserved piece of a stem, to which the smaller scales were originally attached. Ecclesbourne. *Rufford Coll.*

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[1] (1), Carruthers.

[2] (A. 2), Pal. Franç. vol. ii.

V. 2132. Similar specimen, but larger, and the stem impression more distinct. Ecclesbourne. *Rufford Coll.*

V. 2913. Part of a well-preserved scale; shows very clearly the sharp angular contour; the general appearance is very similar to that of a large recent cycadean scale. Cf. *Macrozamia*, sp. Ecclesbourne. *Rufford Coll.*

Other specimens of similar *Eury-Cycadolepis* species: **V. 2134**, piece of *Sphenopteris Fontainei*, Sew., on the same rock; **V. 2236**, **V. 2301**, **V. 2699***d*, **V. 2828**, **V. 2929**. Ecclesbourne. *Rufford Coll.*

V. 2800 and **V. 2733.** These specimens present rather a different appearance to that of most of the larger scales; this may, however, be due to folding over of the edges, of which there is distinct evidence. Some of the specimens of *Cycadolepis* are by no means unlike certain monocotyledous spathes, but there can be little doubt as to their cycadean nature. Ecclesbourne. *Rufford Coll.*

Genus **CARPOLITHES**, Sternberg.

[Flor. Vorwelt, Fasc. iv. p. xl. 1823.]

Fossil seeds are abundant in rocks of various ages, and in some cases their excellent preservation enables us to study in detail the structure of both testa and nucellus, and to refer them, with a considerable degree of certainty, to a particular class, family, or genus of plants. The superb illustrations in Brongniart's posthumous work *Recherches sur les graines fossiles silicifiées*[1] demonstrate in a striking manner, the excellent preservation of isolated gymnospermous seeds under certain favourable conditions; but in spite of the perfection of the mineralized tissues, it is scarcely ever possible to assign the detached seeds to their respective plants. In Mesozoic rocks seeds are by no means

[1] Paris, 1881.

uncommon, but their preservation is usually imperfect, and not such as to throw any appreciable light on their exact botanical position. The Wealden strata of England have as yet been searched in vain, for any satisfactory indications of the existence of angiospermous plants in the flora of that period, and this fact leads us to the assumption that most probably the Wealden seeds are either coniferous or cycadaceous. There are, however, the detached tubers of *Equisetites Burchardti*, Dunk., and *E. Yokoyamæ*, Sew., which may easily be mistaken for seeds. In the first part of this Catalogue[1] doubt was expressed as to the nature of the oval bodies described as seeds by Stokes and Webb, and Mantell, and by some authors referred to *Equisetites*.

The name *Carpolithes* was proposed by Sternberg as a convenient and comprehensive genus for "Fructus seminavi mono- vel dicotyledonea, solitaria, structura interna plane obliterata." This term has been adopted by many authors as a designation for isolated seeds of doubtful position, and its use is in most cases more appropriate than any term indicative of some special class or group of plants. In 1849 Pomel proposed *Ulospermum*,[2] as a generic name for fossil "fruits" resembling those of the recent *Cycadaceæ*, but this term, like many others suggested by the same writer, has not been generally accepted. Schimper instituted the genus *Cycadinocarpus*,[3] for "Semina subglobosa, ovata vel oblonga, quoad magnitudinem valde variantia, nunc parvula, nunc majora volumenque Castaneæ attingentia; epidermide plus minus crassa instructa, lævia, haud raro compressione mutua angulosa, epidermide destituta solida, lignea, sublævia, striata, costata vel reticulata, basi insertionis cicatrice lata notata, apice minute apiculata." In 1875 Saporta substituted *Cycadospermum*, as a more fitting name for detached cycadean seeds than Schimper's genus *Cycadinocarpus*, on the grounds of an implied misconception of the exact morphological nature of the seeds of cycads. The genus is thus defined: "Semina e carpophyllis distracta post maturationem in strata pervagata nunc majora nunc plus minusve parvula, plerumque ovata ovatoque-oblonga haud raro compressione

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[1] Vol. i. pp. 27, 28.
[2] Pomel, p. 16.
[3] Trait. pal. vég. vol. ii. p. 208.

mutua angulosa extus lævia vel longitudinaliter striata costataque, basi semper rotundiore insertionis cicatrice notata apice autem plus minusve attenuata." [1]

As regards the difference between fossil specimens of cycadean and coniferous seeds, it would seem that we cannot trust to any convenient method of distinguishing, in all cases, between the two groups of plants. The large oval, or almost spherical seeds of certain cycads may generally be distinguished from the typical forms of coniferous seeds, but in the latter group we have such forms as *Ginkgo*, *Cephalotaxus*, and others, in which the size approaches more closely to that of the cycadean ovule, than to the smaller seeds of such conifers as *Larix*, *Pinus*, and many others. In many *Coniferæ* the presence of a membranous wing affords a ready means of identification, at least as regards their separation from *Cycadaceæ*, but the seeds of many conifers are without any winged appendage, and even in the case of winged seeds, the thin membrane might readily become detached before the seed had been permanently enclosed in a mass of sediment. Another obvious source of difficulty, worth referring to in this connection, is the very great difference in size exhibited by the seeds of the same plant at different stages of growth. The ripe seeds of such a genus as *Cycas*, preserved with the wrinkled reddish-brown outer coat intact, present a very different appearance from those in which this coat has become detached, thus exposing the perfectly smooth inner coat; and a still greater contrast is afforded by the more spherical kernel (nucellus), with its surface traversed by branching grooves marking the position of vascular bundles.[2] On the whole, it would seem advisable to follow the example of Schenk in his *Flora der Grenzschichten*,[3] and make use of the old term *Carpolithes* for gymnospermous Mesozoic seeds. In certain cases the character of the seeds, or their frequent juxtaposition with cycadean fronds, may enable us to speak of them as cycadean with reasonable certainty; when such is the case it will be well to give expression to our more accurate knowledge, either by adopting Saporta's genus,

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1 Saporta (A. 2), Pal. Franç. vol. ii. p. 235.

2 This is well shown in the seeds of *Cycas circinalis*.

3 Pl. xxxiii. figs. 5–9.

or, possibly the better plan, by adding the word cycadean or *Cycadaceæ* as a descriptive epithet to *Carpolithes*. If some such course as this were generally followed, there would be less cause for the not altogether unwarranted criticisms, which students of recent plants are in the habit of passing on the misplaced dogmatism of palæobotanists. Our records of fossil plants ought surely to be sufficiently trustworthy, to be made use of by botanists in compiling statistics of the geological history of any class or family of plants. It must be admitted that to attempt a history of plant development or distribution in the various epochs of the earth's history, by simply accepting as reliable data the examples of fossil plants, or fragments of plants, described under the names of existing genera, or designated by terms plainly suggestive of botanical affinity, would lead the too trustful student into hopeless error. Occasionally a fossil seed may exhibit some definite and characteristic form, for which some special specific term might be added, but in the majority of cases where the individual differences are merely those of size or slight variation in shape the use of specific terms is to be deprecated. In Fontaine's *Potomac Flora* several seeds are recorded as species of *Carpolithes*, the genus being used in this instance for the "nut-like seeds of conifers."[1] Under the genus *Cycadinocarpus* the same author places "various horny seeds which resemble those of cycadean plants more than those of conifers."[2] It is admitted by Fontaine that the correct placing of these seeds is impossible; his species are founded in some cases on very slight differences in size and shape, and can have but little taxonomic value. Saporta[3] has instituted various species for the French Jurassic seeds referred to gymnosperms; some of these show fairly well-marked characteristic features, but in others it would be difficult to justify the adoption of specific designations. In a recent paper by Dawson, several gymnospermous seeds are wisely grouped together as examples of *Carpolithes*.[4]

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[1] p. 264.

[2] p. 270.

[3] *Loc. cit.* pp. 238-245.

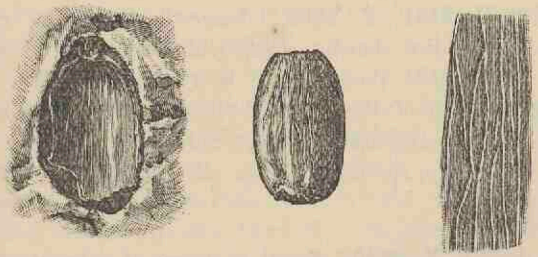
[4] Dawson (2), p. 90.

Under certain circumstances, as suggested by Solms-Laubach in speaking of *Cycadites* (*Cycas*) *Steenstrupii*, Heer,[1] it may be legitimate to refer seeds and fruits to certain species of plants, even in the absence of any actual proof of organic connection; but it can only be in exceptional cases where the association of fronds and seeds renders such a course admissible. As an example of what appears to be an instance of a supposed connection, not sufficiently supported by facts, we may cite Heer's *Zamites globuliferus*,[2] where a frond occurs in association with seeds.

Carpolithes.

Seeds of doubtful botanical position.

Carpolithes (*Cycadaceæ*).



a. *b.* *c.*

Fig. 7.—(V. 2130*.) *Carpolithes* (*Cycadaceæ*).
a. and *b.* Nat. size. *c.* Portion of *b* slightly magnified.

V. 2130*. Fig. 7.

This is a particularly well-preserved example of what must be regarded as a cycadean seed. It is impossible to refer it to any particular genus, but in all probability it belongs to some other

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[1] Fossil Botany, p. 86.

[2] Fl. foss. Arct. vol. vi. pt. i. pl. iv. figs. 1–7, etc.

form than *Cycadites,* if we assume that genus to have possessed seeds similar to those of the recent *Cycas.* Species of *Macrozamia* possess ovules closely resembling the present specimen. The seed has a length of 1·8 cm., and is 1·1 cm. broad. The mould from which the kernel (Fig. 7*b*) is readily removed, is lined with a thin structure probably representing the integumentary portion of the testa (Fig. 7*a*); between this and the matrix there is a layer of coaly substance. The kernel may probably be regarded as a cast of the nucellus, with the impressions of the branched vascular bundles clearly seen on its surface. The fossil figured by Stokes and Webb as *Carpolithus Mantelli,*[1] shows in the enlarged drawing similar branched markings on the surface, suggestive of vascular strands. It may be that Mantell's specimen should be retained under its original genus and not transferred to *Equisetites,* but it is difficult to speak with any certainty, at all events in the absence of the type specimen. Ecclesbourne. *Rufford Coll.*

V. 2129, V. 2131, V. 2699. Large flattened and more or less spherical bodies showing coaly substance on the exposed surface; in **V. 2131** the seed (?) is 4 cm. in breadth. It is possible that some of them may be scales and not true seeds, but their general appearance is not unlike that of some recent cycadean ovules, *e.g.* species of *Cycas.* Ecclesbourne. *Rufford Coll.*

Cf. **V. 2130*, V. 2236.** Small specimen of a badly preserved seed.

V. 2827*a*. Seed with pointed apex, not unlike *Cycadeospermum obovatum,* Font.[2] **V. 2256.** Cast of nucellus with remains of testa, similar to **V. 2827***a*. **V. 2700*.** Cast and mould of imperfect specimen. Ecclesbourne. *Rufford Coll.*

V. 3312. Probably a seed of some cycadean plant; it appears to have split partially open along the longest diameter. Ecclesbourne. *Rufford Coll.*

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[1] (A.), pls. xlvi. and xlvii.

[2] Potomac Flora, pl. cxxxv. fig. 13.

Carpolithes.

V. 2184. Part of a seed-like body. There are several small circular holes on the surface of this and a few other specimens, filled up with a fine brown dusty material, suggesting the borings of some small animal. Similar examples are afforded by **V. 2739**, **V. 2918**. Ecclesbourne. *Rufford Coll.*

The following specimens may also be included under *Carpolithes*: **V. 2130**, **V. 2130*a***, **V. 2130*b***, **V. 2165**, **V. 2700**, **V. 2739***, **V. 2826**, and **V. 2827*b***.

38369. Possibly an imperfect seed, but indeterminable.

Seed-like Bodies of Doubtful Position.

Cf. *OOLITHES*, sp., CARRUTHERS.[1]

Pl. IX. Fig. 5 (**V. 2796*a***). An oval body partially covered with a chitinous-like coat; the dark brown and brittle substance which occurs over part of the specimen, suggests some resemblance to the dried reddish coat of a *Cycas* seed. The central part does not show any signs of a nucellus or seed structure; it consists of an irregularly indented projecting portion of the rock. The external skin exhibits no cellular structure under the microscope.

Compare *Oolithes sphæricus*, Carr.; the figures given by Carruthers of this species, present a striking resemblance to the present specimen and other similar forms in the Rufford Collection. Buckman had previously identified these Stonesfield slate bodies as reptilian eggs, and Carruthers' examination of the same material leads him to accept this determination. It is probable that whatever position be assigned to the Jurassic fossils, it may with equal force be accepted for many of the Wealden seed-like bodies.

V. 2796. In this specimen the outer brown skin has been removed.

V. 2818. Smooth brown skin present. Ecclesbourne. *Rufford Coll.*

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[1] (2), p. 447, pl. xix.

V. 2825. Flattened and subspherical body, with a hard shiny and dark brown skin more or less deeply indented. *Cf.* Carruther's figures of *Oolithes*, sp.

V. 2828. Specimens showing a similar brown skin, enclosing a smooth central kernel.

V. 2817. Small specimen with smooth surface, showing at the two opposite ends of a diameter a number of very small rounded prominences; these are just visible, as small dots, to the naked eye.

V. 2817*a*. Small body, 5 mm. long, with smooth brown coat, similar to **V. 2796***a*, etc. **V. 2165**, fragment. Ecclesbourne.
Rufford Coll.

FLORES.

In Solms-Laubach's *Fossil Botany*,[1] we have a concise and critical *resumé* of the various male and female cycadean flowers described in palæobotanical literature prior to 1887. It will be seen from this account, that our knowledge of the floral structures of fossil cycadean plants is extremely meagre. In the carpophylls of the recent *Cycas*, we have a well-marked and peculiar form of female flower which is readily distinguished from the cone-like collection of carpophylls met with in other genera; occasionally these *Cycas* forms of flowers have been found in close association with the sterile fronds of *Cycadites*, and justify the conclusion that both structures formed parts of the same plant. In other cases, however, we are less fortunate in the records of staminal or carpellary leaves, and there must be considerable hesitation in accepting several of the examples which have been described as true cycadean flowers.

It will be convenient to adopt Schimper's genus *Androstrobus* in speaking of a few Wealden specimens, of what appear to be male flowers of some genus of cycadean plant.

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[1] Solms-Laubach (A.), p. 89.

Genus ANDROSTROBUS, Schimper.

[Trait. pal. vég. vol. ii. p. 199, 1870.]

Schimper has thus defined the genus: "Amenta cycadeacea antherifera, cylindrica, e squamis imbricatis, latere postico antheras sessiles ferentibus efformata."

A sufficient definition of *Androstrobus*, would be to speak of the genus as a convenient term to apply to such fossils as resemble more or less closely the male flowers of recent cycads, and which appear to belong to the *Cycadaceæ*.

The genus was founded on a specimen originally described by Saporta from the Upper Bathonian of Etrochey as *A. zamioides*, but afterwards renamed *A. Balduini*[1] after the discoverer of the specimen, the latter specific term being considered more suitable as not suggesting such a definite resemblance to a particular form of cycad. Saporta's figures show the outline of several pollen-sacs between the spirally arranged staminal leaves, attached apparently in the same manner as in recent species. This author describes another and more imperfect specimen of a male cone, under the name *Androstrobus* (*Zamiostrobus*) *Guerangeri*;[2] the same specimen having been previously referred to by Brongniart[3] as an undoubted example of a male cycadean flower. Saporta compares this fossil with the genus *Dioon*, but, as Solms-Laubach[4] has suggested, there seems to be but slender grounds for such a comparison. The specimens described by Nathorst[5] and Heer[6] respectively as *Androstrobus borealis* and *A. Sibiricus*, are far from satisfactory, and cannot be accepted as entirely trustworthy records of this genus. In addition to

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[1] Pal. Franç. vol. ii. p. 209, pl. cxv. figs. 1 and 2.
[2] *Ibid.* p. 37, pl. lxxviii. figs. 1–3.
[3] Tableau, p. 64.
[4] *Loc. cit.* p. 90.
[5] (A. 1), Flor. Höganäs, p. 49, pl. ii. figs. 12 and 13, and pl. ii. (Helsingborg) figs. 15 and 16.
[6] Fl. foss. Arct. vol. iv. pt. ii. p. 47, pl. iv. figs. 14 and 15.

the genus *Friçia* of Velenovsky,[1] reference may also be made to *Zamites familiaris* (Cord.)[2] from the Lower Quader of Bohemia, which Corda and Carruthers[3] regard as an example of a male cone; the figures of this form lend support to such an opinion. The specimen described by Carruthers in his monograph on cycadean stems as the "antheriferous cone of *Bucklandia*"[4] does not seem to me to afford any distinct evidence in favour of such a determination.

Androstrobus Nathorsti, sp. nov.

Pl. IX. Figs. 1–4.

Type. Specimens of imperfect flowers and detached staminal leaves. British Museum.

It is difficult to give a definition of this species which shall be in any sense complete. The following may serve to indicate the most obvious features of this somewhat unusual form of cycadean cone.

Axis fairly stout, bearing spirally disposed and more or less triangular staminal scales; in section the scales have a hexagonal outline, in side view they show a broad base in close contact with the axis of the flower, and measure about 1–1·5 cm. in length, gradually tapered towards the apex, which is pointed or slightly rounded. On some of the staminal leaves there are rows of regularly placed angular depressions, probably representing the impressions of pollen-sacs, borne towards the basal or proximal end of each scale.

V. 2701. Pl. IX. Figs. 3 and 4.

This specimen shows several fairly well-preserved scales of a male flower, length about 6·5 cm., breadth 4 cm. The central axis is not very clearly seen, but there are indications here and there of the points of attachment of the sporophylls. The axis

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[1] (A. 1), Gym. Böhm. Kreid. p. 8, pl. iii.

[2] Corda in Reuss (A.), Verstein. böhm. Kreid. p. 86, pl. xlix. figs. 10 and 11.

[3] (3), p. 6.

[4] (1), pl. liv. fig. 6.

appears to have been about 1 cm. in breadth, but it is difficult to estimate the dimensions with any accuracy. The surface of the scales is of a brown colour; the longest measures 1·5 cm. in a direction at right angles to the floral axis; the surface is considerably wrinkled and bears obvious traces of having been folded and crushed. Towards one end of the specimen the basal part of a scale is seen in surface view, and on it are clearly preserved what are taken to be the outlines of pollen-sacs (Figs. 3 and 4). These are in the form of small depressed areas radiating from the proximal portion of the scale surface; each depression is bounded by a straight basal wall, and two slightly diverging lateral walls, with two apical walls inclined to one another at an angle of about 35°; from the apex there is a slight median ridge passing to the basal wall. In the upper row there are about 14 of these pollen-sac impressions, and below these there are the remains of a lower set of similar structures. Traces of the pollen-sacs occur on some of the other scales, but less clearly preserved. The striking regularity with which these impressions are arranged, is much more marked than in the pollen-sacs of recent cycads. On the lower surface of a staminal leaf of *Dioon* or *Encephalartos*, we find on the removal of the pollen-sacs a fairly distinct reticulate marking, but of much less regularity than in the fossil. The angular outline of the sacs in the present specimens may be due, to some extent, to the mutual pressure of more or less oval structures, such as we have in the pollen-sacs of recent male flowers.

The tapered free ends of the scales are somewhat similar to the narrowed apices of the staminal leaves of species of *Encephalartos*; *e.g.* the male flower of *E. Altensteinii*, Lehm., *E. pungens*, Lehm., etc. Cf. *Androstrobus Balduini*, Sap., pl. cxv. figs. 2*a* and 2*b*.[1] Ecclesbourne. *Rufford Coll.*

V. 2810. Pl. IX. Fig. 1.

7 cm. in length. This specimen shows several fairly well-preserved scales somewhat closely set on a central axis which is narrower than that in **V. 2701.** Each staminal leaf presents a triangular outline, with a more or less distinct median ridge

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[1] *Loc. cit.*

extending across the middle; if this be clearly seen in the scales on the right-hand side of the axis in Pl. IX. Fig. 1, towards the upper margin of some of the scales there are clear indications of another projecting angle, *e.g.* the third from the bottom on the right of the axis in Fig. 1. There is a close similarity in form between the detached scale figured by Carruthers as *Araucarites Phillipsii*, Carr.,[1] and those of the present specimens. The median line, as seen in the scales of Fig. 1, should be compared with the prominent lateral angles seen in the end view of the scales in Pl. IX. Fig. 2. In one place on the surface of the argillaceous matrix, there were some fairly distinct impressions of pollen-sacs. Ecclesbourne. *Rufford Coll.*

V. 2811. Pl. IX. Fig. 2.

This shows several staminal leaves in end view, some being apparently in place and retaining the spiral arrangement. There can be little doubt as to the identity of these with **V. 2810** and **V. 2701**, the different appearance in the present example being due to the fact that here we have a view of the end, and in the previous specimen, a view of the flattened sides of the scales. The exposed ends show a central depression, and a distinct hexagonal outline. The shape and general appearance of the scales remind one of the staminal leaves in *Zamia*, sp.; but in the present specimen we are presumably looking at the basal, and not the distal ends of the scales; the specimens **V. 2810** and **V. 2701** show the much greater width of the base than the apex. It may be, however, that in Fig. 2 (**V. 2811**) the apices have been depressed, and we have a view of the apical rather than the basal parts of the scales.

Cf. *Androstrobus Guerangeri*, Brong.[2] Ecclesbourne.

Rufford Coll.

V. 2236. A smaller specimen than **V. 2701** and **V. 2810**; the remains of a central axis with a few well-preserved scales attached. No trace of pollen-sacs. Ecclesbourne. *Rufford Coll.*

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[1] Carruthers (5), pl. ii. fig. 8.

[2] *Loc. cit.* pl. lxxviii. fig. 1.

Genus CONITES, Sternberg.

[Flor. Vorwelt, fasc. iii. p. 36, 1823.]

Several writers have called attention to the close resemblance between the cones of certain *Coniferæ* and those of some species of cycads. In attempting to determine the true nature of a fossil cone, of which the internal structure is either very imperfect or entirely wanting, we are met by the great difficulty of clearly discriminating between the female flowers of these two groups of plants. Carruthers[1] has mentioned certain distinctive characters of cycadean cones which, he considers, should enable us to distinguish them from the corresponding structures of conifers, but the main differences which he notes are such as can only be recognized by the help of internal structure; he writes: "Any difficulty in determining the affinity of a cone by its external characters can easily be solved, as to whether it is coniferous, cycadean, or proteaceous, by a transverse section, which would show, if the structure is even a little preserved, the form of the scale and the position of the seed."[2] Unless the structure is fairly well preserved there is often no little difficulty in deciding in favour of one or other of the two orders of plants, *Coniferæ* and *Cycadaceæ*.

In view of the generally recognized difficulty of clearly separating the cones of these plants, and of distinguishing some cones from small cycadean stems, there must be a certain amount of hesitation in choosing the most suitable generic term for cone-like fossils of doubtful affinity.

Endlicher[3] proposed the name *Zamiostrobus* for a cone originally figured by Lindley and Hutton as *Zamia macrocephala*[4]; but Carruthers has since shown that the original reference of this fossil to the *Cycadaceæ* cannot be accepted, and it is now known

[1] Carruthers (4), p. 535.
[2] *Ibid.* p. 536.
[3] p. 72 (No. 707).
[4] Fossil Flora, pl. cxxxvi.

as *Pinites macrocephala* (L. and H.).[1] Owing to the erroneous inclusion of this specimen in the genus *Zamiostrobus*, and the unwarranted application of the name to cones which are clearly not cycadean, Carruthers proposed the generic name *Cycadeostrobus* as a more suitable designation for what are "supposed to be fruits of *Cycadeæ*." In speaking of the cones figured by Carruthers under this genus, Solms-Laubach[2] reasonably suggests that possibly several of the fossils may be either small stems or true cones. The only certain cone he considers to be that figured as *Cycadeostrobus Brunonis*, Carr., but this, he adds, "looks more like a cone of *Araucaria* than of *Cycadeæ*." Having had an opportunity of examining Carruthers' type specimens, I must confess to a considerable amount of scepticism in accepting them as well-authenticated examples of cycadean flowers.

In cases where it seems impossible to express oneself with any degree of certainty as to whether a specimen is a small stem or cone, the better plan is probably to give expression to the doubtful affinity by leaving the fossil unnamed, or by prefixing a query to any name which it may have already received. The practice of replacing some of the older and more indefinite names of the older palæobotanists by newer terms more expressive of definite botanical affinity, has not always marked an advance in accurate knowledge. Such a name as *Conites* does not, indeed, convey any particular information to the mind of botanists as to the nature of the fossils so designated, but, on the other hand, *Zamiostrobus* or *Cycadeostrobus* both definitely suggest either the male or female flowers of some form of cycad.

In the first volume of this Catalogue the term *Algites*[3] was proposed as a useful generic designation for doubtful forms of fossil *Algæ*, in preference to the more committal and frequently misleading names often made use of. Although such a course as this is, in one sense, rather retrogressive than progressive, yet it would at all events minimise the chances of possible error if we adopted the old name *Conites* for several of the cones previously referred to the *Cycadaceæ* on what appears to be too

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[1] Carruthers (4), p. 538.
[2] *Loc. cit.* p. 92.
[3] Seward (2), p. 2.

often insufficient evidence. If we have distinct cycadean cones before us, the name *Cycadeostrobus* would seem a suitable term to apply to them. As in the case of the genus *Carpolithes*, we may always give expression to any bias towards one or other group of plants, by adding the word *Cycadeæ* or *Coniferæ* as qualifying epithets to the more comprehensive generic name.

I would suggest, then, the revival of the old genus *Conites*[1] as a convenient generic name for cones of doubtful botanical affinity.

Conites elegans (Carr.).

1867. *Cycadeostrobus elegans*, Carruthers, Journ. Bot. vol. v. p. 7, pl. lvii. fig. 9.
1867. *Cycadeostrobus ovatus*, Carruthers, *loc. cit.* p. 6, pl. lvii. fig. 1.
1870. *Zamiostrobus elegans*, Schimper, Trait. pal. vég. vol. ii. p. 203.
Zamiostrobus ovatus, Schimper, *loc. cit.* p. 203.
1871. *Zamiostrobus elegans*, Schenk, Palæontographica, vol. xix. p. 228.
Zamiostrobus ovatus, Schenk, *loc. cit.* p. 228.
1889. *Cycadeostrobus elegans*, Bristow, Geol. I. Wight, p. 258.
Cycadeostrobus ovatus, Bristow, *loc. cit.* p. 258.

Type. Pyritized specimens, British Museum.

After an examination of the type specimens of *Cycadeostrobus elegans* and *C. ovatus* which Carruthers has described, I have ventured to include both examples under one specific name. The pyritized specimens do not appear to present any distinctive characters which can be regarded as of specific value. Unfortunately the preservation is not such as to enable us to prove either cycadean or coniferous relationship. Carruthers speaks of *Cycadeostrobus elegans* as an "ovoid cone, truncate below; scales nearly as deep as they are wide,"[2] and of *C. ovatus* as an "ovate cone; scales somewhat broader than deep."[3] In the absence of structural characters it is impossible to give any more complete diagnosis.

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[1] The genus *Strobilites* was suggested in 1840 by Schimper and Mougeot for certain cones from the Triassic beds of the Vosges.

[2] (3), p. 7.

[3] *Ibid.* p. 6.

40962. Journ. Bot. vol. v. 1867, pl. lvii. fig. 9. One of the two specimens is the type of Carruthers' species, *Cycadeostrobus elegans*. In the better specimen, as shown in the figure, the pyritized cone has been more or less compressed; at the base there is a central depression or scar of attachment of a peduncle. The surface view of the scales suggests a wearing down of their distal ends. The second example is less perfect than the type specimen. Brook Point. *Lady Hastings Coll.*

V. 2543. Two specimens, very friable. *Cf.* Carruthers' figure of *Cycadeostrobus ovatus*, Carr. Possibly *Cycadeostrobus truncatus*, Carr.,[1] might also be included as a synonym of the present species. Brook. *Presented by A. Dendy, Esq.*, 1888.

V. 63. Imperfect pyritized specimens. These and **V. 2543** are somewhat larger than the cone represented by Carruthers in Journ. Bot. vol. v. pl. lvii. fig. 9; but they are probably examples of the same species. Brook. *Purchased* 1882.

V. 2853. Portion of a flattened cone; apparently the same as **40962.** Sussex. *Beckles Coll.*

V. 385. Very imperfect pyritized specimens. Brook.
Presented by C. Westendarp, Esq., 1884.

TRUNCI.

In the introductory remarks[2] on cycadean fronds it was suggested that the use of some more general term than that of *Cycadaceæ*, might prove advantageous in dealing with the remains of extinct cycad-like leaves. The chief reason for such a proposal is to be found in the character of the floral structures of the genus, for which Carruthers instituted the name of *Bennettites*. This plant, as we have already shown, cannot well be included in the class *Cycadaceæ* as at present defined for recent species;

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[1] (3), p. 6, pl. lvii. fig. 3.
[2] P. 7.

the same necessity for a more comprehensive class designation is equally apparent in the case of cycad-like stems. It would be impossible to so far extend the present limits of the *Cycadaceæ*, as to incorporate under that term all the fossil stem structures in which characteristic features of cycadean anatomical structure have been recognized; but we must in any case clearly understand that such stems as *Bennettites* and others, although very closely related to recent cycads in histological details, are, however, separated from living forms by certain peculiarities in the morphology of their reproductive organs. The above heading, therefore, of *Trunci* does not exclude such stems as are known to be associated with a bennettitean form of floral structure; it must be taken in a more comprehensive sense than merely including stem structures which agree in all essential features with living members of the *Cycadeæ* or *Zamieæ*.

The study of cycadean stems has been raised to considerable importance by the fact of the preservation, in several instances, of more or less perfect internal structure in fossil specimens. As with fronds, so here again we are debarred from any complete diagnoses of many fossil stems by the isolated occurrence of the leaves and their supporting axes. We must for the present restrict ourselves to an investigation of facts as regards the anatomy of stem structures; and, as in *Bennettites*, of the accompanying floral shoots.

The early records of so-called cycadean stems in Palæozoic rocks have already been referred to. It is often a matter of some considerable difficulty to confidently identify a structureless cast or impression of a cycadean trunk; the imperfectly preserved stems of some forms of *Sigillaria*, *Lepidodendron*, or *Lepidofloyos* may simulate fairly closely the characteristic appearance of cycadean stems. In Grand'Eury's recent monograph on the Coal-field of Gard there is a figure of *Lepidofloyos laricinus*, Sternb.,[1] which may be reasonably compared to a stem of a cycadean plant, bearing lateral appendages suggestive of a bennettitean inflorescence. The tree fern genus *Protopteris*, with its leaf-trace bundle scars imperfectly shown or apparently absent, may be mistaken for a cycadean axis with its prominent

[1] Grand'Eury (1), pl. vi. fig. 17.

petiole bases. An example of such resemblance is afforded by a specimen figured by Hosius and von Marck as probably *Protopteris punctata*, Sternb.; the plant represented in their plate xliii. fig. 186 [1] might well be described as an imperfect cycadean stem. Again, it is almost impossible in some cases to decide with certainty between an imperfect cone and a small cycadean stem. The fossil described by Lesquereux from Colorado as *Zamiostrobus mirabilis*,[2] is obviously a badly preserved stem with basal portions of petioles. An examination of such a stem as that of the living species of *Cycas*, is sufficient to demonstrate the difficulties attending our attempts to separate into specific forms fragments of imperfect stems. The upper part of an old *Cycas* stem with its bud scales still in place, presents a very different appearance to the lower portion of the same axis, from which the scale leaves and petiole bases have become detached, leaving clean-cut rhomboidal scars. As a general rule we have a fairly easy task in identifying fossils as cycadean stems. The frond scars and scale leaves which clothe the woody axis afford a convenient distinguishing feature; but, on the other hand, it is important to keep in view the existence of other forms of stems among recent cycads, in which the well-known covering of leaf bases is absent. In such plants as *Zamia Loddigesii*, Miq., and *Z. Skinneri*, Warsz., the peculiar branched stem, with its transversely elongated wrinklings and small knob-like protuberances, presents a totally different aspect to the trunks of *Cycas*, *Encephalartos*, *Dioon*, and others. It may be noted in this connection that the Lower Greensand fossil which König named *Dracæna Benstedtii*,[3] and of which the National Collection contains several examples from the Kentish Rag of Maidstone, and a few recently added by Mr. Rufford from the Ecclesbourne Wealden Beds, shows a striking resemblance to the stems of the above-named forms of *Zamia*. The fossils have at all events no claim to a generic name implying a monocotyledonous affinity.

We cannot here undertake a descriptive account of the morphology of recent cycadean stems; but for information on this head, reference may be made to the treatment of these

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[1] (A. 1), Palæontographica, vol. xxvi.

[2] Lesquereux (1), p. 70, pl. lxiii. fig. 1.

[3] Morris (A), Brit. Foss. p. 8.

plants in Engler and Prantl's *Die natürlichen pflanzenfamilien.*[1] Saporta[2] and Renault[3] have also given some account of the living cycads, and further details may be found in the writings of Brongniart,[4] Miquel,[5] Richard,[6] Karsten,[7] Carruthers,[8] Solms-Laubach, and others.

By far the greater number of known fossil stems have been found in Lower Cretaceous and Jurassic strata, and it is with these Mesozoic examples that we are at present concerned. In Brongniart's *Prodrome*[9] there is recorded but one example of a cycadean stem; this is the plant described by Buckland from the Portland dirt-bed, and for which the French author suggested the name of *Mantellia*. The common *Clathraria Lyelli*, Mant., is included by Brongniart among the Monocotyledons. In the *Tableau*[10] we find several additions to the list of cycadean stems, and among them is the interesting genus *Medullosa* of Cotta; this Palæozoic plant has been subjected to a detailed investigation by Göppert and Stenzel,[11] Schenk,[12] and others, and we may probably regard it as an extinct type of cycadean structure, using the term cycadean in a wide sense. In 1828 Buckland[13] figured and described some large specimens of silicified stems from the Isle of Portland, and, with the concurrence of Robert Brown, instituted a new family, *Cycadeoideæ*, for their reception. Buckland fully recognized the close resemblance between these "petrified birds' nests" and the stems of certain cycads; but a new family name was proposed on account of some peculiarity as regards the position and size of the rings of wood. In a

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[1] Teil. ii. Abth. i. p. 6. [2] Pal. Franç. vol. ii.

[3] (A. 4), Cours bot. foss. vol. i. p. 33.

[4] (2). [5] (1) and (3).

[6] Richard. [7] Karsten.

[8] Carruthers (1). See also Solms-Laubach (3).

[9] p. 92. [10] p. 59.

[11] Göppert and Stenzel.—In speaking of the *Medulloseæ*, Solms-Laubach remarks (Fossil Botany, p. 100) that "that in their anatomical structure they show many points of resemblance to the *Cycadeæ*, though they depart from them, according to the most recent investigations, in some important particulars."

[12] Schenk. [13] Buckland (1).

later work,[1] this author has given some further description of the Portland fossils, and discusses the question of terminology; the genus *Cycadites* being regarded by Brown as preferable to *Cycadeoidea*, and the name of *Mantellia*, proposed by Brongniart, is thought to be unsuitable, having been already used by Parkinson for a genus of fossil Zoophytes. At the present day[2] it is unfortunately not always held that the use of a particular name by palæozoologists, is a fatal objection to the adoption of the same for a fossil plant. Among the new figures added by Buckland to those given in his earlier paper, we find some drawings of longitudinal sections of petioles and axillary buds; the latter have since been fully described by Carruthers as the inflorescence of *Bennettites*. In 1870 an important monograph appeared by the latter author on *Fossil cycadean stems from the Secondary rocks of Britain*;[3] the memoir contains full reference to earlier records of cycadean stems, and includes figures and descriptions of the following new genera — *Yatesia, Fittonia, Williamsonia,* and *Bennettites*. Five years later, several additions were made by Saporta[4] to our knowledge of the stems of fossil cycads; he founded the genera *Bolbopodium, Cylindropodium, Platylepis, Clathropodium,* and *Cycadeomyelon*. The numerous terms added or substituted for those previously proposed by Carruthers have involved the terminology of cycadean stem structures in some confusion. In more recent years we have a valuable contribution from Solms-Laubach and Capellini[5] on the examples of bennettitean stems preserved in Italian museums. These authors limit the use of the term *Bennettites* to a single species, *B. Gibsonianus*, Carr., and in a still later preliminary paper by Lester Ward,[6] Carruthers' genus is absorbed into the more comprehensive *Cycadeoidea*. We may look for an important monograph at an early date by Lester Ward and Knowlton on the exceedingly fine series of American cycadean stems. In Dana's *Manual of Geology*[7] mention is

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[1] (2), p. 453.
[2] See Quart. Journ. Geol. Soc. vol. l. 1894, p. 435.
[3] Carruthers (1).
[4] Pal. Franç. vol. ii. p. 245.
[5] Capellini.
[6] Ward (1), p. 78.
[7] p. 472.

made of some large stumps of cycads having been found near Baltimore, Maryland, and their age is spoken of by Tyson as probably Upper Jurassic. Fontaine's *Potomac Flora*[1] contains a few photographs of these Maryland stems, and a splendid specimen has lately been received by the Botanical Department of the British Museum. The few facts we so far possess as to these American stems lead us to expect a descriptive monograph of exceptional interest.[2]

The material so far collected from Upper Jurassic and Lower Cretaceous strata has already yielded valuable information with regard to the anatomy of the vegetative, and in some instances of the reproductive, structures of Mesozoic cycadean plants. To further extend our knowledge of these various fossil species, a more intimate acquaintance with the several types of recent cycads is much to be desired; and, as Solms-Laubach[3] points out, we possess no detailed and modern account of the large tuberous stems long ago described by Buckland from the dirt-beds of Portland.

Genus **BUCKLANDIA**, Presl.

[Sternberg, Flor. Vorwelt, fasc. iv. p. xxxiii. 1825.]

This genus was instituted by Presl for a plant discovered by Mantell in the Wealden of Tilgate; the same fossil had been previously referred by Stokes and Webb to *Clathraria*,[4] a term proposed by Brongniart[5] in 1822 for certain forms of sigillarian stems. Mantell[6] was the first to give a description of these Tilgate plants, but he proposed no name for them, merely pointing out a probable affinity with the *Euphorbiaceæ*, or possibly with the arborescent ferns. Carruthers pays a tribute to the "remarkable discrimination"[7] with which Presl recognized the cycadean nature

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[1] Fontaine (A. 2), pls. clxxiv.–clxxx.

[2] MacBride.

[3] Fossil Botany, p. 99.

[4] Stokes and Webb (A.), Trans. Geol. Soc. [2] vol. i. p. 421.

[5] (3), p. 209.

[6] Mantell (A. 3), Illust. Geol. Sussex, p. 42.

[7] *Loc. cit.* p. 682.

of the English fossils. In the *Tableau*[1] Brongniart includes Mantell's plant in the *Liliaceæ*, noting at the same time its resemblance to the stem of a cycad. Schimper[2] retains *Clathraria* for plants of the type of *Clathraria anomala*, Stokes and Webb (*C. Lyelli*, Mant.); and Saporta,[3] who follows Carruthers in preferring the name *Bucklandia* to *Clathraria*, speaks of the plant figured by Schenk as *C. Lyelli* as probably a species of Carruthers' genus *Fittonia*. Nathorst, in his *Floran vid Bjuf*,[4] on the other hand, includes under *Clathraria* two new species, but in the latter part of the same work he substitutes *Bucklandia*[5] for Stokes and Webb's genus. Nathorst's specimens are imperfect fragments of stems with alternating series of narrower and crowded leaf-scars, and broader and more openly arranged leaf bases; he compares them with the stem of *Cycas*.

The separation of such conventional genera as *Bucklandia* and those proposed by Saporta, is often a matter of great difficulty, and so long as we have only imperfect external or internal casts to deal with, there must always be a certain amount of doubt as to the existence of true generic and specific differences. Carruthers thus defines the genus *Bucklandia*:—

"Trunk cylindrical, sometimes bifurcating, reticulate, with the scars of the bases of the leaves, which are arranged in alternating series of large and small scars, the large being placed on swellings and the small on constrictions of the stems. Andrœcium a cone (?), gynœcium a terminal crown of leaves bearing seeds on their somewhat altered margins."[6]

The so-called male cone referred to in this definition was discovered in the same series of strata as those in which *Bucklandia* occurs; it is assigned to this genus on the strength of its occurrence in the same beds, and on account of a resemblance which its scales present to the sporophylls of a male flower of the recent species of *Cycas*. In the absence of more satisfactory evidence than is afforded by this single imperfect specimen, the nature of which does not appear to be by any means established, we are not in a position to include the male flower in a definition of Presl's genus. The alternating swellings and constrictions

[1] Brongniart (A. 4), p. 91.
[2] Trait. pal. vég. vol. ii. p. 182.
[3] *Loc. cit.* p. 307.
[4] Nathorst (A. 1), p. 77.
[5] *Ibid.* p. 124.
[6] *Loc. cit.* p. 682.

of the stem, and the slight difference in the form and size of the leaf-scars, led Carruthers to draw a close parallel between *Bucklandia* and *Cycas*, and to infer the nature of the female flowers.[1] He writes: "If the interpretation I have given of the stem of *Bucklandia* be correct, and if there be good reason, from a morphological point of view, for connecting with it the seeds and male cone found in the same beds, we have a plant which, in these known particulars, cannot be separated generically from *Cycas*."[2] In addition to the original species, *Bucklandia anomala* (S. and W.), Carruthers proposes a second specific name for certain Wealden stems which he considers to be distinct from Stokes and Webb's type. An examination of the British Museum material does not appear to favour this separation into two distinct forms, and I have ventured to incorporate both of the species into *B. anomala*. We cannot hope to separate such imperfect and structureless specimens into specific forms of any real value, seeing what marked variations in surface features we must expect to find in examples of cycadean stems clothed with a number of more or less decayed leaf bases. It may be noted that the upper portion of the specimen of *Bucklandia anomala* figured by Carruthers in pl. liv. fig. 1, shows a close approximation in form to that of some forms of the genus *Fittonia*.

Bucklandia anomala (Stokes and Webb).

1824. *Clathraria anomala*, Stokes and Webb, Trans. Geol. Soc. [2] vol. i. p. 422, pls. xlv., xlvi. fig. 8; pl. xlvii. fig. iv.
1827. *Clathraria Lyelli*, Mantell, Illust. Geol. Sussex, p. 52, pl. i. fig. 2; pl. ii. figs. 4 and 5.
1828. *Clathraria Lyelli*, Brongniart, Prodrome, p. 200.
1833. *Clathraria Lyelli*, Mantell, Geol. S.E. England, p. 233, pl. i. figs. i., ii., and vi.
1844. *Clathraria Lyelli*, Mantell, Medals, vol. i. p. 182, fig. 44.
1847. *Clathraria Lyelli*,[3] Mantell, Geol. Excurs. I. Wight, p. 292.
1848. *Clathraria Lyelli*, Bronn, Index pal. nomencl.

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[1] This suggested resemblance to *Cycas* does not appear to me very close; a comparison of the fossil stem and its pith cast with the stem and pith cast of *Macrozamia*, sp., reveals a striking similarity.

[2] Carruthers, *loc. cit.* p. 685.

[3] The specimen figured by Mantell (p. 293), Abth. i. p. 305, as *Clathraria Lyelli* is a waterworn fragment of *Bennettites*.

1850. *Clathraria Lyelli*, Unger, Gen. spec. plant. foss. p. 314.
1851. *Clathraria Lyelli*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 25.
1851–52. *Clathraria Lyelli*, Bronn, Leth. geog. vol. ii. p. 63, pl. xxviii. fig. 7.
1854. *Clathraria Lyelli*, Morris, Brit. Foss. p. 6.
1870. *Bucklandia anomala*, Carruthers, Trans. Linn. Soc. vol. xxvi. p. 686, pl. liv. figs. 1–3.
Bucklandia Mantelli, Carruthers, *ibid.* p. 686, pl. liv. fig. iv.
1870. *Clathraria Lyelli*, Schimper, Trait. pal. vég. vol. ii. p. 182.
1871. *Clathraria Lyelli*, Schenk, Palæontographica, vol. xix. p. 227, pl. xxx. fig. 7.
1874. *Clathraria Lyelli*, Schimper, Trait. pal. vég. vol. iii. p. 553.
Clathraria Mantelli, Schimper, *ibid.* p. 553.
1875. *Clathraria Lyelli*, Topley, Weald, p. 409.
1889. *Clathraria Lyelli*, Bristow, Geol. I. Wight, p. 258.

Type. Pith casts and structureless casts of the cortical surface of stems. British Museum.

In 1822 Mantell gave a brief description of some fossil stems from Tilgate Forest for which he proposed no name, but suggested that they might be allied to the *Euphorbiaceæ*, or possibly to certain arborescent ferns. Two years later Stokes and Webb proposed to include these fossils in the genus *Clathraria*, and gave them the name of *C. anomala*; the surface-markings suggested to them a resemblance to the recent *Zamia* and *Cycas*. In the *Geology of the South-East of England* Mantell claims priority for his name of *Clathraria Lyelli*; he notes the occurrence of imperfect leaf fragments in association with the stems, and speaks of them as linear-lanceolate in shape. Having mentioned such plants as he considers most closely allied to the Tilgate fossils, Mantell adds: "the impressions of the petioles on the bark bear a great resemblance to those on the stems of *Cycas revoluta* and *C. circinalis*." In a later work[1] the same writer speaks of the axis, roots, leaves, and probably fruit of *Clathraria* as having been discovered in close association or connection with one another. He gives a woodcut showing some of the long linear-lanceolate leaves attached to the stem, and remarks that impressions of such yucca-like leaves have often come under his notice. It is unfortunate that none of the specimens of *Clathraria* afford any evidence whatever as to the form of the leaves as described by

[1] Mantell, Medals, vol. i. p. 182.

Mantell. In the younger stems Mantell notes that the internal axis (pith cast) cannot be distinguished from the outer cortical portion.

Carruthers[1] gives the following detailed definition of *Bucklandia anomala*: "Scars of the leaves subrhomboidal, the lateral angles more or less truncate, inferior angle acute, the superior obtuse or somewhat rounded. The surface of the scar in some specimens marked with a triradiate ridge. The smaller scars oblong, with blunt lateral angles, obtuse inferior, and slightly rounded, almost straight superior angle; the scars equal in breadth to the larger ones, but not nearly so deep; the cicatrix on the upper margin. The bases of the leaves are set somewhat obliquely on the stem, their upper margin following the direction of the right-hand spiral. Each series of leaves occupies a considerable length of the stem. The phyllotaxy is represented by the fraction $\frac{5}{13}$."

The new species, *Bucklandia Mantelli*, is thus described: "Scars of the leaves rhomboidal, the lateral angles acute, the inferior and superior angles obtuse, the latter somewhat rounded. The small scars equal in breadth to the large ones, and increasing in depth from the bottom of the constriction upwards. Each swelling of the stem bearing three or four series of leaves, the constricted portion much longer, and crowded with the smaller scars, forming twelve or fourteen vertical series. The base of the leaves set horizontally on the stem. The phyllotaxy is represented by the fraction $\frac{5}{13}$."[2] It will be noticed that the more acute lateral angles of the leaf-scars and certain other slight differences, constitute the chief distinctive features of *Bucklandia Mantelli*, Carr. The close agreement between these two forms will be pointed out in the following descriptive notes on the British Museum specimens:—

In the original figures of *Bucklandia anomala* a specimen is shown with the cortical portion of the stem separated by some coaly substance—no doubt the carbonized remains of the wood—from a central sandstone cast; the latter, with its "interrupted longitudinal ridges," being a cast of the pith cavity, and the ridges the impressions of spaces in the xylem cylinder which were

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[1] *Loc. cit.* p. 686.

[2] *Ibid.* p. 686.

originally occupied by the cells of the primary medullary rays. In speaking of the numerous specimens of these pith casts, Carruthers admits the impossibility of referring them with any certainty to their respective species of bucklandian stems, and suggests that probably they may belong to three or four distinct forms of the genus. Saporta[1] has instituted a comprehensive genus, *Cycadeomyelon*, with the following definition: "Medulla centralis primum substantiæ cellularis disperditione evanida, dein sedimento cylindrum lignosum intus vacuum cumulorite substitula et tunc post ligni circumfusi abolitionem cylindrum plenum plus minusve compressum fasciculorum meatuumque impressionibus superficialiter notatum efformans."

In cases where we cannot be certain as to the relation between casts of the pith cavity and those of the cortical surface of a stem, it will be convenient to make use of Saporta's genus as a useful designation to express the absence of sufficient data for any more accurate identification. In some specimens we have the clathrarian pith cast enclosed in a bucklandian cortex, but in most cases the internal and external casts have been separated. Although very probably, as Carruthers suggests, the detached pith casts belong to more than one species of *Bucklandia*, yet the very striking resemblance between those internal casts, which are still surrounded by the cortical surface, and the isolated specimens is sufficient reason for the inclusion of such forms under the present genus. Hosius and von der Marck[2] have described an Aptien fossil stem as *Clathraria* (?) *galtiana*, and compare it with *Clathraria Lyelli* as figured by Schenk[3]; it is, however, probably not identical with the English type, and should perhaps be referred to the genus *Fittonia*.

8262. Figured by Stokes and Webb, Trans. Geol. Soc. [2] vol. i. pl. xlv. fig. 1. Mantell, Illust. Geol. Sussex, pl. ii. fig. 1.[4] Carruthers, Trans. Linn. Soc. vol. xxvi. pl. liv. fig. 3.

From one end of the specimen the cast of the hollow pith projects beyond the encasing wood and cortex; it shows the

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[1] *Loc. cit.* p. 331.

[2] (A. 1), Palæontographica, vol. xxvi. pl. xlii. fig. 180.

[3] (A. 2), Palæontographica, vol. xix. pl. xxx. fig. 7.

[4] Mantell explains the repetition of Stokes and Webb's plates in his "Illustrations of the Geology of Sussex" in a note on page 52 of that work.

characteristic ridges of *Clathraria*. The petiole scars have rounded or truncate lateral angles, but those towards the lower part of the specimen have their lateral angles more acute; this is indicated in Carruthers' figure on the left of the pith cast. Probably specifically identical with specimen **V. 3309**, figured by Carruthers as *Bucklandia Mantelli*. Tilgate Forest.

8358. Figured by Stokes and Webb, *loc. cit.* pl. xlv. fig. 2. Mantell, *loc. cit.* pl. ii. fig. 2.

The figure of this specimen does not do full justice to the details shown on the stem surface. If some of the scars be compared with the lower petiole bases of **V. 3308** it will be found to be a matter of some difficulty, not to say impossible, to point to any distinct difference between the two forms, the former of which Carruthers speaks of as *Bucklandia Mantelli*, and the latter as *B. anomala*.

A second smaller specimen in the form of a slightly compressed hollow cast of the bark with weathered petiole bases, and on the upper portion bearing scars of scale leaves. Very similar to Mantell's pl. iii. fig. 4*a*. As shown in Mantell's figure, there is a distinct projecting ridge above the petiole scar, and separated by a depression from the main part of the petiole; this is probably due to the irregular or unequal weathering of sclerenchymatous and parenchymatous tissue. *Cf.* a stem of *Cycas*. Tilgate.

V. 3308. Figured by Mantell, Geol. S.E. England, pl. i. fig. 2, and by the same author in Illust. Geol. Sussex, pl. i. fig. 2.

Here again the figures do not do justice to the specimen. In this stem the petiole scars are clearly preserved and larger than in the other examples of the same species; they are not so much obscured, as in many specimens, by the irregular surface ridge and projections which Carruthers regards as the remains of a gummy exudation on the original plant stem. Some of the more prominent scales resemble the form which occurs in close association with **V. 2749**, and the lower portions of some of the larger scales suggest a reticulate marking like that in **V. 2749** and in several of the isolated scales. The lateral angles of the scars are for the most part rounded or obtuse, but in some the angles are much more acute. The form of many of the leaf base scars points to a partially decayed petiole rather than a clean-cut surface of a persistent corky base. *Cf.* Carruthers, *loc. cit.* pl. liv. fig. 1; *cf.* also *Fittonia.* Tilgate Forest.

V. 3309. Figured by Carruthers, pl. liv. fig. 4, as *Bucklandia Mantelli.*

In this specimen the two kinds of scars are clearly shown, also the increased diameter of the axis where the large scars occur. The lateral angles of the scale scars are more obviously truncate than those of the petiole bases. *Cf.* **46644.** Cuckfield.

V. 3310. Figured by Carruthers, pl. liv. fig. 2.

In describing this specimen Carruthers speaks of a "triradiate ridge" on the surface of the scars, but I am unable to recognize any such character; the markings are probably the result of some secondary changes and cannot be regarded as an original character.

V. 713. This specimen shows the clathrarian pith cast, as in **8262**, but much more clearly. The flattened internal cast has a length of 45 cm., and exhibits the usual surface features characteristic of *Clathraria Lyelli.* Part of it projects beyond the surrounding cortical cast, but it is enclosed to some extent by the remains of leaf bases, and between the cortical shell and the pith there is a space about 5 mm. in width, here and there filled with coal; this no doubt represents the portion of the stem originally occupied by woody tissue. The pith case is flattened and shows alternations of broader and narrower portions; the surface markings, in the form of narrower and tapered ridges, do not appear to be disposed with any regularity. The large leaf bases are approximately 3 cm. in depth and 4·3 cm. in breadth. Some of the leaf bases have projecting upper surfaces, as in **V. 3308**, suggesting partially decayed petioles, but in other parts of the stem the scars are much flatter and more like the clean-cut bases of detached fronds.

V. 713*a*. 23 cm. in length. In the broader and lower part of the specimen the petiole bases are fairly large, and have much the same form as in **V. 713.**

V. 713*b*. Poor specimen. On one side an irregularly marked surface is exposed, which probably represents the impression of the external portion of the wood. Hastings. *Dawson Coll.*

V. 2132*b*. Imperfect impression of a stem. Shows some resemblance to **V. 2132**, but differs in having two well-marked forms of scars, and in the absence of ramenta. Part of a scale in close connection with the stem, identical with **V. 2699**, etc. Mr. Rufford informs me that he has frequently found large scales, such as **V. 2799**, in association with this form of stem; the base of **V. 2799** might well have been in attachment with scars like those of the present specimen.

? **V. 2132*c*.** A small specimen showing petiole scars: this may be an example of *Bucklandia*, but it also closely resembles the genus *Fittonia*, and its precise nature must be a matter of uncertainty. Ecclesbourne. *Rufford Coll.*

V. 2749. Small piece of a stem with two or three fairly distinct petiole scars, and some narrow and longer scars to which scales were probably attached. A single detached scale, with the reticulate surface markings, occurs in close association with the stem. *Cf.* Carruthers, *loc. cit.* pl. liv. fig. 4 (*Bucklandia Mantelli*).

V. 2749*a*. In the lower part of the stem the petiole scars are shown with a flat surface, and higher up there appear to be casts of the lower portions of the petioles; the latter bear a strong resemblance to some of the smaller examples of scales. This, like many other specimens, shows a general resemblance to *Fittonia*. Ecclesbourne. *Rufford Coll.*

8372. Small specimen showing petiole scars. Tilgate Forest.

46644. A portion of a small stem with the scars characteristic of *Bucklandia*. Tilgate Forest. *Bowerbank Coll.*

V. 3311. Species showing narrow scale scars. *Cf.* Carruthers, *loc. cit.* pl. liv. fig. 4.

Cycadeomyelon (Bucklandia), sp.

V. 2332. Probably a portion of a pith cast; but the larger medullary ray impressions suggest some other stem than that with which the ordinary *Clathraria Lyelli* is occasionally found.

V. 2804. Considerably flattened sandstone cast. The form of the medullary ray impression and of the leaf-trace bundle is more distinctly shown than in most specimens. Schenk's figure also shows this feature clearly. The form of the medullary ray casts in Weiss' genus *Tylodendron* is very similar to that of the corresponding structures in the present specimen. Good figures of *Tylodendron* will be found in a paper on that genus by Potonié.[1] *Cf.* also similar casts in *Voltzia*.

V. 2804a. Similar specimen, but less flattened. Part of a scale at one end of the cast. Ecclesbourne. *Rufford Coll.*

8268, 12333. Portions of pith casts; probably of the lower portion of the stem axis. Tilgate Forest.

8264. Figured by Mantell, Illust. Geol. Sussex, pl. i.: 93 cm. in length; at broadest part the diameter is 13 cm. The details of surface characters not very clearly preserved. Tilgate Forest. *Mantell Coll.*

8269. 79 cm. long, diameter 13 cm. A large branched specimen, showing at the summit an apparently dichotomous bifurcation. In addition to the large branches, there are the scars of six or seven smaller lateral branches, about 2 cm. in length; the smaller scars are all on one side of the specimen and arranged in a fairly regular line. *Cf.* Göppert's figure of *Cycas revoluta* with the numerous large and small branches.[2] Tilgate Forest. *Mantell Coll.*

8274. 78 cm. long, 7·5 cm. in diameter. The breadth varies, but there is no regular alternation of narrower and thicker portions. Tilgate Forest. *Mantell Coll.*

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[1] Potonié (2).

[2] Göppert (3), pl. ix. fig. 3.

V. 3307. A long specimen with distinct constrictions at fairly regular intervals; the surface projections are rather broader than in many examples, and resemble those in **V. 2332**; they show a considerable variation in size, some being identical with the usual clathrarian form of medullary ray cast, and others larger and more prominent.

V. 3306. Here again there is a marked variation in the size of the ray impressions. A well-defined branch scar.

V. 713*c*. Hastings. *Dawson Coll.*

V. 1880. Near Hastings. *Dawson Coll.*

V. 2249. Ecclesbourne. *Rufford Coll.*

8272. Large specimen.

Genus **FITTONIA**, Carruthers.

[Trans. Linn. Soc. vol. xxvi. 1870, p. 690.]

This generic name was proposed by Carruthers for an unusually perfect specimen of a structureless cycadean stem, which was probably obtained from the Wealden of Brook, in the Isle of Wight. Mantell first figured and described this specimen as *Clathraria Lyelli* in his *Geological Excursions round the Isle of Wight*[1]; a larger and more complete figure appears in Carruthers' Monograph. The genus is thus defined:—

"Trunk short, obovate; woody axis slender, enlarging upwards; cortical layer large. Scales and bases of the petioles large, imbricated, at first reflexed, then ascending."

Carruthers notes the absence of any fruit or foliage which can be referred to this form of stem, but he considers the resemblance to *Encephalartos* sufficiently distinct to justify him assigning *Fittonia* to a position near to the living genus. Saporta adopts the name, and points out the resemblance between *Fittonia* and *Bucklandia*; he calls attention, however, to certain points

[1] p. 297.

of difference, and considers that Mantell's specimen has been correctly made the type of a new genus. In *Bucklandia* the stem appears to have been frequently branched, but no such habit is indicated in the specimens of *Fittonia*; in the latter genus the increase in size both of the petiole and scale-leaf bases, and of the lower portion of the petioles as well as the scale leaves, with the subsequent disarticulation of the upper part of the frond axis, constitute constant and characteristic features. The pith is large and surrounded by a narrow zone of wood. The scale leaves, associated here and there with the bases of fronds, are distinguished from the latter by their thinner distal margins, and the absence of any distinct surface of articulation. As Saporta remarks, there is a striking resemblance between some forms of *Fittonia* and *Bucklandia*; this similarity has already been noted in the descriptions of some of the Museum examples of the latter genus, and it is also clearly seen in Carruthers' type specimen in the Jermyn Street Museum of Practical Geology. It may be that the two genera are not really distinct, but merely represent different forms of preservation of very similar, if not identical, plants. In describing the single English specimen of *Fittonia*, Mantell quotes the opinion of Brongniart,[1] to whom a drawing of the fossil was sent, that it is probably the upper portion of a clathrarian stem with persistent petioles. It may be more convenient, with the evidence at present available, to retain both generic names, and to make use of *Fittonia* as a useful designation for a certain form of cycadean trunk.

Fittonia Ruffordi, sp. nov.

[Pl. IX. Fig. 6.]

Type. Large impressions of stems. British Museum.

The lower portion of the petioles persistent, showing a well-marked surface from which the upper part of the frond has been detached. The persistent and swollen bases are regularly disposed in the stem surface, and apparently without any alternation of petiole scars and scale-leaf scars.

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[1] Mantell (A. 7), Geol. Excurs. I. Wight, p. 298.

V. 2238. Pl. IX. Fig. 6.

18 cm. in length, 10 cm. broad. An impression of part of the lateral surface of a cycadean stem, covered with a carbonaceous layer. The petiole bases are shown with unusual definition, and the form of the surface of articulation is particularly clearly marked. The swollen portion or cushion below the petiole scar presents a fairly close resemblance to some forms of *Sigillaria Brardii*, Brong., with its similarly situated leaf-scar, which agrees closely in shape with that of *Fittonia*. The petiole base or cushion has a length of 1·7 cm. The form of the leaf-scar is practically identical with that of the cleanly-cut end of the frond of *Otozamites Göppertianus* as figured in Pl. I. Fig. 2. *Cf. Fittonia squamata*, Carr.,[1] and *F. insignis*, Sap.[2]; the present species differs from these in the smaller size of the leaf base and in their much more regular and uniform arrangement on the stem. Ecclesbourne. *Rufford Coll.*

V. 2121. 77 cm. long, 8–9 cm. broad. Here again the surface of the stem has been carbonized, and the petiole bases present a similar appearance to those in **V. 2238**, but are rather less perfectly preserved. The comparatively long and narrow form of the leaf base is clearly shown. Ecclesbourne. *Rufford Coll.*

V. 2244. 35 cm. long. Probably this may be referred to *Fittonia Ruffordi*, but the petiole bases are much less clearly preserved. In all the specimens the characteristic feature is the great length as compared with the breadth of the petiole bases. Ecclesbourne. *Rufford Coll.*

?**V. 3181.** Possibly a specimen of this species. Ecclesbourne. *Rufford Coll.*

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[1] Carruthers (1), pl. lvi.

[2] Saporta, Pal. Franç. vol. ii. pl. cxxv. figs. 1–3.

Genus **BENNETTITES**, Carruthers.

[Trans. Linn. Soc. vol. xxvi. 1870, p. 681.]

In 1855 the President of the Linnæan Society of that year, Robert Brown, exhibited a new form of cycadean stem which had been found by Saxby at Bonchurch, in the Isle of Wight.[1] The name *Cycadites Saxbyanus* was suggested by Brown for this new fossil, of which the two most striking features were the elliptical outline of the stem as seen in transverse section, and the presence of a bud in the axil of each leaf. Fifteen years after the discovery of this stem, Carruthers[2] published a full and scientific description of several examples of the same species. As a result of careful investigation of the morphology of these specimens, Carruthers instituted the generic name *Bennettites* for the new form of stem, which he found could not be classed under any of the recognized subdivisions of the Order *Cycadaceæ*. After speaking of the elliptical form of the axis and the presence of buds in the axils of many of the leaves, Carruthers proceeds to describe the anatomical structure of the stem, and calls special attention to the leaf-traces as affording another characteristic feature of the genus. "In all the known members of the Order (*Cycadaceæ*)," [3] says Carruthers, "the leaf-traces arise in the interior of the cylinder of wood, as bundles of small size, and, passing through the meshes of the ligneous cylinder, and then through the cortical parenchyma, as small distinct bundles, after running for a short distance, at least in some genera, in a horizontal direction parallel to the periphery of the stem, they pass in the petiole of the leaf." In *Bennettites*, however, "the vascular tissue for each leaf springs from the woody cylinder in a single large compact bundle, which as it passes outwards breaks up into the different bundles required for the service of the leaf." This peculiar behaviour of the leaf-traces is also referred to by Solms-Laubach[4] as an important distinctive character of

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[1] Brown, p. 130.

[2] (1).

[3] *Ibid.*

[4] (2), p. 422.

Carruthers' genus. The structure of the petiole bases and the ramenta-like scales has been fully described by Carruthers and others. In the axils of some of the petiole bases which surround the woody axis of the stem, there occur the lateral branches which constitute the most important and interesting feature of the genus. "These organs," writes Carruthers, "are not properly buds, for although they do not appear to have pushed themselves beyond the surfaces of the permanent bases of the leaves, they are fully developed organs, and differ from the secondary axes of *Mantellia*, which are generally broken off beyond the surfaces of the permanent bases of the petioles, and show there a woody cylinder agreeing in structure with the principal axis of the plant. The secondary axis consists of a very short and slender stem, bearing a number of simple linear acuminate leaves. These are the only foliar organs hitherto found connected with these fossils."[1] Each of the axillary branches terminates in a subpyriform enlargement, bearing seeds; this terminal portion with its seeds are fully described and illustrated by Carruthers and Solms-Laubach. The former author, in summing up the affinities of the genus, expresses the opinion that "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 *Coniferæ*."[2]

In his *Einleitung in die Paläophytologie* Graf Solms confirms many of the characteristics of *Bennettites* as described by Carruthers, and by a careful examination of the English material he is able to settle certain doubtful points, and to carry a stage further our knowledge of this interesting type.[3] A more detailed account was afterwards published by Solms in the *Botanische Zeitung*,[4] and the article subsequently appeared in English in the fifth volume of the *Annals of Botany*.[5] Without entering at length into a histological description of *Bennettites*, we may call attention to some of the more striking and characteristic features. The structure and course of the

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1 Carruthers, *loc. cit.* p. 697.
2 *Ibid.* p. 698.
3 Solms-Laubach (A.), p. 94.
4 *Ibid.* (1).
5 *Ibid.* (2).

leaf-trace as described by Carruthers, and the analogy which he noted between the trellis-work form of the vascular cylinder and the bundle system of a fern stem are confirmed by Solms; he adds, however, that a "closer examination will doubtless disclose a greater affinity with the course of the vascular bundles in many *Coniferæ*."[1] The pith and cortex are traversed by numerous and large gum-canals, and the stems are enclosed in the armour of leaf bases characteristic of recent cycads. Between the petioles of *Bennettites* and those of living cycads there is the closest agreement; the bases of the leaves are separated from one another by a felt of ramenta-like outgrowths from the petiole surface. Occasionally the substance of the petiole has rotted away, leaving deep cavities occupying the meshes in a network of intervening projecting ridges. In *Bennettites Gibsonianus* the structure of the lateral branches bearing the remarkable form of fructification is very perfectly preserved, and it is evident that we have to deal with a plant differing in many important respects from the present types of cycads. Referring to the cycadean character of the stem and leaf-stalk of *Bennettites*, Solms remarks: "We arrive at the surprising result that all the Jurassic and Neocomian stems which are termed *Cycas*-stems, so far as anything is known of their structure, belong to *Bennettiteæ*, and that not a single one of them has been proved to be a genuine stem of *Cycadeæ*. This further shows how precarious is the identification of fossil remains when it rests on superficial characters only."[2] The form of the lateral fructification branches may be summarized as follows: They occasionally arise exactly over a leaf base, but in some cases have been pushed somewhat to the side; as a rule it appears impossible to "determine the precise relative position of the two kinds of organs."[3] The flower-bearing shoots are, at all events, not terminal structures, as in recent cycads. Each fertile branch is made up of several short internodes, and bears spirally-arranged lanceolate acuminate bracts; in structure the bracts agree for the most part with the larger leaf bases of the

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[1] Solms-Laubach (2), p. 422.
[2] *Ibid.* p. 424.
[3] p. 431.

main stem. The apex of the fertile shoots has the form of a hemispherical parenchymatous cushion, from which are given off a number of closely crowded stalks united into a club-shaped group; between these stalks or seed-bearing cords there occur smaller structures, the so-called interstitial organs. External to these is a comparatively broad parenchymatous band of tissue, which arises from a lower level on the cushion than the cords and interstitial organs. Surrounding this homogeneous peripheral tissue we have several lanceolate bracts encircling the entire fructification. Towards the upper surface of the spadix, and near its periphery, there are numerous seeds situated just internal to the homogeneous tissue, which becomes rather more strongly developed towards the apex of the fructification. Each seed lies in a flask-shaped pit, and is borne on a long stalk or cord; in some seeds the structure of the embryo with its radicle, plumule, and two cotyledons, may be clearly recognized. Solms suggests that the homogeneous tissue which overtops the spadix and contains the seeds, has been formed by the union of interstitial organs. A surface view of the terminal portion of the fructification would present a number of areolæ, probably raised to the form of pyramidal projections, and between these areolæ or distal ends of interstitial organs, there would be seen the narrow openings leading to the flask-shaped seed cavities.

In his description of *Bennettites*, Solms compares its fructification with that described by Saporta and Marion as *Williamsonia Morierei* from the Oxfordian of Vaches-Noires. This French specimen, with its histological details preserved in unusual perfection, has recently been thoroughly examined and described by Prof. Lignier, of Caen. His description clearly shows that Saporta's and Marion's species must be referred to *Bennettites*, and is closely allied to the English species of that genus.[1] In the main Lignier's description agrees with those of Carruthers and Solms; there are, however, one or two points in which the French author's account is slightly at variance with that of the former writers. *Bennettites Morierei* has the form of a detached ovoid fossil, with a length of 55 mm. and a breadth

[1] Lignier. See also Seward (3) for a short abstract of Lignier's paper.

of 35 mm. At the base a fractured surface reveals the existence of a slightly convex receptacle, from which is given off a compact cluster of long peduncles, each of which bears at its apex an oval seed. The seed-bearing peduncles are surrounded by several involucral bracts closely applied to the surface of the fruit. Numerous thin lamellæ occur in association with the seminiferous peduncles; to these Lignier applies the term interseminal scales. The seeds are arranged side by side close to the upper surface of the mass of peduncles and interseminal scales; the latter passing between and beyond the seeds, and their swollen distal ends forming a protective covering to the blunt hemispherical apex of the fruit. In surface view, the upper part of the specimen appears to be made up of a large number of small projecting areas with polygonal bases and rounded summits. Here and there the projections arrange themselves in the form of rosettes round a small central cavity, marking the position of a seed.

As in *Bennettites Gibsonianus* the fruit is covered by involucral bracts, but we have the interesting suggestion of Lignier that these were not simply linear acuminate in form, but that the portion of the bracts preserved is merely the petiolar part of a leaf structure of which the pinnate or flabellate lamina has been detached. This inference is drawn from a detailed examination of the vascular strands traversing each bract. After comparing and contrasting *Bennettiteæ* with the *Cycadaceæ* and *Coniferæ*, Lignier concludes that they represent "a family which has been derived with the cycads from common ancestors, but not from the cycads themselves. Of these common ancestors the two families have preserved the form of the trunk, the structure of certain tissues, the foliar origin of the ovule, etc. But whilst the cycads have retained a grouping of carpophylls on a single axis, and have acquired special characters, such as the complication of the leaf-trace and the lateral position of the ovules, the *Bennettiteæ* have retained the simple leaf-trace and have acquired a terminal position of the ovules, the reduction of the fertile axes to single carpophylls, the grouping of these fertile reduced axes, and the modification of the neighbouring leaves."[1]

In a recent paper on fossil cycadean trunks from North

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[1] Lignier, *loc. cit.* p. 73.

America, Lester Ward[1] transfers Carruthers' species of *Bennettites* to Buckland's genus *Cycadeoidea*; he considers the fact of the fruit being known in a single species, *B. Gibsonianus*, is not a sufficient reason for the retention of the genus. Solms-Laubach[2] had previously restricted Carruthers' term to the species in which the characters of the fructification are known, viz. *Bennettites Gibsonianus*; this use of the term is probably the most convenient, and it would seem much better to retain Carruthers' name for stems bearing the bennettitean inflorescence than to include these under such a comprehensive and purely provisional genus as *Cycadeoidea*.

Bennettites (Cycadeoidea) Saxbyanus (Brown).

1851. *Cycadites Saxbyanus*, Brown, Proc. Linn. Soc. vol. ii. p. 130.
1854. *Cycadeoidea Saxbyana*, Morris, Brit. Foss. p. 7.
1870. *Bennettites Saxbyanus*, Carruthers, Trans. Linn. Soc. vol. xxvi. p. 698.
1874. *Bennettites Saxbyanus*, Schimper, Trait. pal. vég. vol. iii. p. 558.
1878. *Bennettites Saxbyanus*, Carruthers, in Dixon's Geol. Sussex, p. 281.
1894. *Cycadeoidea Saxbyana*, Ward, Biol. Soc. Washington, vol. ix. p. 80.

Type. Stems showing internal structure. British and Oxford Museums.

The specific name of this plant was proposed by Robert Brown in honour of Mr. Saxby, who found the first specimen near Bonchurch, in the Isle of Wight. The following definition of the species was given by Carruthers :—

"Trunk elliptical, with large medulla, and thin, much interrupted woody cylinder, vascular bundles passing upwards and outwards and breaking up into two rows of small bundles, which are parallel to the superior and inferior surfaces of the petiole; section of petiole subtriangular."

In accordance with the narrower use of the genus *Bennettites*, as suggested by Solms and others, the present species ought to be transferred to Buckland's *Cycadeoidea*, but for the present it may

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[1] Ward (1), p. 78.
[2] Capellini and Solms-Laubach, p. 29.

be better to retain Carruthers' generic name, and by the addition of *Cycadeoidea* to indicate our incomplete knowledge of the fructification. *Cycadeoidea* is employed, therefore, in the wider sense of the term, including stems with a circular as well as an elliptical transverse section.

46628 (**V. 3233**[1]). Figured by Carruthers, Trans. Linn. Soc. vol. xxvi. 1870, pl. lvii. fig. 3, as *Bennettites Saxbyanus*.

Length 21 cm.; at one end the specimen shows the transverse and polished section as represented in Carruthers' figure; at the opposite end the stem has been considerably worn. The varying degrees of wearing in this specimen show remarkably well the striking differences in appearance presented by the several surfaces of cortical or woody tissue exposed to view. Carruthers calls attention to the striking similarity "between these fossil stems and the caudex of a tree fern"[2]; the U-shaped petiolar bundles shown in section on part of the specimen present a distinct resemblance to the corresponding leaf-traces in fern stems. Brook Point, Isle of Wight. *Saxby Coll.*

V. 3234. Figured by Carruthers, *loc. cit.* pl. lvii. fig. 4.

The surface of the specimen shows fairly good sections of petioles with numerous vascular bundles; the portion represented in Carruthers' figure shows the inner face of the wood, and a radial section through the cortex in which the course of the leaf-trace bundles is clearly seen. I am unable to detect any difference between the present specimen and that bearing the number **38360**, which has been labelled by Carruthers *Bennettites Gibsonianus*. In his definition of *B. Saxbyanus*, Carruthers speaks of the petioles as subtriangular in section, whilst those of *B. Gibsonianus* are described as subquadrangular. Each of the above specimens shows both forms of petioles, and in other respects there appear to be no real differences.

V. 3235. Figured (in part) by Carruthers, *loc. cit.* pl. lvii. fig. 7.

The figure shows very clearly the form of the petiole bundles as seen in a tangential section of the cortex. The resemblance

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[1] A second number recently added (1895).

[2] Carruthers, *loc. cit.* p. 696.

between these bundles and the leaf-traces of *Protopteris punctata*, Sternb., is fairly close. Other portions of this specimen demonstrate very clearly the mode of origin and course of the petiole bundles. The tangential section of the wood, close to the inner (pith) face, presents the same appearance as figured by Carruthers (pl. lvii. fig. 6).

V. 3236. Figured by Carruthers, *loc. cit.* pl. lvii. figs. 1 and 2. The figured portion is the smaller half of a fine specimen in the Museum Collection. The surface is made up of triangular cavities which constitute the meshes in a network of projecting ridges of interpetiolar ramenta. A few inflorescences, or rather the cavities originally occupied by inflorescences, are seen in surface view, and also in the longitudinally cut face represented in Carruthers' figure. The woolly or finely fibrous ramenta appear to be identical with the corresponding interpetiolar structures in some specimens in the Rufford Collection from Ecclesbourne (*cf.* **V. 3177**, **V. 2349**, and **V. 2132**). There is a distinct similarity between the slightly raised base forming the floor of one of the inflorescence cavities, and the rounded receptacle seen in some of the Ecclesbourne examples of isolated inflorescences (*Bennettites* [*Williamsonia*] *Carruthersi*), *e.g.* **V. 2129*b***, etc. Brook Point.

38363. A waterworn specimen showing petiole base projecting somewhat beyond the ramental network. *Cf.* **V. 3234** (pl. lvii. fig. 4) and **38360.** Solms[1] refers to this and some other specimens as no doubt examples of *Bennettiteæ*, but without traces of fructification. An old label on the specimen gives Tilgate as the locality; this has been altered to Brook. Brook. *Mantell Coll.*

Cf. Bennettites Saxbyanus.

V. 2132. Part of a large stem, resembling the specimen of *Bennettites Saxbyanus* figured by Carruthers in pl. lvii. fig. 3. The external surface shows numerous imperfectly preserved leaf

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[1] Solms-Laubach (2), p. 426.

bases. Between the petioles there appears to have been a fairly wide space occupied by ramenta. A side view of the specimen shows the inward prolongation of some of the petioles, and demonstrates that the so-called bases as seen on the surface simply represent the level in the leaf armour to which disorganization has extended. The inner face of the block is probably the outer surface of the wood. No fructification seen. Ecclesbourne. *Rufford Coll.*

Bennettites Gibsonianus, Carr.

1851. *Clathraria Lyellii*, Mantell, Petrifactions, p. 46.
1854. *Clathraria Lyellii*, Mantell, Medals, vol. i. (edit. 2), p. 163.
1854. *Clathraria Lyellii*, Mantell, Geol. Excurs. I. Wight, p. 214.
1870. *Bennettites Gibsonianus*, Carruthers, Trans. Linn. Soc. vol. xxvi. p. 700.
1874. *Bennettites Gibsonianus*, Schimper, Trait. pal. vég. vol. iii. p. 559.
1878. *Bennettites Gibsonianus*, Carruthers, in Dixon's Geol. Sussex, p. 281.
1890. *Bennettites Gibsonianus*, Solms-Laubach, Bot. Zeit. 1890, p. 789, pls. ix. and x.
1891. *Bennettites Gibsonianus*, Solms-Laubach, Annals Bot. vol. v. p. 419, pls. xxv. and xxvi.
1894. *Bennettites Gibsonianus*, Lignier, Mém. Soc. Linn. Normandie, vol. xviii. p. 76.
1894. *Cycadeoidea Gibsoni*, Ward, Biol. Soc. Washington, vol. ix. p. 80.

Type. Portions of a large block showing internal structures. British Museum and Kew.

The specimens on which Carruthers founded this species are recorded by him as of Lower Greensand age, and Solms-Laubach has since confirmed this determination.[1] The examples of *B. Saxbyanus* are regarded as Wealden, and were obtained from Brook Point, in the Isle of Wight; *B. Gibsonianus* was found in Luccomb Chine, Isle of Wight, by Mr. Gibson. Some of the specimens which Carruthers has referred to the present species are apparently from Brook, and from the same beds as *B. Saxbyanus*.

Carruthers defines the species as follows :—

"Trunk compressed, elliptical, with small medulla, and a thick subcontinuous woody cylinder; vascular bundles passing almost

[1] Solms-Laubach (2), p. 429.

directly outwards and breaking up into a double series of small bundles, which are parallel to the superior and inferior surfaces of the petiole, except that a loop is sent down from the upper series into the centre of the petiole. The section of the petiole is sub-quadrangular."

Lignier has recently extended this definition to include the characteristic features of the inflorescence; he makes the following addition to the above diagnosis [1]:—

"*Fruit* haut de 3 centim. ½. *Bractées involucrales* lancéolées, acuminées, dépourvues de limbe. *Poils écailleux* peu larges, souvent ventrus, à cellules allongées perpendiculairement aux faces. *Graines* longues de 3 à 4 millim., larges de 1·2 à 2·5, non anguleuses (ou à peine anguleuses), dépourvues d'épiderme rayonnant. Assise réticulée scléreuse et formée de cellules qui ont 60 μ de longeur sur 50 μ de large."

The following specimens are included here as somewhat doubtful examples of *Bennettites Gibsonianus*:—

38360. Figured by Mantell as *Clathraria Lyellii*, Medals of Creation, vol. i. 1854 (edit. 2), p. 163; Petrifactions and their Teachings, 1851, p. 46; Geological Excursions round the Isle of Wight, 1854, p. 214.

The old label on this specimen gives Tilgate Forest as the locality, but Carruthers has substituted Brook Point. The preservation of this waterworn example is very different from that of the larger blocks of *Bennettites*. The surface, as figured by Mantell, shows the characteristic ramental network with the meshes occupied by petiole bases. Towards the right-hand upper corner of the specimen there appears to be an inflorescence shown on the waterworn surface. In the absence of any well-defined inflorescence, and in view of the striking similarity to, if not identity with, **V. 3234** (labelled by Carruthers *B. Saxbyanus*), it will be better to regard the exact position of this specimen as somewhat doubtful. Solms [2] quotes Mantell's description of this fossil, and says he believes he recognizes the specimen in the British Museum (Geological Department) Collection as one on which the word "Brook" is written in ink on the upper surface. There

[1] Lignier (1), p. 76.
[2] *Loc. cit.* p. 420.

can be no doubt as to the original of Mantell's figure; the fact of its being figured is recorded on the label, but there is no word "Brook" written on it. No doubt Solms is referring to some other specimen; in another place the same author speaks of Mantell's figure as a very good representation of a specimen in the Geological Department.

38361 and **38362.** Solms[1] refers to this specimen (cut into two pieces, bearing the above registered numbers) as being without fructification. On the smaller piece there appears to be inflorescences shown in transverse and longitudinal section. The label on one piece bears the name *Clathraria Lyellii*. Possibly this specimen should be referred to *Bennettites Saxbyanus*.

V. 3232. Another waterworn specimen cut into three pieces, one transverse slice and two larger portions. It would seem impossible to definitely refer this imperfect example to one or other species of *Bennettites*.

Bennettites (Cycadeoidea), sp.

[Pl. XV.]

V. 3177. The chief interest of this specimen is in the numerous casts of inflorescences which occur on the stem. The surface features cannot be accurately made out; the portions shown in Pl. XV. Fig. 1 exhibit the conical cavities originally occupied by the fertile axes, and the impressions of petioles and ramental tissue. The whole surface presents a somewhat waterworn appearance, and instead of showing a surface view of the petiole bases in the form of rhomboidal sections, it has the form of a worn-down surface with an oblique view of petiole casts and ramental tissue.

In longitudinal section the fertile axes have the form of cavities narrowed towards the distal end; these cavities were no doubt originally occupied by the fleshy terminations of inflorescences. The wall of such a cavity (Pl. XV. Fig. 3) shows clearly preserved

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[1] *Loc. cit.* p. 426.

casts of the bases of crowded involucral bracts. The bracts themselves are represented partly by cavities and partly by carbonaceous matter; between the bracts the woolly or hair-like ramenta are distinctly shown, and these, as frequently happens in such tissue in cycadean stems, have been permeated by a mineralizing solution, and so preserved. The bracts appear to be somewhat expanded distally (Pl. XV. Fig. 2), as described by Lignier in *Bennettites Morièrei* (Sap. and Mar.).[1] In Pl. XV. Fig 3 an inflorescence cast is shown, of which the surface is covered by a fine and well-marked reticulation; in the upper portion of the cavity this reticulum has the form represented in Fig. 5, a fairly regular network formed by thin plates projecting from the surface, and some of the meshes are partially filled by round or oval bodies suggesting very small seeds; the meshes thus filled are less angular than those without seed-like bodies. In Fig. 4 is shown a wax cast of the inflorescence cavity of Fig. 3, and in Fig. 6 the small dot-like depressions on the surface of the cast correspond to the small bodies in the meshes of Fig. 5. Towards the base of Fig. 4, the reticulum is rather larger, and there are no dots in the more basal portion, owing to the absence of any "seeds" in this part of the inflorescence (Fig. 7). In the middle of one side of this reticulately marked cavity there is a narrow longitudinal ridge, probably representing a median groove in the inflorescence. The portion of inflorescence figured in Pl. X. Fig. 4, should be compared with the present specimen. Further reference is made to this stem in the description of the detached specimens referred to a new species, *Bennettites Carruthersi*. *Cf.* Pl. X. Figs. 1 and 4, and Saporta's figures of *Williamsonia gigas*, Carr., in the Pal. Franç., vol. iv. pl. xiii. fig. 2, and pl. xiv. figs. 1 and 2. Ecclesbourne. *Rufford Coll.*

V. 2896. Imperfectly preserved stem, 26 cm. in length, and 20 cm. in broadest part; leaf-stalks and ramenta shown, but no inflorescence. *Beckles Coll.*

V. 2816. Smaller specimen; no actual stem surface visible. The woolly ramenta suggest a connection with **V. 2132** and *B. Saxbyanus* (Brown). Ecclesbourne. *Rufford Coll.*

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[1] Lignier (1), p. 25.

Bennettites (Williamsonia).

FLORES.

In the Rufford collection of Wealden plants from the neighbourhood of Hastings, there are several specimens which must be assigned to the same position as the well-known Jurassic *Williamsonia.* For reasons which are stated more fully below, I have referred these Wealden fossils to the genus *Bennettites,* and am led to regard them as portions of the inflorescence of that plant. Hitherto typical Williamsonias have not been recorded from any Wealden or Lower Cretaceous rocks in England; the importance of the discovery is considerably increased by the fact that the specimens appear to throw some new light upon the nature and affinity of this anomalous form of inflorescence. Before describing the individual fossils in detail, it may be convenient to give a short summary of our present position with regard to the opinions of palæobotanists on the nature of *Williamsonia.*

In *A Geological Survey of the Yorkshire Coast,* by Young and Bird, published in 1822, there is a figure of a specimen from the ironstone of Saltwick, which is spoken of as resembling the head of an artichoke (*Cynara integrifolia*), with the "covering or calyx consisting of numerous lanceolate and striated leaves."[1] Another figure in this work represents "a petrified nut of a singular kind"; these two fossils are examples of what was subsequently named *Williamsonia.*[2]

Part of a cycadean frond from the "Oolitic rocks of Scarborough" is figured by Lindley and Hutton, and named by them *Zamia gigas*[3]; a few years later Williamson notes the occurrence with this form of frond of "a remarkable fossil, apparently connected with the fructification of a *Cycas.*"[4] In 1849 Yates[5] draws attention to the identity of *Zamia gigas,* L. and H., *Zamia Mantelli,* Brong., and *Cycadites lanceolatus,* Phill. He recognizes the difficulty of connecting the leaves and stem with the peculiar form of inflorescence associated with them, and while favouring the view

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1 Young and Bird, pl. ii. fig. 6, p. 183.

2 *Ibid.* pl. iii. fig. 7, p. 186.

3 Fossil Flora, vol. iii. pl. clxv.

4 Williamson (1), p. 230.

5 Yates.

that *Zamia gigas* and the fructification are parts of the same plant, admits the absence of any actual proof. In the same year Mantell[1] figures a specimen of *Williamsonia* in his *Medals of Creation*, as the fruit of *Zamites lanceolata*, and describes the lanceolate involucral bracts as concealing the seeds of the inflorescence. In a short communication to the Yorkshire Philosophical Society, Williamson gives a vertical section of a restored inflorescence, and represents the ovoid body of the fructification as terminating in a cone.[2] Brongniart calls attention in his *Tableau*,[3] to the similarity between the Scarborough fossils and a specimen described by Buckland[4] from the Inferior Oolite of Charmouth, Dorset, under the name of *Podocarya*. This comparison is one which has, I believe, been justified by recent investigations, and it is highly probable that Buckland's specimen is a particularly well-preserved bennettitean inflorescence. It is to be hoped that this valuable specimen may be rediscovered,[5] and subjected to a careful examination.

The name *Podocarya* was chosen by Buckland for this Oolitic fossil, on the suggestion of Robert Brown. It is described as chiefly resembling the inflorescence of the recent genus *Pandanus*, and by most subsequent writers it is included in the *Pandanaceæ*. Saporta,[6] in his volume on *Types proangiospermiques*, reproduces Buckland's figures, and substitutes *Williamsonia* for *Podocarya* as the generic name; Unger[7] had previously named the species after Buckland.

In a specimen figured by Leckenby in 1864[8] we have leaves of *Palæozamia pecten* (Lind.) in close association with a small form of *Williamsonia*, which Nathorst afterwards referred to the new species *Williamsonia Leckenbyi*. Carruthers,[9] writing

[1] Mantell (1), p. 161.

[2] Williamson (2), p. 47.

[3] p. 88.

[4] Buckland (2), vol. i. p. 466, pl. lxxxiv.

[5] It is said to be in the Oxford Geological Museum, but cannot be found.

[6] Pal. Franç. vol. iv. p. 127, pl. ccxxxviii. figs. 1–3, and pl. ccxxxix. fig. 1.

[7] Unger (A. 2), Gen. spec. plant. foss. p. 327.

[8] Leckenby (A.), Quart. Journ. Geol. Soc. vol. xx. p. 77, pl. ix. fig. 4*a*. This specimen is in the Woodwardian (Geological) Museum, Cambridge. It agrees closely with Williamson's "carpellary disk" of *Williamsonia gigas*, Carr., except in its smaller size.

[9] Carruthers (3). This paper was also printed in the Geol. Mag. vol. iv. 1867.

in 1867, refers to the opinions of Yates and Williamson, and adds: "I have examined numerous specimens of this fossil (*Williamsonia gigas*) in the British Museum, but have been unable to determine anything satisfactorily in regard to the precise structure of this anomalous fruit. It presents so many peculiarities unknown in the fruit of any modern cycad, that for the present at least, and notwithstanding its *Zamia*-like leaves, I must consider it a doubtful cycad."

In the volume of the Linnean Society's Transactions for 1870 we have the first exhaustive treatment of this Oolitic fossil.[1] From his intimate knowledge, both of the fossils and their manner of occurrence in the rocks of the Yorkshire coast, Williamson was peculiarly fitted to attack this difficult problem. Williamson describes and figures what he regards as the stem of *Zamites gigas*, L. and H.; the surface is made up of broad lozenge-shaped areas, and is compared with the trunk of a recent *Cycas*. One example is referred to as "obviously the apex of a stem with portions of seven or eight diverging fronds." The fronds are next described, also certain structures spoken of as the "squamous peduncles" of the fructification. The greater part of the paper is, however, devoted to a detailed examination of the "organs of fructification." Surrounding the ovoid inflorescence we have a number of linear bracts constituting an involucrum; usually these involucral leaves have been broken off towards the base, and immediately below the broken ends there is exposed an annular area of "radiating cells." In pl. lii. fig. 7, Williamson represents a specimen in which the bracts have been completely preserved and are continued to the base of the fructification. The central part of the whole structure is occupied by a pyriform cavity which contracts apically, and then expands into a funnel-shaped appendage. In one of the figured specimens the form of this central cavity is clearly seen, and from its being filled with carbonaceous matter, it is assumed that the axis was originally a solid structure. A very similar appearance is presented by one of Rufford's recently discovered specimens.[2] The ring of radiating cells seen at the base of most of the examples is considered to be the lowest margin of a layer

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[1] Williamson (3).

[2] Fig. 8, p. 16.

of cells which "formed a cortical layer, arranged vertically upon and extending over the entire surface of the pyriform axis." In another type of specimen figured by Williamson, we have a disk-shaped structure with a central depression, and split up peripherally into several short and narrow segments; this is named the "carpellary disk," and towards the apex of each of these rays there are said to be two small pits on the lower surface. These pits are regarded as the places of attachment of ovules; but it is now generally agreed that there is no good evidence for the existence of well-defined depressions which could be described as marking the position of seeds. The general conclusion arrived at, and expressed by a restoration of the whole plant, is that the two forms of fructification are probably the male and female organs of *Zamites gigas*; the commoner ovoid fossil being the male flower, with a pyriform axis originally invested by a deciduous antheriferous tissue, and the female flower being represented by the much less abundant "carpellary disk," with the ovules inserted in pits towards the tips of the star-like rays.

As a convenient provisional name for these anomalous structures Carruthers instituted the genus *Williamsonia*, and placed it in a new tribe—*Williamsoneæ*. The genus is thus defined:[1] "Stem cylindrical, elongated, marked with the equal-sized, tumid, rhomboidal scars of the fallen leaves. *Leaves* ovate-lanceolate or linear acuminate, segments numerous, attached to the rachis by the central portion, with small free margins; veins numerous, parallel, at the base slightly diverging into the free margins. *Flowers* terminal, stamens surrounding a fleshy axis, ovules borne on the upper surface of an orbicular laciniate spadix."

Carruthers thus expresses himself with reference to Williamson's work: "He has introduced a clearer apprehension of the different forms of the supposed organs of reproduction, by the suggestion that the two kinds represent the different sexes, and by the discovery of a seed-bearing spadix."[2] In the second volume of his *Plantes Jurassiques*, Saporta considers the problem of *Williamsonia*,[3] and denies the existence of any satisfactory grounds

[1] Carruthers (1), p. 691.
[2] *Ibid.* p. 692.
[3] Saporta, Pal. Franç. vol. ii. p. 53.

for the supposed connection between the fronds of *Zamites gigas*, the cycadean stem, and the floral structures; the last-mentioned he prefers to regard as some primitive form of a monocotyledonous inflorescence, probably a pandanaceous type, analogous to *Yuccites*, *Podocarya*, *Eolirion*, etc.

In the *Palæontologica Indica* there have been described by Oldham and Morris,[1] and afterwards by Feistmantel,[2] various specimens of *Williamsonia*. The latter author figures certain cycad-like stems found in association with the *Williamsonia* fossils as belonging to the plant which bore the *Williamsonia* inflorescence. Further additions to our knowledge of the distribution of this fructification were made by Nathorst in 1880,[3] and he put forward the opinion that *Williamsonia* should be placed with the *Balanophoreæ*. This idea he afterwards abandoned, and in a later paper[4] upholds the view that *Williamsonia* was the inflorescence of a plant bearing cycadean fronds. He gives a restoration of *Anomozamites minor* (Brong.) bearing in the forks of a branched stem large flowers of the type *Williamsonia angustifolia*, Nath. The restored species presents an appearance certainly more suggestive of some extinct form of plant than of anything at present in existence.[5] Nathorst associates his other species, *W. Leckenbyi*, with *Anomozamites Lindleyanus*, Schimp., and connects *W. gigas*, Carr., with *Zamites gigas*, L. and H., adding that possibly Braun's *Weltrichia* may be regarded as the inflorescence of *Otozamites*. In another place[6] the same writer refers to the likelihood of a connection or identity of *Bennettites* and *Williamsonia*.

In Zigno's second volume of the *Flora fossilis formationis Oolithicæ*,[7] certain specimens from Italian rocks are described under the new generic name of *Blastolepis*; the figures of the two species of this genus, *B. otozamitis* and *B. falcata*, Zig., are strikingly suggestive of Carruther's genus. There can be little doubt that these specimens should be assigned to the genus *Williamsonia*.

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[1] Oldham and Morris (A), p. 32, pl. xxxii. fig. 12.

[2] Feistmantel (2). [3] Nathorst (3). [4] *Ibid.* (4).

[5] Since this was written, I have had an opportunity of examining Nathorst's specimens, and can bear testimony to the accuracy of his description.

[6] *Ibid.* (1), p. 97.

[7] Zigno (1), p. 173, pl. xlii. figs. 9–11.

In a recent volume of the *Plantes Jurassiques*, Saporta [1] gives a full account of the *Williamsonia* question, and discusses at length such views as have been advanced as to the nature of the genus. Several of the Yates' specimens, now in the Paris Museum (Jardin des Plantes), and many others are figured in Saporta's monograph. Some of these figures were originally drawn for Brongniart,[2] whose intention it was to publish a memoir on the subject. In addition to this very important contribution by Saporta, reference should be made to a paper by him in conjunction with Marion in the Comptes Rendus for 1881,[3] and also to the account by the same authors in *L'Évolution du règne végétal.*[4] The genus *Williamsonia*, with *Yuccites*, *Goniolina*, *Weltrichia*, and others, is included in the special class of "Types proangiospermiques." "Ces types sont appelés par nous des Proangiospermes, parce, qu'ayant en réalité précédé dans l'ordre des temps les Angiospermes véritables et ne pouvant être classés méthodiquement parmi ces dernières, ils se distinguent pourtant très nettement de tous les végétaux passés en revue jusqu'ici, et qu'ils s'écartent à la fois et des Cryptogames et des Gymnospermes, n'ayant d'ailleurs de points de contact appréciables ni avec les Cycadées, ni avec les Salisburiées, encore moins avec les Conifères."[5] As an introduction to the examination of the genus, Saporta writes:[6] "Avec les *Williamsonia* nous abordons un des problèmes les plus difficiles, un des sujets les plus controversés, mais aussi les plus curieux, peut-être même le plus remarquable de tous ceux que nous offre l'ensemble des plantes jurassiques." He agrees with Brongniart that *Williamsonia* is probably generically identical with Buckland's *Podocarya*. Some of Williamson's conclusions he does not accept; the "carpellary disk" of that author, Saporta regards as a terminal expansion of the male spadix. One important point to note in reference to Saporta's conclusions is his interpretation of two forms of specimens; that figured by Williamson in his pl. lii.

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[1] Pal. Franç. vol. iv. 1891.
[2] *Ibid.* p. 90 (footnote).
[3] Saporta and Marion (1).
[4] *Ibid.* (2), Les Phanérogames, vol. i. p. 235.
[5] Saporta, Pal. Franç. vol. iv. p. 63.
[6] *Ibid.* p. 89.

figs. 3–6 [1] is described as the male inflorescence, and another form, of which several figures are given in the *Paléontologie Française*, is regarded as the female inflorescence. Like Williamson, Saporta sees in the fibrous layer at the base of the common form of *Williamsonia* an antheriferous tissue; the pyriform central axis he describes as expanding distally into a large structure like that figured by the English writer as the carpellary disk; this terminal expansion appears to have been readily separated by a natural surface of disarticulation from the rest of the axis. In the whole inflorescence, according to Saporta and Marion, we have a male involucre surrounding a conical axis with its base enclosed in a circular zone marked by radiating striæ; the external edge of this zone being occupied by a number of small compartments of an irregular hexagonal form, which seem to correspond to pollen-sacs. The basal zone represents the sterile and persistent portion of an androphore, which, when complete, covered the whole of the conical receptacle with a layer of staminal appendages. In the female inflorescence the bracts are somewhat shorter; the centre was occupied by a more or less globular axis, having its surface marked out into a number of compartments arranged in the form of facettes grouped in rosettes; the general appearance of the whole structure being very similar to that presented by Buckland's *Podocarya*. The ovules were situated in subcortical cavities, which communicated with the surface by small openings; the latter appearing as the central points of groups of comparatively small meshes of the superficial reticulum. In 1869 Morière described a petrified fruit from the Oxfordian beds of Vaches-Noires (Calvador),[2] and this specimen is regarded by Saporta and Marion as throwing considerable light on the nature of *Williamsonia*. The recent examination of this specimen by Lignier [3] has already been alluded to; his work has afforded us very important data with regard to the connection between *Bennettites* and *Williamsonia*.

Saporta draws attention to a close resemblance between the terminal infundibuliform expansion of *Williamsonia* and the fossil

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[1] Williamson (3).

[2] Morière, pl. ii. fig. 4.

[3] Lignier (1).

dealt with many years ago by Braun.[1] Braun's genus *Weltrichia* was instituted for a specimen discovered in the neighbourhood of Baireuth, and referred to as a new genus of the *Rhizantheæ*. Schenk [2] expresses himself as very sceptical as to the correctness of Braun's description of this fossil, and does not consider it of any scientific value.

In discussing the systematic position of *Williamsonia* and other genera, Schenk very reasonably calls attention to the absence of any satisfactory evidence in favour of a pandanaceous alliance; he suggests that possibly *Bennettites* and *Williamsonia* should be classed together, but refers to the absence of histological characters as a serious obstacle to any decided conclusion. In Zittel's *Handbuch*, Schenk [3] refers to *Williamsonia* as the female inflorescence of *Bennettites*, and refers to Nathorst's and Solms' work in support of this opinion. Solms-Laubach [4] agrees with Nathorst and Saporta & Marion as to the absence of trustworthy evidence of the connection between *Zamia gigas* and *Williamsonia*. After referring to Morière's important specimen, he concludes: [5] "I have no doubt, therefore, that this specimen belongs to *Bennettites*, but in saying this I have no intention of prejudging the question of its relation to *Williamsonia*; for it is still possible that further discoveries may show the fructifications of *Bennettites* and *Williamsonia* both belong to similar stems resembling the stems of *Cycadaceæ*, and confirm the opinion of Williamson and Carruthers. But until the truth of these conjectures is ascertained, we must be content to leave the relationship of *Williamsonia* undetermined." In another place, Solms [6] draws attention to the probability that we have long been familiar with the male inflorescence of *Bennettites* in the fossil known as *Williamsonia*.

In his account of *Bennettites etrusca*, Cap. and Solms,[7] Solms figures and describes certain boat-shaped sacs which he regards as pollen grains. He goes on to say that, if his interpretation of these structures be correct, the inflorescence of *Bennettites*

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[1] Braun (1).

[2] Schenk (A. 8), p. 190.

[3] Zittel (A.), Handbuch, p. 805.

[4] Fossil Botany, p. 370.

[5] *Ibid.* p. 372.

[6] Note on *Bennettites* in Saporta's Pal. Franç. vol. iv. p. 303.

[7] Capellini and Solms, p. 202, pl. v. figs. 7 and 8.

apparently bore anthers and pollen grains in its early stage of development, and afterwards assumed the female condition. The figures of isolated "pollen grains" are not thoroughly convincing; but if Solms' opinion be correct, we have a most important addition to our knowledge of this interesting genus.

My examination of the Wealden examples of *Williamsonia* leads me to support the view that this problematical fossil is generically identical with *Bennettites*, and so far as our evidence goes, we are, I believe, justified in regarding the former genus as a form of inflorescence of the same type as that which has been found in organic union with bennettitean stems. This opinion is chiefly based on the Wealden forms, but if the suggested relationship or identity of these with *Bennettites* be admitted, we have a very strong case for including the Jurassic species in the same category. A critical discussion of the Oolite specimens must be deferred until the French material has been studied; such a question will be best dealt with in a later volume devoted to the Jurassic flora.

As regards the question of male and female inflorescences, I am unable to recognize any sexual difference in the various examples from the Wealden beds, and there does not seem to be any good reason for regarding the so-called male Williamsonias among the Jurassic specimens, as in any way proved to be of that nature. In comparing *Williamsonia* with *Bennettites* we have to rely entirely on the female inflorescence of the latter plant, and it would seem that so far as our present evidence goes, we have more reason for speaking of *Williamsonia* as the female inflorescence. As to the nature of the male inflorescence we are still without any very satisfactory evidence.

The following records have been made of *Williamsonia*, showing a fairly wide distribution; but probably some of these species cannot well be retained as trustworthy examples of the genus.

ENGLAND.	*Williamsonia gigas*, Carr.	Inferior Oolite.
	W. Leckenbyi, Nath.	" "
	W. Bucklandi (Ung.).	" "
FRANCE.	*W. Pougneti*, Sap.	Lower Lias.
	W. Morièrei, Sap.	Oxfordian.
	W. pictaviensis, Sap.	"
	W. Zeilleri, Sap.	Kimmeridgian.
	W. Gagnierei, Sap.	Portlandian and Purbeckian.
PORTUGAL.	*W. minima*, Sap.	Lower Cretaceous.

SWEDEN (SCANIA).	*W. angustifolia*, Nath.	Rhætic.
BORNHOLM.	*W. Forchhammeri*, Nath.	Jurassic.
GREENLAND.	*W. cretacea*, Heer.	Cenomanian.
ITALY.	*W. (Blastolepis) otozamitis*, Zig.	Inferior Oolite.
	W. (Blastolepis) falcata, Zig.	,, ,,
	W. (Blastolepis) acuminata, Zig.	,, ,,
CANADA.	*W. recentior*, Daws.	Middle Cretaceous.
	Williamsonia?	Neocomian.
AMERICA.	*W. virginiensis*, Font.	Potomac.
	W. elocata, Lesq.	Dakota.
	W.? Riesii, Hollick	Cretaceous.
INDIA.[1]	*W. Blanfordi*, Feist.	Kach (Umia beds; Up. Oolite).
	W. cf. *gigas*, Carr.	Rajmahal (Lias).
	W. microps, Feist.	,, ,,

The second English species, *W. Leckenbyi*, is founded on a small rayed disk like the large "carpellary disk" of Williamson, and is regarded by Saporta as a lobed terminal expansion and not an involucre as suggested by Nathorst. Saporta considers it possible that the forms referred to this species may be simply a "morphological variation"[2] of *W. gigas*.

Buckland's *Podocarya* is transferred by Saporta to *Williamsonia*,[3] and it is highly probable that this plant is a bennettitean inflorescence.

The French species *W. Pougneti*, Sap.,[4] is founded on an imperfect specimen which does not admit of any exact determination, and hardly justifies the institution of a new species. *W. Zeilleri*, Sap.,[5] is also founded on a very poor specimen, and cannot be diagnosed with any exactness. *W. minima*, Sap.,[6] recently described from Portugal, is represented by an imperfect cluster of small bracts, and cannot be accepted as a satisfactory record of the genus.

Saporta has pointed out that Heer's species, *W. cretacea*, from Greenland, shows many points of divergence from the typical

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[1] A fossil figured by Sharpe as *Asterophyllites*? from South Africa resembles an involucre of *Williamsonia*; but Hooker's description of the specimen is more suggestive of such a genus as *Schizoneura* (Sharpe, Trans. Geol. Soc. vol. vii. [2], p. 227). I am indebted to Prof. Rupert Jones for calling my attention to Sharpe's figure.

[2] Saporta, Pal. Franç. vol. iv. p. 167.

[3] *Ibid.* p. 127.

[4] *Ibid.* p. 124, pl. ccxxxvii.; see also Saporta and Marion (2), vol. i. p. 234.

[5] *Ibid.* p. 181, pl. ccxxxiv. fig. 3.

[6] Saporta (1), p. 105, pl. xix. fig. 9.

form;[1] it may possibly be an inflorescence of some cycad-like stem, but is far from satisfactory.[2] One of the forms figured by Zigno[3] (*Blastolepis acuminata*) is named by Saporta[4] *W. Italica.* Dawson's *W. recentior* is an exceedingly poor specimen and hardly worthy of any name.

It is difficult in the case of some of the above fossils to precisely define their geological horizon. The Bornholm species, *W. Forchhammeri*, Nath.,[5] is from beds which have recently been shown by Bartholin to contain 46 species of plants, of which 25 are regarded as Rhætic, and about 15 as indicating a Lower Oolitic age.

The fragment described by Dawson[6] as *W. recentior* is from the Canadian Middle Creek series, which is compared with the Patoot series of Greenland and the Dakota group of the Western United States.

The unnamed *Williamsonia* is from the Kootanie formation, which is correlated with the Neocomian of Europe.[7]

Fontaine's Potomac series includes rocks differing somewhat widely in age, Jurassic and Cretaceous strata being incorporated in one formation.

Williamsonia? *Riesii* is probably a true *Williamsonia* with numerous and unusually narrow bracts; the author of the species compares it with some composite flower.

As regards the Indian beds, it has long been a difficult problem to determine their exact geological position; the Rajmahal beds are spoken of by Oldham,[8] in the recent edition of the *Manual of Indian Geology*, as Liassic, the Kach (Cutch) or Umia beds being correlated with the Upper Oolite, but the precise horizon can only be approximately stated.

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[1] Saporta, Pal. Franç. vol. iv. p. 118.

[2] Heer, Flor. foss. Arct. vol. vi. p. 59, pl. xii. fig. 1; pl. xiii. fig. 9. [Since writing the above I have examined Heer's type specimen of *W. cretacea* in the Geological Museum in Copenhagen, and find the impression is very indistinct and unsatisfactory.]

[3] Zigno, *loc. cit.* p. 173, pl. xlii. fig. 10.

[4] Saporta, *loc. cit.* p. 180, pl. ccli. fig. 3; and pl. cclii. fig. 4.

[5] Nathorst (4). See also Bartholin, p. 112.

[6] Dawson (A. 5), p. 12, pl. iv. fig. 1.

[7] Dawson (2), p. 87.

[8] Medlicott and Blanford, p. 207.

Bennettites (Williamsonia) Carruthersi, sp. nov.

[Pl. X., and Pl. XI. Fig. 8.]

Type. Specimens in the British Museum from the Fairlight clays, Fairlight, near Hastings.

As a matter of convenience, a new specific name is adopted for several specimens in the Rufford Collection. Without a fuller knowledge of their anatomical structure it is impossible to give an exact specific definition, but the general characters may be briefly expressed as follows :—

Inflorescence ovoid, surrounded by numerous linear bracts, enclosing a central axis (from which seed-bearing peduncles and interseminal structures were given off); between the involucral bracts and the periphery of the spadix there was a regular reticulum of projecting ingrowths marking out the surface of the inflorescence into small areolations.

In dealing with detached inflorescences or portions of such structures, it is impossible to clearly discriminate between different specific forms, as distinct from portions of the same species or the same inflorescence in different stages of development. The most important features in the following specimens are those which serve to connect them, on the one hand with the typical *Bennettites*, and on the other with the Jurassic *Williamsonia*. Some of the examples of these Wealden forms differ from the majority in having short and broad bracts at the base of the inflorescence; these we may speak of as *B.* (*Williamsonia*) *Carruthersi* var. *latifolius*. I have ventured to associate the name of Mr. Carruthers with the present species; it is to his work that we are primarily indebted for our knowledge of *Bennettites*.

V. 3177. Pl. X. Figs. 1, 1*a*, and 1*b*.

This specimen is one of the most important of those to be described. In general form and appearance it is very similar to *Bennettites Morièrei* as figured by Lignier,[1] except that in the present specimen the linear bracts are distinctly shown, about

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[1] Lignier (1), pl. v. figs. 55 and 56.

twelve in number, and, as occurs so commonly in the Jurassic Williamsonias, they are broken off basally, leaving an annular area immediately surrounding the base. This annular area shows very distinctly numerous parallel longitudinal striations; these I regard as corresponding to the so-called "antheriferous tissue" of some writers in *Williamsonia gigas*, Carr. At the base we have a well-defined rim surrounding a central short and conical cavity (Fig. 1*b*); a similar form of axis occupied by carbonaceous matter occurs in the specimen represented in Fig. 8. Compare also Saporta, pl. xxvi. fig. 3. Length of **V. 3177** 6 cm., breadth 3·5 cm. In Fig. 1*a* the truncated base of one of the bracts is represented as seen from below; this shows a number of regularly placed projections from the face of a bract, extending from the latter to the internal fibrous structures. In some of the figures of the inflorescence of *Bennettites Gibsonianus*, Carr., given by Solms-Laubach,[1] there are similar internal projections represented in the inner face of the "outer layer" of the fructification. In describing the structure of the inflorescence, Solms writes: "Not unfrequently sharp and tolerably deep indentations penetrate from without into this homogeneous external layer; these indentations are covered with the epidermis, and probably answer to the cross-sections of a superficial areolation of the entire fructification; they are particularly well and clearly seen near the base of the spadix in fig. xii. of pl. xxv." The same indentations are seen in Solms' pl. xxv. fig. 8, fig. 10, and fig. 11. These ingrowths are, I believe, the structures seen in our Fig. 1*a*, Pl. X. In the longitudinal section of *Cycadeoidea etrusca*, Cap. and Solms,[2] figured by Capellini and Solms, pl. iv. fig. 1, we have the structures clearly represented, and again, on a larger scale, by Carruthers[3] in *B. Gibsonianus* (pl. lx. fig. 3). In his description of the latter species, Solms speaks of the interstitial organs as becoming much more numerous towards the periphery of the spadix (pl. xxv. figs. 8 and 11); Lignier also refers to this character, and in a figure of the peripheral region of the fructification (p. 31, fig. 2), shows the superficial bracts on the outside, and internal to these much smaller interseminal bracts and atrophied seed-bearing

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[1] Solms-Laubach (2), pl. xxv. figs. 8 and 10–12.

[2] Capellini.

[3] Carruthers (1).

peduncles. The fine longitudinal lines seen on the surface of the specimen figured by Lignier on pl. v. figs. 55 and 56, and described by him as the peduncles, bear a very close resemblance to the fine lines traversing the basal annular area in our figure (Pl. X. Fig. 1), and to the so-called antheriferous tissue of *Williamsonia gigas*. It is, I believe, the interseminal structures or possibly atrophied peduncles that are seen in such specimens of *Bennettites Carruthersi* as are represented in Pl. X. Fig. 1, Pl. X. Fig. 2, Pl. X. Fig. 3, and Pl. XI. Fig. 4. The central conical cavity was originally occupied by a fleshy axis, on which were borne the seed-bearing peduncles. Ecclesbourne. *Rufford Coll.*

V. 3201. Pl. X. Fig. 4.

In this specimen we have the outer part of the basal portion of a larger form, or older inflorescence. In the centre there is a somewhat oval area with an uneven surface 2·3 cm. in diameter, surrounded by a series of slightly raised structures; external to this is a concave rim, with its surface marked by a well-defined reticulum of projecting ridges. The appearance of this saucer-like rim suggests that there were originally numerous narrow bracts in close contact with it; the outline of these being indicated by the shallow depressions and intervening ridges as shown in the figure. This specimen approximately corresponds to the basal portion of **V. 3177** (Pl. X. Fig. 1), the external margin of the reticulately marked rim coinciding with the truncated bases of the involucral bracts of such examples as **V. 3177** (Pl. X. Fig. 1) and **V. 2129** (Pl. X. Fig. 2). The network is probably formed by the same regular indentations which are seen in Fig. 1*a*, and described by Solms[1] as forming a regular areolation over the surface of the spadix. Between the reticulately marked rim and the central boss there would be the continuous external layer of the peripheral zone. *Cf.* Solms, pl. xxv. figs. 4 and 7–12. Ecclesbourne.

Rufford Coll.

V. 3202. Pl. X. Fig. 2.

Here again we have the characteristic *Williamsonia gigas* base, somewhat larger than in **V. 3177** (Pl. X. Fig 1). The linear bracts are unevenly broken, exposing the numerous fine, interseminal,

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[1] *Loc. cit.* p. 437.

fibre-like structures. Probably in this specimen the whole inflorescence is partially expanded, and is not so conical in form as the more completely closed example shown in Pl. X. Fig. 1. Cf. *W. gigas* as figured by Williamson (pl. lii. fig. 3), *W. Gagnierei* as figured by Saporta[1] (pl. xxvi. figs. 1–3), etc. Ecclesbourne. *Rufford Coll.*

V. 2129*b*. Pl X. Fig. 3.

The remains of a fructification similar to but rather smaller than **V. 3177** (Pl. X. Fig. 1). Occupying the centre is a well-defined hemispherical boss, 8 mm. in diameter, differing from that in Pl. X. Fig. 1*b* in its more spherical form; its surface is covered with small punctations. At the base of this boss there appears to be a small projecting rim, and external to this an almost vertical involucre of narrow bracts. Resting on the inner face of these bracts is a fibrous material, consisting probably of the same slender structures as those seen in **V. 3202** (Pl. X. Fig. 2), and like them being the small interseminal scales, or peduncles, which make up the peripheral portion of the spadix. Compare *B. Gibsonianus*, Carr.: in that species the central boss is more cushion-like in form. At a distance of about two-thirds from the base the bracts are bent outwards, as shown in the figure. Ecclesbourne. *Rufford Coll.*

V. 2129*c*. Pl. X. Fig. 5.

A star-like cluster of broader bracts, closely resembling such a form as *Williamsonia* (*Blastolepis*) *acuminata*, Zig. (= *W. Italica*, Sap.).[2] The bracts are arranged in a close spiral, and do not form a true whorl. In some there are a number of fine hairs obliquely attached to the margin; these are shown on the lower margin of the middle left-hand bract in the figure. The hairy margin corresponds with that in *Cycadolepis villosa*, Sap.,[3] and our **V. 2802**,[4] etc. This specimen probably represents a series of bracts which surrounded the base of an inflorescence. Ecclesbourne. *Rufford Coll.*

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[1] Pal. Franç. vol. iv.

[2] Saporta, Pal. Franç. vol. iv. pl. ccli. fig. 3.

[3] *Ibid.* vol. ii. pl. cxiv. fig. 4.

[4] p. 97.

V. 2793. Pl. XI. Fig. 1.

The bracts in this specimen are of large size, and less complete. In the centre we have the remains of the base of the axis to which seed-bearing peduncles were originally attached: *cf.* **V. 3201** (Pl. X. Fig. 4). On one side of the central boss a portion of the fibrous annular ring is preserved, showing the impressions of some of the peripheral structures of the spadix; external to this we have traces of a reticulate structure resembling that of **V. 3201** (Pl. X. Fig. 4). Ecclesbourne. *Rufford Coll.*

V. 2129*d*. Pl. XI. Fig. 2.

Portions of large and spreading bracts surrounding a slightly irregular conical cavity; on the inner face of this there are numerous fine reticulations. Probably of the same type as **V. 3177** (Pl. X. Fig. 1), but much less complete. Ecclesbourne. *Rufford Coll.*

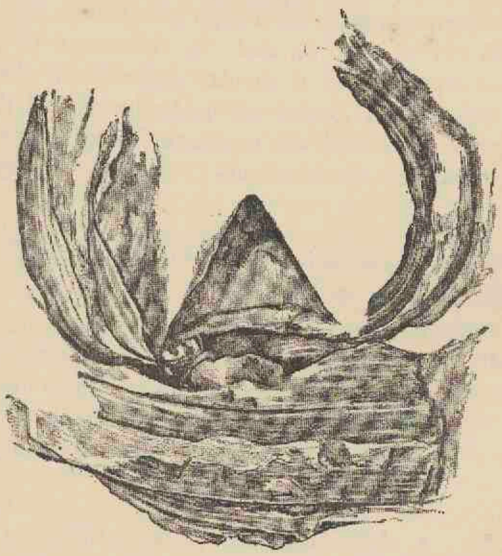

Fig. 8.—*Bennettites* (*Williamsonia*) *Carruthersi*, sp. nov. (nat. size). Specimen in the possession of Mr. Rufford.

This specimen (Fig. 8) shows the clearly outlined central structure, of conical form, similar to the smaller conical cavity in **V. 3177** (Pl. X. Fig. 1). The impression immediately below the inflorescence is probably not in organic connection with it. Preservation imperfect. Fairlight.

V. 2913. Involucral bracts, surrounding a central boss. Towards the base of one of the bracts, and on the surface of the rock, there are some traces of the reticulate structure usually met with in this position. Ecclesbourne. *Rufford Coll.*

V. 3172. Fairly broad involucral leaves surrounding a small central cavity. *Cf.* **V. 3177** (Pl. X. Fig. 1). Ecclesbourne. *Rufford Coll.*

V. 2913*a*. Small specimen showing a portion of the annular zone,[1] with narrow irregular projecting ridges towards its inner margin, passing towards the outer edge into distinct reticulations: *cf.* **V. 3201** (Pl. X. Fig. 4), etc. In the centre is a slightly raised boss, separated by a circular groove from the annular zone; in the circular groove was probably situated the "continuous external layer of the peripheral zone," as figured and described by Solms.[2] Ecclesbourne. *Rufford Coll.*

V. 2793*a* and **V. 2793*b*.** Very similar to **V. 2129*c*** (Pl. X. Fig. 5).

V. 2801. This specimen shows a central portion like that in **V. 3201** (Pl. X. Fig. 4); surrounding this there are irregular radiating lines gradually passing towards the periphery into a regular reticulation. Ecclesbourne. *Rufford Coll.*

V. 2913*b*. A circle of narrow bracts surrounding a central area. *Cf.* Pl. XI. Fig. 1 (**V. 2793**).

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1 There is a specimen very similar to this in the Leckenby Coll. (Cambridge).

2 Solms (2), pl. xxv.

V. 2129*g*. Two specimens with an involucre of broader bracts surrounding a central boss. It is difficult to decide how far the breadth of the bracts may constitute a specific difference. These examples are somewhat intermediate between the specimens referred to the variety *latifolius*, and the narrow leaved forms. *Cf*. **V. 2793***b* and **V. 2129***f*, etc.

V. 2254. Small portion of the annular zone. Ecclesbourne. *Rufford Coll.*

V. 2129. Small specimens showing a central cavity bordered by an annular zone of fibrous structures.

Bennettites (Williamsonia) Carruthersi, sp. nov., var. latifolius mihi.

V. 2129*e*. Pl. XI. Fig. 4.

Compare with a figure of *Williamsonia gigas* given by Oldham and Morris. In the centre is a depressed boss, as in **V. 2793** (Pl. XI. Fig. 1), **V. 3201** (Pl. X. Fig. 4), surrounded by a narrow ring, and external to this a rim of fibrous structures, about 1·3 cm. broad. At a lower level than the fine radiating fibrous structures (peripheral interseminal scales or abortive peduncles), we find here and there an impression of a reticulately marked surface; this reticulum is probably identical with that in **V. 3201** (Pl. X. Fig. 4), and in **V. 3177** (Pl. X. Fig. 1). External to the annular ring are the blunt and rounded tips of a few broad bracts. The specimen consists of the detached basal portion of an inflorescence seen from the inside. Ecclesbourne. *Rufford Coll.*

V. 2129*f*. Pl. XI. Fig. 3.

Very similar to **V. 2129** (Pl. XI. Fig. 4); an involucre of short and broad bracts like those of the preceding specimen, but in this case seen from the outside. In places where portions of the bracts have been removed, a fine reticulate structure is seen on the rock-surface. In the centre of many of the polygonal meshes a slight magnification reveals the presence of a small black dot of coaly substance. A mesh with such a central dot presents some resemblance to the section of a peduncle as figured by Lignier,[1] the dot representing the central vascular bundle. Ecclesbourne. *Rufford Coll.*

V. 2129*a*. Very similar to **V. 2129***f*.

? Bennettites.

V. 2304, V. 3174, V. 3176. Indistinct remains of carbonized hairy bracts; may possibly belong to *Bennettites*. Also **V. 2830** and **V. 2816**. Ecclesbourne. *Rufford Coll.*

V. 3163 and **V. 3164.** A short axis, about 4 cm. in breadth, terminating in partially expanded bracts. The bracts and hairy ramenta closely resemble those of **V. 3177** (p. 144), and suggest the same plant. May possibly be an axis which bore a *Williamsonia* inflorescence. Ecclesbourne. *Rufford Coll.*

V. 2305, V. 2306. May be portions of similar stems, but cannot be accurately determined. Ecclesbourne. *Rufford Coll.*

V. 2349. A mass of hairy or woolly structures evidently arranged round some axis; pressed together as so many thin laminæ. Very similar to the hairy scale leaves, etc., in the stem previously described (**V. 3177**, p. 144). Ecclesbourne. *Rufford Coll.*

V. 2930. Woolly scales or masses of ramental structures. Ecclesbourne. *Rufford Coll.*

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[1] Lignier (1), pl. v.

Genus **YATESIA**, Carruthers.

[Trans. Linn. Soc. vol. xxvi. 1870, p. 687.]

This generic name was proposed by Carruthers for a form of cycadean stem originally described as *Cycadeoidea Yatesii*, Carr.[1] The genus is thus defined :—

"Trunk cylindrical, of uniform thickness, and covered with the short persistent bases of the petioles; scars of the aborted leaves scattered among those of the true leaves. Andrœcium unknown; gynœcium forming a cone, each carpophyll of which bears two reflexed ovules."

The characters of the floral structures are based on certain cones of somewhat doubtful affinity, which have not been found in actual connection with *Yatesia* stems, and cannot, therefore, be regarded as of much value. In some of the specimens referred to this genus, the general arrangement of the tissues, and to some extent the histological structure, have been preserved, but the latter are but very imperfectly known. If we examine the figures of stems included in *Yatesia*, we shall find it a difficult task to distinguish some of the examples figured by Carruthers from stems referred to the genus *Bucklandia*. The form of the leaf-scars in *Bucklandia Milleriana*, Carr.,[2] agrees closely with that in the *Yatesia* stems; and in *Y. Joassiana*, Carr.,[3] there appear to be distinct indications of the transverse constrictions in the stem, as in many bucklandian stems; the form of the leaf bases is also very similar in the two genera. Questions as to differences in age, stages of growth, and the manner of preservation of the stems, render the discrimination and exact limitation of generic types exceedingly difficult, or even impossible; my impression is, that at all events in some of Carruthers' species there are no satisfactory grounds for the application of two generic names. It does not seem possible to draw any distinct line of

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[1] Carruthers (6).

[2] Carruthers (1), pl. lv. fig. 1.

[3] *Ibid.* pl. lv. fig. 8.

separation between some of the smaller stems of *Bucklandia* and the yatesian form of trunk. Schimper includes *Yatesia Joassiana*, Carr.,[1] in the genus *Clathraria*, and expresses surprise that it has been referred by Carruthers to another genus.

The specimens of *Yatesia Morrisii*, Carr., described by the author of the species, were obtained from the Lower Greensand beds of Potton and Leighton Buzzard. One of the examples in the National Collection is described as being from the "Wealden" beds of Leighton Buzzard. The exact age of fossils from these beds must be a matter of some uncertainty, owing to the fact of many of them being clearly derived forms; it may be noted, however, that some of the plant fossils from Potton appear to be specifically identical with Wealden types.

Among the genera instituted by Saporta, that of *Cylindropodium* includes some forms of stems which bear a striking resemblance to Carruthers' species of *Yatesia*.

Yatesia Morrisii, Carr.

1867. *Cycadeoidea Morrisii*, Carruthers, Geol. Mag. vol. iv. p. 199.
1870. *Yatesia Morrisii*, Carruthers, Trans. Linn. Soc. vol. xxvi. p. 688, pl. lv. figs. 3–6.
1874. *Yatesia Morrisii*, Schimper, Trait. pal. vég. vol. iii. p. 555.

Type. Stem with internal structure imperfectly preserved. Royal Agricultural College, Cirencester.

The following is Carruthers' definition of this species:—

"Stem cylindrical, covered with the bases of the petioles, which are rhomboidal in form, and terminate in a tumid boss, the apex of which is directed upwards. The cellular axis is very large. The pith has disappeared, except in one specimen, where sufficient of it remains to show that it was permeated with vascular bundles. The woody cylinder surrounding the pith, in the specimen figured, consists of two rings (figs. 5 and 6); it is everywhere pierced by medullary rays, which are often so large as to break the continuity of the wood (fig. 6). The sides of the wood-cells parallel to the medullary rays are covered with disks

[1] Schimper, Trait. pal. vég. vol. iii. p. 554.

in two or three rows (pl. lx. fig. 13). The inner surface of the woody cylinder exhibits numerous narrow grooves, being the meshes for the passage outwards of the vascular bundles to the leaves. These meshes are larger and more regular on the outer surface of the wood. A very thin layer of cortical tissue separates the wood from the base of the petioles. The bases of the petioles spring from this layer, at right angles to the stem. Externally they present a rhomboid form, the horizontal diameter of which is but little more than the perpendicular."

Although the Potton and Leighton Buzzard sands, in which the examples of this species have been found, are of Lower Greensand age, the plant may be reasonably included in the present list as possibly a member of the Wealden flora.

47029. Portion of a stem preserved in oxide of iron. The inner face of the wood is shown, with the elongated medullary ray cavities; an impression of this face would present a similar appearance to the medullary cast of *Bucklandia*. Pith large, surrounded by a zone of wood 1·4 cm. in width, and consisting of two concentric rings. The transverse section does not show any well-marked medullary rays traversing the wood. The petiole bases fairly distinct; some of them terminate apically in a manner suggestive of a clean surface from which the frond has been detached. Leighton Buzzard. *Morris Coll.*

V. 221. Two smaller specimens. A distinct variation in the size of the leaf bases: *cf.* **V. 2610.** Leighton Buzzard. *Morris Coll.*

Cf. **Yatesia Morrisii**, Carr.

[Fig. 9.]

The following specimens in the Beckles Collection, from the Wealden rocks of Sussex, while agreeing fairly closely with *Yatesia Morrisii*, possess certain points of resemblance to the genus *Bucklandia*. The external characters correspond to some extent with those in Saporta's genus *Cylindropodium*,[1] but the

[1] Saporta, Pal. Franç. vol. ii. p. 265, pl. xlix.

specimens from the French beds are in a better state of preservation, and admit of a more complete diagnosis, than the English examples.

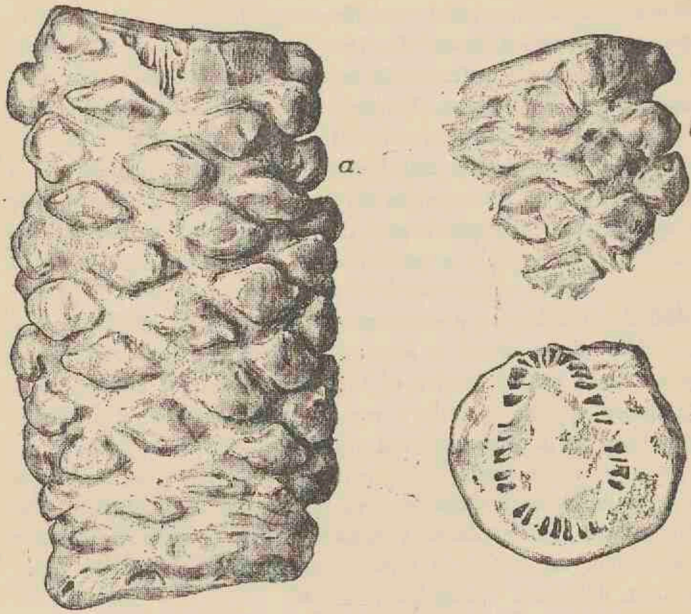

Fig. 9.—Cf. *Yatesia Morrisii* (nat. size). (V. 2610*b*.)

V. 2610*b*. Fig. 9.

Leaf bases very prominent and considerably waterworn (Fig. 9, *a* and *b*). At the upper end of the specimen, as seen in Fig. 9*a*, the outer surface of the wood is exposed; in a view of the transverse section (Fig. 9*c*) there is seen to be a single ring of wood, with the bundles separated by broad primary medullary rays, the spaces in the structureless cast representing the xylem bundles. The small development of wood points to a young stem, in which no second cambium had been formed. *Cf.* Carruthers' figures of *Y. Morrisii* (pl. lv. figs. 3, 5, and 6).[1]
Sussex. *Beckles Coll.*

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[1] Carruthers (1).

V. 2607. Two specimens. The leaf bases present for the most part a different appearance to those in the other specimens; they are closer together and not separated by the deep grooves shown in Fig. 9 (**V. 2610***b*). Some of the bases, however, project exactly as in the preceding example, and there can be little doubt as to their specific identity. There is a distinct disparity in the size of the petiole bases. Sussex. *Beckles Coll.*

V. 2610. Waterworn stem with leaf bases as in **V. 2610***b*. There is only one ring of wood, but this is no doubt merely a matter of age, and shows that the stem was younger than that of **47029** (*Yatesia Morrisii*).

V. 2610*a*. Smaller example.

V. 2610*c*. Two impressions of the worn surface of a stem, or possibly a large cone. *Cf.* **V. 2610***b* (Fig. 9). Sussex. *Beckles Coll.*

V. 2612. An impression of the outer surface of a stem, or less probably of a cone. *Cf.* **V. 2607**, also **V. 2749***a* (*Bucklandia anomala*, Stokes and Webb).[1] Sussex. *Beckles Coll.*

Trunci (Cycadaceæ).

Cf. "*Dracæna Benstedtii*," König.

[Pl. XII. Figs. 4 and 5.]

In a paper on Mesozoic Angiosperms, contributed to the Geological Magazine in 1886 by Starkie Gardner, we find the following statement: "The stems of *Endogenites erosa*, so common in the Wealden and Neocomian, are now known to be cycadeous, and it is probable that the *Dracæna*-like stems from Tilgate Forest and elsewhere, so often referred to by Mantell, are referable to the same group."[2] *Endogenites erosa* is now recognized as a fern (Vol. I. p. 148); but the *Dracæna*-like stems are in all probability, as Gardner suggests, cycadean. Unfortunately no reasons are given for this opinion. In the Second Report of the Committee on British Tertiary and Secondary Beds, Gardner writes:[3] "We

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[1] p. 129.

[2] Gardner (A. 1), p. 201.

[3] Gardner (A. 2), p. 243.

are not able to speak with certainty regarding the supposed liliaceous or *Dracæna*-like stems from the Wealden, so frequently mentioned by Mantell, since it is not easy now to identify the particular specimens referred to by him." Mantell[1] refers to the fossil stems discovered by Bensted at Maidstone, as nearly related to *Yucca* or *Dracæna*. On examining the large specimens of stems in the British Museum, from the Iguanodon quarry[2] at Maidstone, I was struck by their resemblance in external characters to the stem of such recent cycads as *Zamia Loddigesii*, Miq., *Z. Skinneri*, Warsz., and *Z. pumila*, L.

In 1868 Carruthers referred to the Maidstone fossils under the name *Dracæna Benstedtii* of König,[3] and expressed his opinion that they exhibit a closer resemblance to the stem of a *Pandanus* than to that of a *Dracæna*; but he refers to certain specimens in the British Museum which appear to show the remains of internal woody tissue, and thinks it possible that a closer examination might not lend support to the comparison with either monocotyledonous genus. In one or two of the Maidstone Kentish Rag stems, there are portions of what closely resembles woody tissue showing well-marked rings of growth, but a section cut from this wood-like material proves it to be simply a deposit of carbonate of lime formed in such a way as to closely simulate the structure of wood. One of these so-called *Dracæna* stems was figured and briefly described in the *Geologist* for 1862,[4] but the drawing does not give a very accurate idea of the specimen. In a footnote to a paper by Bensted, Mackie[5] points out the absence of any figure or description of *Dracæna Benstedtii* by König.[6] Morris[7] gives this name as König's, but adds after the author's name "British Museum," and gives no reference to any published account. In attempting to trace the geological history of Monocotyledons, we are confronted on every hand with

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[1] Mantell (1), vol. i. p. 186.

[2] Bensted.

[3] Carruthers (7), p. 154 (footnote).

[4] Mackie, Geologist, vol. v, p. 401, pl. xxii.

[5] Bensted, Geologist, *loc. cit.* p. 336.

[6] König was sometime Keeper in the Mineralogical Department of the British Museum.

[7] Morris (A.), Brit. Foss. p. 8.

exceedingly doubtful fossils which cannot be relied upon as satisfactory records; many of the supposed oldest monocotyledonous plants have been shown to be either inorganic fossils, or to belong to some other class of plants. These Maidstone Lower Greensand stems, and the smaller Wealden examples of what appear to be the same form of plant, do not afford any trustworthy evidence of the existence of angiospermous plants at this horizon. The resemblance to *Dracæna* or *Pandanus* does not bear the test of any careful comparison with the recent genera; in the fossils we have none of the regular transversely elongated leaf-scars so characteristic of these living monocotyledons. The method of branching and the general surface characters are much more in harmony with certain species of the genus *Zamia*. It may perhaps be advisable to institute a new generic name for this form of fossil stem, but for the present we are chiefly concerned with the small Wealden examples, and need not introduce any new term.

V. 3162. Pl. XII. Fig. 5.

This specimen is probably the impression of a stem at a point where branching is taking place; the surface is deeply and irregularly wrinkled, and studded with round or oval prominences showing no regularity of disposition. On the surface of the specimen there is a small amount of carbonaceous matter, which probably represents altered cortical tissue. A comparison of this specimen with *Dracæna*, and with *Zamia Loddigesii* or *Z. Skinneri*, shows a much more striking resemblance to the latter genus. In these forms of *Zamia*, as in the fossil stems, there is not the characteristic armour of petiole bases, but a surface marked by transverse and irregular wrinklings, with here and there small knob-like protuberances. There is some slight resemblance to Saporta's *Changarniera inquirenda*[1]; but this is described as a leaf, and not a stem structure. Very similar to some of the Maidstone specimens. Ecclesbourne. *Rufford Coll.*

V. 2350. Pl. XII. Fig. 4.

A portion of the specimen shown in the figure. The surface is slightly convex, suggesting a small segment of a large stem. The surface markings resemble those of **V. 3162**, but in this

[1] Saporta, Pal. Franç. vol. iv. p. 246, pl. cclxx. fig. 2, etc.

case they assume the somewhat more definite form of transversely elongated elliptical areas. Were it not for the convexity of the specimen, one might, perhaps, be inclined to regard it as a pith cast showing impressions of medullary rays. It closely resembles the stems referred to as *Dracæna Benstedtii.* A very thin layer of a mineral substance occurs on the surface of the stem. Ecclesbourne. *Rufford Coll.*

V. 2322. Part of a smaller stem than **V. 3162**; at one end it shows the same form of branching as in the figured specimen (Pl. XII. Fig. 5). Just below the place of origin of the large branch there is a smaller branch or lateral appendage. Interrupted transversely running ridges and numerous circular and elliptical scars constitute the surface features. Ecclesbourne. *Rufford Coll.*

V. 2170. An impression of what seems to be the surface of a stem like **V. 2322**, etc. Ecclesbourne. *Rufford Coll.*

Trunci, etc. (incertæ sedis).

V. 2807. Small specimen of some cylindrical structure; surface marked with irregular longitudinal ridges; apparently crushed. Mr. Rufford suggests that this may be the axis on which a williamsonian fructification was borne. Ecclesbourne. *Rufford Coll.*

V. 2259. Similar specimen, but more like some pith cast. Cf. *Fittonia insignis*, Sap. (Pal. Franç. vol. ii. pl. lvi.). Ecclesbourne. *Rufford Coll.*

V. 2133. This specimen shows several more or less rhomboidal scaly structures, which may be the petiole bases of a cycadean stem. Ecclesbourne. *Rufford Coll.*

V. 3237. Possibly the impression of a petiole base, showing what appear to be the impressions of vascular bundles, and other smaller black spots, which may be gum canals. Ecclesbourne. *Rufford Coll.*

V. 2132*a*. **V. 3187.** Ecclesbourne. *Rufford Coll.*

Specimens of Doubtful Position.

Genus **WITHAMIA**, gen. nov.

In the second volume of the *Plantes Jurassiques*, Saporta figures two specimens under the generic name *Cycadorachis*,[1] *C. armata*,[2] Sap., from the Lower Kimmeridgian, and *C. abscissa*,[3] Sap., from the same horizon. The former species is represented by a fairly stout axis bearing four spinous recurved appendages, having the appearance of rose thorns. This is not unnaturally compared with the rachis of a cycadean petiole, in which, as in recent species of *Cycas* and *Dioon*, the lower pinnæ are reduced to spiny processes.

The genus is thus defined :—

"Rachides frondium foliolis destitutæ vel etiam frondium partes inferæ, petioli dictæ, sive nudæ sint, sive aculeis armatæ, aut ad basin insertionis causa paullo dilatatam squamatis e tomento piloso constantibus ad utrumque latus præditæ videantur."

Such a provisional genus like that of *Rachiopteris* among ferns, is a useful institution, and the species *Cycadorachis abscissa* may well be included in it; but the discovery by Mr. Rufford of several specimens very similar to Saporta's *C. armata*, negatives the suggested relationship to a cycadean frond.

In the Ecclesbourne (Hastings) specimens there are large leaf-like structures attached to the axis in the axils of the spines, and, without attempting to speak definitely as to the precise nature of these two kinds of appendages, it would seem unwise to retain a generic designation indicating a cycadean alliance. Although it is held by some a wrong course to adopt, I propose to substitute, in the case of *Cycadorachis armata*, Sap., and the almost identical fossils from the English Wealden, a new generic name in place of that instituted by Saporta. To retain Saporta's genus, with

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[1] Pal. Franç. vol. ii. p. 193.
[2] *Ibid.* p. 196, pl. cxvii. fig. 1.
[3] *Ibid.* p. 198, pl. cxiv. fig. 3.

the recently discovered specimens before us, would be practically equivalent to assigning the plant to a position which appears to be entirely at variance with the facts. I propose, therefore, to institute the new genus *Withamia* for these spiny axes with leaf-like appendages, and in doing so to place on record some slight recognition of the immensely important service which Witham of Lartington rendered to palæobotanical science. The *Internal Structure of Fossil Vegetables*[1] is widely known as a classic work marking the beginning of a new method of investigation; but so far as I am able to discover, the name of the author of this epoch-making book has not been made use of as a genus of plants. We may define *Withamia* as follows:—

A woody axis bearing two rows of spiny appendages, in the axils of which are borne flat leaf-like appendages.

Withamia Saportæ, gen. et spec. nov.

[Pl. II. Figs. 1 and 2; Pl. V. Fig. 1.[2]]

Type. Specimens in the British Museum.

There is a very strong likeness between Saporta's species, *C. armata*, and the English specimens as regards the axis and recurved spines, but the absence of any leaf-like appendages in the former, and the difference in geological age, render it advisable to adopt a new specific name for the present examples of the genus. I have chosen as a specific designation the name of the author who first described this form of fossil plant. The species may be defined as follows:—

Axis having a breadth of about 1 cm., striated longitudinally, bearing stout recurved spines arranged laterally in two rows, and at slightly irregular intervals. In the axils of the spinous processes there are attached more or less orbicular or obcuneate leaf-like structures, having a distinct flabellate (*Cyclopteris* type) venation.

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[1] Edinburgh, 1833.

[2] For *Saportaia* on Pl. II, substitute *Withamia*; the former name being too nearly identical with *Saportæa* (Fontaine and White, The Permian or Upper Carboniferous Flora. Harrisburg, 1880).

A purely provisional genus like *Withamia* seems decidedly preferable for the present species, to one which in any way implies a definite botanical position. It is by no means clear how such a plant can well be included in the *Cycadaceæ*; and we have no evidence of sufficient value to enable us to assign the species to any other particular group. In the English Wealden rocks there has not so far been found any trustworthy record of an angiospermous plant. The Conifers and Ferns may be mentioned as possible groups in which to include this species, but as yet we have not sufficient evidence to warrant the selection of a generic name, which would imply a connection with one or other of these sub-classes.

In a letter written about a fortnight before his death, the Marquis of Saporta wrote to me at some length in answer to an expression of doubt on my part as to the cycadean nature of his *Cycadorachis armata*, and our more perfect English species. The following sentences are taken from his letter, written on January 10th, 1895[1]; his words may be quoted in full; they are valuable, not merely as giving the opinion of one so well qualified to speak on such a question, but as some of the last from the ready pen of this indefatigable and accomplished student.

"Je suis en effet ravi l'apprendre que vous avez rencontré dans votre Wealdien une portion de fronde, encore munie de pinnules en place de mon *Cycadorachis armata* (Pal. franç. Cycadées, p. 195, pl. cxvii. fig. 1). Point de doute relativement à l'étroite conformité de votre échantillon avec le mien les épines sont égales des deux parts et distribuées de la même façon sur le rachis. Du Kimmeridgien au Wealdien la distance verticale n'est pas telle que la même espéce de Cycadées n'ait pu se maintenir et réparaitre sans changement appréciable. Le type est assurément curieux, et mérite d'obtenir une dénomination générique. A votre place je donnerais à ce type de Cycadées le nom d'*Acanthozamites*. Remarquez d'abord, cher Monsieur, qu'il n'y a dans la présence de ces épines acérées disposées le long du rachis de la fronde rien d'insolite et pour en être persuadé vous n'avez qu'à consulter la figure 1, pl. xi. du volume des Cycadées de mes plantes Jurassiques. Cette figure represente la base d'une

[1] The Marquis of Saporta died at Aix-en-Provence on January 26th, 1895.

fronde de *Cycas* avec les épines, qui sauf la dimension plus petite sont pareilles à celles du type fossile Wealdien et Kimmeridgien. Seulement au lieu d'un Cycas ou d'un Dioon, comme je le présumais, nous avons ici un type eteint dont les frondes portaient. En même temps des épines et à leur aisselle vers milieu du rachis des folioles, sans doute caduques dont le ressemblance avec celles du *Sphenozamites latifolius*, Brong. (Pal. franç. Cycadées, pl. cxvii. et pls. cxii. and cxiii. pour les folioles de *Sphenozamites*), doit être prise en considération. Il l'agit seulement de décider si la présence de ces épines constitue un caractère générique ou seulement spécifique, puisque nous savons par l'échantillon de ma planche cxii., que le rachis du *Sphenozamites latifolius* n'était pas armé d'appendices épineux. Je crois que dans l'incertitude on est fondé à reconnaitre au moins dans cette particulité l'indice d'un sous-genre ou section à part qu'il est naturel de désigner par un dénomination à part, comme serait celle de *Acanthozamites* que je proposais plus haut ou toute autre à votre convenance.

Mon sentiment est donc ici que le rapprochement avec les *Phyllocladus* n'aurait aucune vraisemblance tandis que celui avec les Cycadées et les Sphenozamites en particulier dont être adopté comme le plus naturel."

My reason for not adopting the genus *Acanthozamites*, as suggested by Saporta, is that it suggests a cycadean affinity which is hardly supported by the nature of the specimens. As regards the spines, these in themselves are by no means opposed to a cycadean rachis, but the structures in their axils seem to me quite inconsistent with the morphological character of any recent cycadean frond. Mr. Carruthers suggested to me that the specimens show some resemblance to certain ferns, and expressed an opinion in favour of the *Filicinæ* as the most likely plants with which to compare the fossil species. We have various recent fern fronds which are more or less spinous[1]; but the general habit of the fossil form, the nature of the spines, their disposition on the axis, and their definite relation to the leaf-like structures constitute important points of divergence from any living *Filicinæ*.

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[1] An interesting form of fossil fern, *Gleichenia Hantonensis*, is figured by Starkie Gardner from the Eocene plant-beds of Bournemouth, in which strongly recurved climbing organs are preserved. [Gardner (2), p. 60.]

In answer to my question as to the probability of such a fern-affinity, Mr. Baker, of the Kew Herbarium, wrote as follows: "I should not think this very curious fossil is likely to be a fern. *Phyllocladus* seems far more likely. But, of course, without flower and fruit there can be no certainty. The climbing stem and hooked prickles recall *Calamus*." I had suggested the possibility of the Wealden plant being compared with the New Zealand conifer, *Phyllocladus*,[1] in the recent species of which we have small scaly leaves subtending flattened cuneiform branches (phylloclades). If the leaves were modified into climbing-hooks, we should have a fairly close approximation to *Withamia*, but the evidence at hand does not allow of any great weight being attached to such a comparison. In a palm such as *Calamus* or *Desmoncus* we find somewhat analogous spines, but in these monocotyledonous plants, there is not the same relation as regards position on the axis between hooks and leaf segments as in *Withamia*. For the present, then, I propose to leave the position of *Withamia* an open question, in view of the difficulty of deciding the morphological value of the stout recurved spines and leaf-like appendages, and the insufficient evidence afforded by incomplete vegetative structures.

V. 2134. Pl. II. Fig. 2.

Length of axis 12·2 cm., about 1 cm. broad, striated longitudinally. In the axil of each stout recurved hook there occurs a portion of a leaf-like appendage; these leaves or phylloclades are imperfectly preserved, but enough is seen to demonstrate the flabellate venation, and to suggest a form similar to that of the detached "leaf" represented in Pl. II. Fig. 1 (**V. 2195**). The markings shown on the surface of the uppermost left-hand spine are merely cracks, and not the remains of any original structure; the two highest spines are attached to the axis in a manner indicative of an alternate arrangement, the middle pair are opposite, and the lowest subopposite. Ecclesbourne.

Rufford Coll.

V. 2915. Pl. II. Fig. 1.

This well-preserved *Cyclopteris*-like leaf appears to have been

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[1] Species occur in New Zealand, Tasmania, and Borneo.

sessile; the veins are numerous and clearly shown. The irregularity of the margin is probably an original character; in some other examples of these "leaves" the margin is much more indented, and the form of the "leaf" longer and narrower: *cf.* **V. 2134***e*, **V. 2798**, etc. There is a distinct similarity between this specimen and an unusually entire *Ginkgo* leaf. Saporta's figure of a *Sphenozamites latifolius*[1] leaf agrees very closely with the Wealden specimen; if this form of leaf were attached to *Withamia* (*Cycadorachis*) *armata* it would make the resemblance between the French and English species still more striking. Ecclesbourne.

Rufford Coll.

V. 2134*a*. Pl. V. Fig. 1.

Axis 18 cm. in length, and 9 mm. broad. The longitudinal striations very clearly shown, also the stout nature of the hooks. Very incomplete fragments of the flat appendages in the spine axils. The spines are less regularly placed than in **V. 2134** (Pl. II. Fig. 2) and farther apart. Cf. *Cycadorachis armata*, Sap. Ecclesbourne. *Rufford Coll.*

V. 2805. A short piece of an axis with two well-preserved recurved spines. No leaves shown.

V. 2805*a*. 20 cm. long, showing seven spines. Traces of flattened appendages in the axils of some of the spines. Ecclesbourne. *Rufford Coll.*

V. 2134*b*. Portion of a large leaf, apparently about 7·8 cm. in length. A good specimen of *Sphenopteris Fontainei*, Sew., on the same piece of rock.

V. 2134*c*, **V. 2134***d*, **V. 2134***e*, and **V. 2134***f*. Portions of "leaves," showing venation. Ecclesbourne. *Rufford Coll.*

V. 2182, **V. 2732**, and **V. 2798**. Specimens of "leaves" Some have a more cuneiform shape than the example figured (**V. 2915**, Pl. II. Fig. 1). Ecclesbourne. *Rufford Coll.*

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[1] *Loc. cit.* pl. cxiii.

V. 2923. Axis 43 cm. long, 1–1·3 cm. broad. Portions of four hooks seen on one side, smaller than those of **2134***a* (Pl. V. Fig. 1). The appearance of this specimen is suggestive of a hollow axis, but this is probably due to the preservation of the cortex apart from the internal woody tissue. Ecclesbourne. *Rufford Coll.*

Genus **BECKLESIA,** gen. nov.

The specimens included under this genus are difficult to describe with any completeness, on account of the fragmentary and imperfect nature of the material. So far as I have been able to discover, it is impossible to include these fossils in any known genus; the above name is therefore proposed as a convenient generic term, and one which does not imply any exact botanical position. The National Museum owes some of its valuable examples of Mesozoic plants to the enthusiasm of the late Mr. Beckles; I have therefore made use of his name as a generic designation. As a specific name for the few examples referred to the genus *Becklesia,* the term *anomala* may be adopted.

Becklesia anomala, gen. et spec. nov.

[Pl. XIV. Figs. 2 and 3.]

Type. Fragments, British Museum; from Ecclesbourne, near Hastings.

The type species of the genus may be defined as follows :—

Axis comparatively broad, giving off (on one side?) stout and stiff branches, attached to the axis of higher order in different positions, either laterally or on the surface, and at irregular intervals. On one surface the branches show a number of parallel longitudinal striations, and on the other surface a broad median rib with a small groove on either side.

The specimens are, however, too imperfect to admit of any satisfactory generic or specific diagnosis.

In his monograph on fossil cycadean stems, Carruthers makes a brief reference to a specimen found at Maidstone, which is spoken of as possibly a bennettitean frond. This fossil bears in some respects a distinct resemblance to the present species. Carruthers thus describes the Maidstone specimen: "It is a very large leaf, with numerous long linear segments, attached very obliquely to the rachis. The segments are simple on the upper part of the frond, but the lower ones give off, at regular distances, several long and slender ultimate segments."[1] Mr. Carruthers afforded me an opportunity of examining these Lower Greensand specimens, and suggested that the Wealden examples figured in Pl. XIV. Figs. 2 and 3, represent the lateral segments of the Maidstone "frond" with their lateral long and slender segments. Although there undoubtedly exists a distinct resemblance, yet one cannot speak at all positively as to the identity of the two sets of fossils. In the Wernsdorf flora of the northern Carpathians, an abundant and characteristic species is that described by Ettingshausen as *Thuites Hoheneggeri*, Ett.,[2] and afterwards by Schenk as *Frenelopsis Hoheneggeri* (Ett.).[3] Of the specimens so named, some of those figured by the latter author present a more or less close resemblance to *Becklesia anomala*; this is especially the case with those represented in Schenk's pl. v. figs. 1 and 2. *Frenelopsis* was proposed by Schenk as a generic name for plants having a similar habit to the recent genus *Frenela*, and possessing among other characters cylindrical articulated branches bearing small scaly leaves. The majority of the Wernsdorf examples of this genus show these characters very clearly, but those in pl. v. figs. 1 and 2 are apparently without them, and in some degree conform to the present species. Without examining Schenk's material, it is impossible to speak definitely as to the exact nature of these particular examples; it may be that a difference in age or manner of preservation, is sufficient to account for the apparent absence of the articulations and small leaves. Schenk[4] speaks of these two specimens (pl. v. figs. 1 and 2) as older examples, in which the leaves are only partially preserved. The chief point of contact between the Wealden fossils and those from the Wernsdorf beds, described as older portions of *Frenelopsis Hoheneggeri*, lies in the

1 Carruthers (1), p. 697 (footnote).

2 Ettingshausen (A. 4), Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 26. pl. i. figs. 6 and 7.

3 Schenk (A. 3), Palæontographica, vol. xix. p. 13, pls. iv.-vii.

4 *Loc. cit.* p. 14.

long and stiff lateral branches. In the English specimens there are no signs of any articulations or of leaf structures; so that they cannot well be included in the genus *Frenelopsis*. The typical form of the genus is well illustrated by Ettingshausen's figures, as also by those of Heer[1] and Saporta.[2] In Fontaine's *Potomac Flora*,[3] several specimens are referred to Schenk's genus, but these have recently been transferred by Nathorst to a new genus, *Pseudofrenelopsis*,[4] on the ground that the American forms have been incorrectly interpreted by Fontaine. As regards habit, there is some slight resemblance between *Becklesia* and *Camptopteris spiralis*, Nath.,[5] from Bjuf. On the whole, however, Carruthers' specimens offer the greatest similarity to the following fragments, the nature of which must be left entirely unsettled.

V. 2361*a*. Pl. XIV. Fig. 2.

In the portion of the specimen represented in the figure the characters of the lateral segments are fairly clearly shown. A small piece of the branch at the right-hand upper corner of the drawing, shows the parallel striation and apparently woody nature of the segments; a little below, this branch is crossed by another in which the broad median ridge may be seen. Most of the lateral segments are flattened, and do not present such distinct surface features.

V. 2361*c*. Pl. XIV. Fig. 3.

The flattened main axis fairly distinct, with the irregularly placed lateral branches. The third branch from the top does not appear to arise laterally, but rather from the exposed face of the broader axis.

V. 2361*b*. Smaller fragment. Ecclesbourne. *Rufford Coll.*

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[1] Heer (A. 6), Secc. Trab. Geol. Portugal, p. 21, pl. xii. figs. 3–7. (The specimens figured by Heer in his Flor. foss. Arct., and referred to *Frenelopsis*, are probably not true examples of this genus.)

[2] Saporta (1), pp. 113 and 139, pl. xxi. figs. 9–11, and pl. xxvi. fig. 16.

[3] Fontaine (A. 2), p. 213, pls. xcv.–xcix., cxi., cxii., and clxviii.

[4] Nathorst (5).

[5] *Ibid.* (A. 1), p. 33, pl. iii.

Cf. Becklesia anomala, sp. nov.

[Pl. XIV. Fig. 1.]

V. 2608. Pl. XIV. Fig. 1. ($\frac{1}{3}$ nat. size.)

The nature of this specimen is very doubtful, and its imperfect preservation does not allow of any accurate description. Length 46 cm., breadth about 1 cm. From the central flattened axis a number of comparatively straight lateral branches are given off at irregular intervals; many of these appendages are separated from one another by about 1·5 cm., and have a breadth of 3 cm.; they are linear in form and of a uniform breadth; one branch, in which the tip is not shown, measures 13 cm. There appear to be a small number of parallel veins in each segment. In some cases the branches appear to bifurcate close to the point of attachment to the central axis. Possibly we have here a larger specimen of *Becklesia*, but the occurrence of branches on both sides of the axis makes it difficult to be at all certain as to specific or even generic identity with the previous specimens. Among recent plants there is a form of *Macrozamia heteromera*, *M. heteromera* var. *glauca*, Moore,[1] in which the bifurcate pinnæ bear a certain resemblance to the Wealden fossil, but in the former the more regular disposition of the segments affords an important point of divergence. *Cf.* Schenk's *Frenelopsis Hoheneggeri* (Ett.),[2] as shown in pl. v. figs. 1 and 2; also *Camptopteris spiralis*, Nath.[3] *Beckles Coll.*

V. 2359. Two detached forked segments, probably the same as **V. 2608.**

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[1] Moore, p. 5.

[2] Schenk, *loc. cit.*

[3] Nathorst, *loc. cit.*

Genus **DICHOPTERIS**, Zigno.

[Mem. Instit. Veneto, vol. xii. p. 217, 1864.]

This genus is defined by Zigno as follows:—

"Frons bipartita, bipinnata, rachide primaria, crassa, striata. Pinnæ liberæ, pinnatifidæ, alternæ, vel suboppositæ. Pinnulæ coriaceæ integerrimæ, sæpe basi angustatæ, in rachides alatas decurrentes. Nervi æquales pauci, simplices, interdum furcati, e rachide seriatim orti, ad apicem marginemve pinnularum flabellatim excurrentes. Sori rotundi, prominuli, sparsi. Capsulæ (Sporangia) ovato-globosæ, sessiles, vel subsessiles, annulo completo cinctæ. Filices elasticæ, rachide crassa bipartita, facie Gleicheniacearum."

Zigno's genus is classed by Solms-Laubach[1] with *Nilssonia*, *Thinnfeldia*, and others, which "have been shifted backwards and forwards by different authors from cycads to ferns, and from ferns to cycads." In looking over the references to *Dichopteris* by various writers, we find a considerable difference of opinion, both as regards the necessity for such a generic designation, in distinction to the much older genus *Pachypteris* of Brongniart, and as to the affinity of the plants described under this name. Schimper, in the first volume of the *Trait. pal. vég.*,[2] includes *Dichopteris* under *Pachypteris*, and remarks that it is "impossible to doubt the identity of the two genera"; in the third volume[3] of the same work, he includes the former among the ferns as an independent genus. Saporta includes some species of *Dichopteris* in his genus *Scleropteris*[4]; *e.g.* the two plants originally described by Phillips from the Lower Sandstone and Shale of the Yorkshire Coast as *Sphenopteris lanceolata*,[5] Phill., and *Neuropteris lævigata*,[6] Phill., but the nature of these species has been a matter of

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1 Fossil Botany, p. 87.

2 p. 492.

3 p. 490.

4 Saporta, Pal. Franç. vol. i. p. 364.

5 Phillips (A. 2), p. 200, pl. x. fig. 6.

6 *Ibid.* p. 201, pl. x. fig. 9.

much discussion and need not be considered here. Feistmantel [1] describes certain plant remains from the Gondwana flora of India, which closely resemble Zigno's species; he prefers to go back to Brongniart's *Pachypteris*, and extends the original definition so as to make it embrace, not only plants with the ultimate segments "enerviis vel uninerviis" [2] but those in which the veins are more numerous. In Schenk's monograph on *Die fossile Flora der Grenzschichten* . . . . a specimen is figured as *Dichopteris incisa*, Schenk,[3] but, as Feistmantel suggests,[4] the characters do not seem to agree with Zigno's genus. The larger and more perfect specimens of *Dichopteris* figured by Zigno [5] would seem to favour the inclusion of such plants among the *Filicinæ*; but, as Schenk points out,[6] the fructification is too indistinct to be of any taxonomic value. It is safer, therefore, while expressing a bias towards the pteridophytic nature of the genus, to speak of it as occupying a somewhat doubtful position.

Dichopteris, sp. *Cf.* **D. lævigata** (Phill.).[7]

[Pl. XII. Fig. 6.]

V. 3145. Part of a single pinna, showing the coriaceous ultimate segments without any distinct venation.

Cf. *Dichopteris Visianica*, Zig., *D. lævigata* (Phill.), and *Scleropteris Pomelii*, Sap.[8] Ecclesbourne. *Rufford Coll.*

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[1] Foss. Fl. Gond. vol. ii. p. 29.

[2] Brongniart (A. 3), Hist. vég. foss. p. 166.

[3] Schenk (A. 1), p. 121, pl. xxviii. figs. 5–8.

[4] *Loc. cit.* p. 30.

[5] (1), pls. xii. and xiii.

[6] (A. 8), Schenk's Handbuch, p. 41.

[7] =*Neuropteris lævigata*, Phill., *Pachypteris lævigata* (Phill.), *Scleropteris lævigata* (Phill.).

[8] Saporta, *loc. cit.* pl. xlvii.

Order CONIFERÆ.

Stem much branched, leaves usually small and simple. Flowers unisexual and without a perianth, plants monœcious or diœcious.

The past history of the *Coniferæ* is but imperfectly known, and, owing to peculiar difficulties connected with the determination of fossil forms, the evidence of palæobotany as to the development and geological distribution of these plants, must be accepted with the greatest caution. It would take us far beyond the limits of the present work to discuss at length the distribution in time of coniferous types. In the Palæozoic rocks there are various representatives of this Class, and we have an example, in such an extinct genus as *Cordaites*, of a synthetic type in which coniferous characteristics are combined with certain structural features met with in other Orders of gymnosperms. As a general rule, fossil conifers are perhaps the most unsatisfactory plants with which the palæobotanist has to deal: structureless and imperfectly preserved fragments of broken twigs, isolated cones, leaves or seeds, have usually to be determined separately, and it is only in comparatively rare instances that we are in a position to connect cones and vegetative branches. Coniferous wood, with its mineralized tissues more or less well defined, is met with in rocks of nearly every age, but here, again, the stems or thick branches must be determined as far as possible from histological structure alone, and without any leafy twigs or reproductive organs. Göppert,[1] Kraus,[1] Kleeberg,[1] Felix,[1] Schenk,[2] Knowlton,[3] and others have attempted to devise convenient methods of classifying and identifying fossil *Coniferæ* by means of the peculiarities of structure presented by the secondary wood and the distribution of resin ducts. For the most part, however, fossil conifers are represented by structureless casts or impressions of leafy branches, occasionally bearing characteristic cones or other forms of reproductive organs.

In treating of the *Cycadaceæ*, some general account was attempted of the difficulties and possible sources of error which ought to be

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[1] For references see Solms-Laubach's Fossil Botany.

[2] Zittel (A.), Handbuch, p. 848.

[3] Knowlton (A. 2), Bull. U.S. Geol. Surv. No. 56, 1889. (See also Göppert and Menge, Die Flora des Bernsteins, vol. i., and Conwentz.)

kept in mind in the identification of fossil specimens. It may be useful to draw attention to similar difficulties in the case of *Coniferæ*, which have not always been observed by palæobotanical writers.

If we examine the external characters of older branches of recent conifers from which the leaves have been detached, it will be found impossible to institute on such a basis any useful classification. It happens, not infrequently, that the leaves and cortical tissues become readily detached from the surface of the wood, leaving a smooth axis in place of the corticated branch or stem. A good example of this is afforded by such specimens as those represented in Pl. XVII. Figs. 4–6. Occasionally we have to deal with pith casts having the surface covered with lozenge-shaped prominences, simulating elongated leaf bases. A good example of such a medullary cast is afforded by Weiss' genus *Tylodendron*, of which the true nature was pointed out by Potonié[1] in 1887. Again, in some specimens of the Triassic *Voltzia*[2] we have smaller pith casts of similar form. In his *Introduction to the Study of Palæontological Botany*, Balfour[3] calls attention to the unnecessary multiplication of fossil species, and illustrates the need for careful observation of the characters of recent stems, by reference to the striking differences presented by a branch of *Araucaria imbricata*, Pav., when the bark is viewed intact, and after it has been more or less completely stripped off the surface of the wood. In *Araucaria Cunninghami*, Ait., we find equally striking contrasts between the younger branches, with their stiff falcate leaves, the slightly older stems, on which only the rhomboidal leaf bases are left, the smooth surface of the wood, from which overlying tissues are readily detached, and finally, the surface features presented by a pith cast.

In the long needles of *Pinus* and the broad flabellately veined leaves of *Ginkgo*, we have sufficiently well-marked characters to enable us in most cases to arrive at a generic determination. In many instances, however, it is a hopeless task to attempt to found any accurate determination on leaves alone. Among recent genera we have a deciduous habit in such plants as *Larix*, *Ginkgo*, *Taxodium*

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[1] Potonié (2).

[2] Seward (4).

[3] Balfour, p. 4

distichum, Rich.; also, to a certain extent, in *Sequoia sempervirens*, Endl., *Thuja occidentalis*, L., *Libocedrus decurrens*, Torr., etc.[1]; but in most species the leaves remain on the tree for more than one year. Occasionally, the manner of occurrence of detached leaves or leafy shoots in a fossil state may afford evidence of the existence of deciduous species. A careful examination of branches of recent conifers bearing vegetative leaves, enables us to realize the impossibility of relying for accurate determination or comparison on such uncertain characters as leaf form or arrangement. The univeined leaves of *Podocarpus* in some forms of the genus, may be confused with the foliage of araucarian species, in which the veins are imperfectly preserved; in such a plant as *Podocarpus andina*, Pöpp., the long narrow leaves agree closely with those of some forms of *Cephalotaxus*, and the detached leaves of either bear a strong resemblance to single pinnæ of *Cycas*. A specimen of an unnamed species of *Cephalotaxus* in the British Museum possesses leaves measuring 11 cm. in length and 4 mm. broad, a close approach to the pinnæ of *Cycas* species. The genus *Agathis*, e.g. *A. Australis*, Salisb., cannot be readily distinguished from some forms of *Araucaria*, if we have only the leaves to guide us. The large leaves of *Agathis Dammara*, Rich., and the broad pinnæ of *Podozamites* cannot always be separated with certainty, at least in such specimens as do not show distinct venation. If we have not the general habit of the tree, or characteristic differences of colour to help us, it is practically impossible to discriminate with accuracy between the leafy twigs of many recent genera. Without entering into any detailed comparison of living forms from this point of view, we may note the close agreement between *Taxodium distichum*, Rich., *Sequoia sempervirens*, Endl., and *Taxus baccata*, L.; between *Cryptomeria*, sp., and *Araucaria*, sp.; between different genera of the *Cupressinæ*, etc. Similar examples might be readily multiplied; but an examination of the recent species will at once demonstrate the futility of attempting generic distinction on such data, and will emphasize the unfortunate habit of some writers of applying to fossil fragments the unaltered names of recent genera. Another pitfall as regards leaf form, is the fairly common occurrence of heterophylly among coniferous plants. Writing in 1803, Lambert

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[1] Stark.

says:[1] "I must here observe a remarkable peculiarity belonging to the *Coniferæ* of the Southern Hemisphere, which is, that while the trees are young their leaves are long and divaricating, but when they become old enough to bear fruit, those leaves fall off, and are succeeded by short scales, closely imbricated on the branches, so that, seeing them in their different states, one could hardly suppose it possible that they could belong to the same species." This young form of leaf may be retained for some few years before the adult foliage is developed, and thus present a possible source of error in the determination of fossil branches. In such a species as *Pinus pinea*, L., we have the young leaves retained for some considerable time previous to the development of the needles and short shoots. An interesting case of this difference between the leaves of young and adult plants was pointed out to me at the Royal Gardens, Kew: the young plants of the new species of *Widdringtonia*, *W. Whytei*, Rend.,[2] from Nyassa-Land, bear comparatively long needles, in marked contrast to the small scale leaves of the older tree. A striking instance of a similar kind is afforded by some specimens of *Araucaria excelsa*, R. Br., in the Herbarium of the British Museum: there is a seedling with its long and spreading leaves, an older specimen with narrow and spreading leaves, and another with the stiff leaves of the adult plant. In *Dacrydium Kirkii*, F. Muell.,[3] from New Zealand, we find a marked difference between the small and closely adpressed leaves, and the much larger and more spreading leaves of other branches; also, in *D. elatum*, Wall., *D. Westlandicum*, Kirk.,[4] and other forms, there is a striking disparity in the leaf form. In *Podocarpus cupressina*,[5] R. Br., there is a decided difference between the young and old forms of leaves. In *Athrotaxis selaginoides*, Don.,[6] we have various forms of leaf, from the longer and more openly disposed to the smaller and closer leaves. Among other species exhibiting similar differences in the shape and size of the leaves, we may note the well-known *Juniperus Chinensis*, L., *Biota orientalis*, Endl., *Juniperus Bermudiana*, L., *Glyptostrobus heterophyllus*, Endl., etc.

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[1] Lambert, p. 89.
[2] Rendle, p. 60.
[3] Hooker (1), pl. MCCXIX.
[4] *Ibid.* pl. MCCXVIII.
[5] Brown and Bennett, pl. X.
[6] Don, pl. XIV.

Examples of heterophylly have been recorded among fossil forms—e.g., *Voltzia heterophylla*, Brong.,[1] from the Bunter beds; and the specimens of *Sequoia Tournalii* (Brong.), figured by Gardner[2] from the Bagshot beds of Bournemouth, show a considerable difference in the form of the leaves. The microscopical examination of the epidermal cell-outlines of fossil coniferous leaves has been successfully adopted in some instances, *e.g.* by Zeiller[3] in the case of *Frenelopsis Hoheneggeri* (Ett.), and by Schenk[4] in several instances.

In addition to the similarity of leaf form in different species and genera, and the heterophylly in the same species, it is important to note the common occurrence of more than one method of leaf arrangement in the same tree. Masters,[5] in his useful paper in the Journal of the Linnean Society for 1891, has drawn attention to this variation in leaf arrangement among recent species of conifers.

In describing cycadean flowers, it was pointed out how difficult it is in some cases to distinguish between the cones of cycads and those of certain genera of conifers, when we have only external form to guide us. The seeds of *Cephalotaxus*, *Ginkgo*, *Torreya*, and other genera may be easily mistaken for those of *Cycas* and other cycads. There is in many instances, the same difficulty in identifying the detached cones of recent conifers as in determining detached leafy twigs. Schimper and Mougeot, recognizing the difficulty of discriminating between fossil cones, suggested the general generic term *Strobilites*,[6] which they used in a somewhat similar sense to that in which I have used the more comprehensive genus *Conites*.

Hitherto the number of *Coniferæ* recorded from English Wealden strata has been extremely small. In addition to isolated cones described by Carruthers, Gardner, and others, we have only one species represented by a leaf-bearing branch—*Sphenolepidium Kurrianum* (Dunk.). The Rufford Collection has enabled us to recognize as British plants several of the species previously described from Germany and elsewhere, and to make several additions to the list of Wealden *Coniferæ*.

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[1] Brongniart (5), p. 451. See also Schimper and Mougeot, p. 22, pls. vi.–xiv.

[2] Gardner (2), pl. v.

[3] Zeiller (3), p. 231, pl. xi.

[4] Schenk (A. 1), Fl. foss. Grenz. Keup. Lias, and (A. 2) Palæontographica, vol. xix.

[5] Masters, p. 244.

[6] Schimper and Mougeot, p. 31.

PINOIDEÆ — ABIETINEÆ — ARAUCARINÆ.	*Araucarites* cf. *Conites elegans* (Carr.), etc.
	Araucarites, sp.
PINOIDEÆ—ABIETINEÆ—ABIETINÆ.	*Pinites Dunkeri*, Carr.
	Pinites Carruthersi, Gard.
	Pinites Solmsi, sp. nov.
	Pinites Ruffordi, sp. nov.
	Pinites, sp.
PINOIDEÆ—ABIETINEÆ—TAXODIINÆ	*Sphenolepidium Kurrianum* (Dunk.).
	Sphenolepidium Sternbergianum (Dunk.).
	Sphenolepidium cf. *S. subulatum* (Heer).
PINOIDEÆ—CUPRESSINEÆ	*Thuites*, sp.
TAXODIEÆ—PODOCARPEÆ	*Nageiopsis*, sp., cf. *N. heterophylla*, Font.
GENERA ET SPECIES INCERTÆ SEDIS	*Pagiophyllum crassifolium*, Schenk.
	Pagiophyllum, sp.
	Brachyphyllum obesum, Heer.
	Brachyphyllum spinosum, sp. nov.

In the above list of *Coniferæ* described in this volume, I have suggested the probable position of various species in the classification adopted in Engler and Prantl's recent work. It must, however, be admitted that at present we cannot feel great confidence in the attempts to determine, even the approximate affinities of such provisional genera as *Sphenolepidium*, *Pagiophyllum*, and *Brachyphyllum*.

Genus **ARAUCARITES**, Presl.

[Flor. Vorwelt, Fasc. vii. p. 203, 1838.]

In the present instance this genus is used as a convenient designation for certain female cones which resemble, in their form and structure, those of the recent genus *Araucaria*.

Araucarites (Conites), sp. *Cf.* **Conites elegans** (Carr.) and **Kaidocarpon minor**, Carr.

[Pl. XII. Figs. 1 and 2.]

It has already been pointed out that the specimen figured by Carruthers as probably a male cone of *Bucklandia* has little or no claim to be regarded as cycadean; it very closely resembles the specimens figured in Pl. XII. Figs. 1 and 2, and like them should probably be referred to the genus *Araucarites*. Another fossil which is probably identical with these Wealden cones is that described by Carruthers as *Kaidocarpon minor* from the Potton beds of Bedfordshire; the type specimen[1] of this species in the Woodwardian Museum shows the general characters of a somewhat waterworn female araucarian cone. The same form of cone, but one belonging to another species, is illustrated by a beautiful specimen in the York Museum, which has been described and figured by Carruthers from the Coralline Oolite of Malton, in Yorkshire, under the name of *Araucarites Hudlestoni*.[2] Mr. Carruthers tells me he is disposed to regard some of the fossils described by him as monocotyledonous inflorescences, as more probably araucarian cones. It is proposed to discuss elsewhere, at greater length, the value of several of the published records of supposed monocotyledonous plants from Jurassic and Wealden strata.

V. 2180. Pl. XII. Fig. 2.

In this specimen we have a view of the proximal ends of the scales, their broad and flattened form is clearly seen, also the lozenge-shaped cavity in which the seeds were originally situated. The form of the scales and the more or less globose form of the cone, present a strong resemblance to the female strobili of species of *Araucaria*; *e.g.*, *cf.* the figure given by Martius in pl. cx. of his *Flora Brasiliensis*, with the specimens in our Pl. XII. Figs. 1 and 2.

V. 2180*a*. Pl. XII. Fig. 1.

The stout central axis is clearly shown, with the spirally disposed points of insertion of the broad scales. Breadth of axis about 4 cm.; the scales probably wider towards the distal end, showing prominent lateral angles or wings with a slightly convex and wrinkled upper and lower surface. In one part of the specimen the impressions of the scale apices show a prominent distal end with a central dot, as in **V. 2148**. Some of the scales show a clearly defined cavity, originally occupied by the small seeds which were narrowed towards the cone axis. There are three small seeds which seem to have fallen out from this cone.
Ecclesbourne. *Rufford Coll.*

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[1] The specimen has not been figured.

[2] Carruthers (8).

V. 2331. Two specimens, in the form of oblique sections, of a cone, probably belonging to the same species as **V. 2180.** *Cf.* Carruthers,[1] pl. vi. figs. 1 and 9. Ecclesbourne. *Rufford Coll.*

V. 2180*b*. Two specimens, showing an impression of the cone surface. In size, and as regards the form of the scales, very similar to Carruthers' supposed bucklandian male cone, pl. liv. fig. 6.[2] *Cf.* **V. 2148.** Possibly this specimen should be referred to another species; it is smaller than **V. 2180** (Pl. XII. Fig. 2). Ecclesbourne. *Rufford Coll.*

V. 2148. The impressions of the distal ends of the scales show a small central depression, corresponding to an umbo on the scale apex. This and other examples should be compared with *Araucarites Pippingfordensis* (Ung.), the original of which is in the Museum Collection. Ecclesbourne. *Rufford Coll.*

V. 2265*a*. Scales clearly preserved, showing in side view a longitudinal depression, suggesting a shrinking of the seed cavity. **V. 2265.** A well-preserved, but smaller specimen. Ecclesbourne. *Rufford Coll.*

V. 2277. *Cf.* **V. 2148. V. 3185.** The thick central axis clearly shown, also impressions of scales in side view. Ecclesbourne. *Rufford Coll.*

V. 3173. Cone in cross section; scales with seeds clearly preserved. Other specimens referred to this form of *Araucarites*: **V. 2245, V. 2263, V. 2263*a*, V. 2264, V. 2279.**

Araucarites, sp.

V. 2266 and **V. 2280.** Two specimens of small subspherical cones imperfectly preserved; of the same form as the preceding examples, but considerably smaller. Ecclesbourne. *Rufford Coll.*

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[1] Carruthers (3).
[2] *Ibid.* (1).

Genus **PINITES**, Endlicher.

[Synopsis Coniferarum, 1847, p. 283.]

In dealing with detached and imperfect cones, in which the scales have a flattened form like those of *Abies* and certain species of *Pinus*, it is difficult, or indeed impossible, to arrive at a very accurate generic determination. The use of Endlicher's genus in a wide sense is, therefore, a matter of convenience, and in most cases preferable to the application of the generic name of *Pinus* to detached cones which cannot be referred with absolute confidence to a narrowly defined recent genus.

Endlicher defines this genus as follows:—

"Folia, amenta staminigera et strobili, diversis Pinuum speciebus similes." The term is a convenient one to adopt, if we do not confine its use within the limits of the genus *Pinus* as defined in modern systematic works.

Several detached cones have been described by Carruthers, Gardner, and others from the Wealden rocks of England, under the generic name *Pinites*. Their general character justifies the choice of this genus, but an examination of several of the type specimens lends no support to the existence of so many distinct species as have been described. In the second report of the Committee appointed for the purpose of reporting on the fossil plants of the Tertiary and Secondary beds of the United Kingdom, Starkie Gardner figures and describes the following new species: *Pinites valdensis, P. Carruthersi, P. cylindroides*, and *P. Pottoniensis*, from the Wealden rocks of the Isle of Wight and the Lower Greensand of Potton. The Potton specimens are probably of Wealden age. In the case of *Pinites cylindroides*, from Potton, Gardner describes the solitary specimen as being "in excellent condition, certainly not derived from any older bed." An inspection of the type specimen in the Woodwardian Museum, Cambridge, leads me to unhesitatingly describe it as distinctly worn and rolled, and imperfectly preserved. The figure does not convey a very accurate idea of the actual fossil; the scales are very imperfect, and their half-moon form spoken of by the author of the species, is almost certainly due to wearing, and cannot, I believe, be accepted as an original character.

Pinites cylindroides may possibly be identical with *P. Dunkeri*, Carr., and even with *P. Carruthersi*, *P. Pottoniensis*, and *P. valdensis*. The type specimen on which the species *P. Pottoniensis* is founded is too small to admit of any specific diagnosis, and does not appear to me to have any claim to be regarded as specifically distinct from *P. cylindroides*. It must be admitted, however, that there is considerable risk in attempting to discriminate between these imperfect and detached cones; but it is surely a mistake to multiply the number of species without stronger evidence for the existence of any real specific differences.

A careful revision of the cones of Mesozoic *Abietineæ* is very desirable; the number of species would no doubt be considerably reduced.

In the Rufford Collection there are some specimens of fairly well-preserved cones attached to their branches, and in addition to these, several isolated specimens in other Wealden collections, which differ in their greater length from those preserved in the position of growth. The larger detached cones I have referred to Carruthers' species *Pinites Dunkeri*; the others, with their branches and leaves, are placed in a new species, *P. Solmsi*.

Pinites Dunkeri, Carruthers.

1853. *Abietites Dunkeri*, Mantell, Geol. I. Wight, p. 452.
1866. *Pinites Dunkeri*, Carruthers, Geol. Mag. vol. iii. p. 542, pl. xxi. figs. 1 and 2.
1867. *Pinites Dunkeri*, Carruthers, Journ. Bot. vol. v. p. 14, pl. lix. figs. 1 and 2.
1870. *Abietites Dunkeri*, Schimper, Trait. pal. vég. vol. ii. p. 307.
1878. *Pinites Dunkeri*, Dixon's Geol. Sussex, p. 279.
1886. *Pinites Dunkeri*, Gardner, Rep. Brit. Assoc. p. 5.
1889. *Pinites Dunkeri*, Bristow, Geol. I. Wight, p. 258.

Type. Isolated cones. British Museum.

The following definition is given by Carruthers for this species :—"Cone elongated cylindrical; scales broad, with a rounded and thin apex; axis slender; seeds oval compressed."

The largest cone referred to this species has a length of over 33 cm. and is 3 cm. broad. Cones of a similar form have been described by Velenovský[1] under the name of *Pinus longissima*, having a length of 31 cm. and 3 cm. broad. It is difficult to decide in many instances between *P. Dunkeri* and *P. Carruthersi* as the most suitable species to which to refer the specimens.

46654. Portion of a long cone, with the scales partially expanded, showing some clearly preserved cavities from which the small oval seeds have fallen. Very similar to *Pinites Carruthersi*, Gard. Several specimens with this registered number containing iron pyrites, and very friable. Brook, I. Wight. *Bowerbank Coll.*

Pinites Carruthersi, Gardner.

[Pl. XX. Fig. 5.]

1886. *Pinites Carruthersi*, Gardner, Brit. Assoc. Rep. 1886, p. 4, fig. 6.

Type. Imperfect cone. Woodwardian Museum, Cambridge.

Gardner speaks of the type specimen as a long cylindrical cone with numerous persistent, leathery, imbricated scales, tapering towards the base, with scales thicker than those of *Pinites valdensis*, Gard., but thin at the edges, smooth, without a keel, and with entire rounded margins.

This form of cone is very similar to that represented by the more perfect specimens which I have included under a new species, *Pinites Solmsi*. In *P. Andræi*, Coem.,[2] *P. Coemansi*, Heer,[3] and other Mesozoic forms, the same type occurs; as a rule, however, it is impossible to determine the precise affinities of these detached examples.

V. 2611. Pl. XX. Fig. 5. **V. 2852.**

Cones in a crumbling condition, partly preserved in iron pyrites. Larger than those of **V. 2146** (Pl. XIX. Fig. 1), but it is possible that they both belong to the same species. Ecclesbourne. *Rufford Coll.*

V. 2266. Two smaller specimens, probably belonging to this species. Ecclesbourne. *Rufford Coll.*

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[1] Velenovský (A. 1), p. 26, pl. i. figs. 14–17.
[2] Coemans (A.).
[3] Saporta, Pal. Franç. vol. iii. p. 474, pl. cxci. figs. 6 and 7.

Pinites Solmsi, sp. nov.

[Pl. XVIII. Figs. 2 and 3. Pl. XIX.]

Type. Cones attached to leaf-bearing branches. British Museum.

Some of the specimens referred to this species, closely resemble *Pinites Carruthersi*, Gard., but in view of the much more perfect nature of the Rufford material, and the doubtful identity of Gardner's type, I have ventured to found a new species. The specific name *Solmsi* has been adopted as a slight record of Graf zu Solms-Laubach's services to Mesozoic palæobotany. The species may be thus defined :—

Short lateral branches covered with well-marked elongated bases of the scale leaves, in the axil of which are borne the short shoots with long needle-like leaves. Cones oblong in form, with broad scales similar to those of the *Strobus* section of the recent genus *Pinus*, or those of *Picea* and *Abies*.

In *Pinites Carruthersi* the scales have a similar form, but slightly larger, and with a more flattened thin upper border. In a few specimens of this species the needles are in place, but do not show the manner of attachment of the leaves with sufficient clearness, to enable us to determine how many needles are borne on each short shoot. It is possible, indeed, that the leaves arise direct from the large branches, as in *Abies* and *Picea*, but the form and size of the needles are much more in accordance with the characters of the genus *Pinus*.

V. 2146. Pl. XIX. Fig. 1.

Portions of four unripe cones, apparently in place; possibly the three uppermost cones are in their natural position, and the lower one displaced. The clearly marked impressions of the bracts show their rounded outline very distinctly: cf. *P. Carruthersi*, Gard., and *P. Andræi*, Coem., as figured by Gardner.[1] Similar to *Abietites ellipticus*, Font.,[2] but smaller. The surface of the cones is marked by a number of fine longitudinally running striations. The branches are covered with well-preserved decurrent leaf cushions. There are no leaves in their position of growth, but several fragments of needles occur on the rock surface. Ecclesbourne. *Rufford Coll.*

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[1] Gardner, *loc. cit.* fig. 1.

[2] Potomac Flora, pl. cxxxiii. figs. 2–4.

V. 2169. Pl. XVIII. Fig. 2.

Here again the leaf cushions are clearly preserved; at the ends of the short lateral branches there are borne clusters of long needles, but it is impossible to make out with certainty the actual leaf arrangement, or manner of attachment to the leaf-bearing axes. A few of the leaves show an acuminate apex. The general habit of the specimen is similar to that of *Cedrus* or *Larix*, but the greater length of the branches and the form of the leaves offer a still stronger resemblance to *Pinus*. If we compare young branches of some species of *Pinus* with this and other specimens we find a very close agreement. The portion of a cone below the main branch probably belongs to this species. There is some resemblance to *Leptostrobus longifolius*, Font.[1] Ecclesbourne.

Rufford Coll.

V. 2147*a*. Pl. XIX. Fig. 4.

With some of the scales in this specimen there appear to be associated narrow and pointed structures, similar to the seminiferous scales, and shorter and broader bract scales of such a form as *Tsuga Douglasii*, Sab. This appearance is, however, probably deceptive, and is the result of our seeing some of the bracts edgewise. There can be very little doubt as to the identity of this cone with those in **V. 2146** (Pl. XIX. Fig. 1). Ecclesbourne.

Rufford Coll.

V. 2146*a*. Pl. XIX. Fig. 3.

In this specimen we have two female cones which appear to be in place, and a branch continued above them, on the upper portion of which there appear to be the remains of imperfectly preserved structures, which may possibly be male cones. There is not, however, sufficient evidence on which to found any very definite statement. Ecclesbourne.

Rufford Coll.

V. 2255. Pl. XVIII. Fig. 3.

Part of a somewhat smaller cone, and a cluster of needles borne on a short lateral branch. Probably the same species as the larger specimens. Ecclesbourne.

Rufford Coll.

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[1] *Loc. cit.* pl. cii. figs. 1 and 2.

V. 2147. Pl. XIX. Fig. 2.

Part of a cone like that of **V. 2147***a* (Pl. XIX. Fig. 4), attached to a branch bearing the characteristic leaf cushions. The difference between this specimen and **V. 2146** (Pl. XIX. Fig. 1) is due to the scales being open in the present example.

V. 2147*b*. Open cone, and portions of branches with well-preserved leaf cushions. *Cf.* Pl. XIX. Fig. 1. Ecclesbourne. *Rufford Coll.*

V. 1069. Branches with leaf cushions fairly distinct; cones imperfectly preserved. Somewhat similar to the specimens described in Volume I. as rhizomes of *Onychiopsis Mantelli* (Brong.).[1] Ecclesbourne. *Rufford Coll.*

V. 3167. In this specimen the leaf cushions are clearly shown, and the limits of annual growth are suggested by the closer arrangement of the cushions in certain parts of the branch. Ecclesbourne. *Rufford Coll.*

V. 3165. Very small needles, like those of **V. 2255** (Pl. XVIII. Fig. 3). A fairly long branch with short leaf-bearing lateral branches.

V. 2270. A cone in longitudinal section.

V. 2291. Possibly a different plant, but too imperfect to determine with any certainty. Ecclesbourne. *Rufford Coll.*

Other specimens of cones and branches referred to this species: **V. 1069***a*, **V. 1069***b*, **V. 1069***c*, **V. 1069***d*, **V. 2291**, **V. 3165**, **V. 3168**.

Pinites, sp.

V. 2922. A single winged seed. Numerous fragments of *Onychiopsis Mantelli* (Brong.) on the same piece of rock. Ecclesbourne. *Rufford Coll.*

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[1] Vol. I. p. 52.

Pinites Ruffordi, sp. nov.

V. 2304. A specimen of coniferous wood with the minute structure clearly preserved, and showing the characters of the genus *Pinites*. It is proposed to publish elsewhere a detailed description of the anatomy of this specimen of *Pinites*, under the name of *Pinites Ruffordi*. The annual rings are very clearly marked; resin ducts fairly numerous; the tracheids in radial section show either a single row of bordered pits, or a double row having the arrangement characteristic of the genus *Pinites*. Ecclesbourne. *Rufford Coll.*

Genus SPHENOLEPIDIUM, Heer.

[Secc. Trab. Geol. Portugal, 1881, p. 19.]

The generic name *Sphenolepis*, proposed by Schenk in 1871,[1] was changed by Heer to *Sphenolepidium*, on account of the previous use of the former name by Agassiz as a genus of fishes. Heer's new term is adopted by Schenk in his account of fossil *Coniferæ* contributed to Zittel's *Handbuch*.[2] The species of this genus have been included by Schenk and others in the family *Taxodieæ*, but Solms-Laubach[3] considers that the botanical nature of these fossils is too imperfectly known to admit of any precise localization among existing subdivisions of the Group *Coniferæ*. Previous writers have drawn attention to the resemblance of the Wealden species, *Sphenolepidium Kurrianum*, to *Athrotaxis*, and *Sequoia* has also been referred to as the nearest living genus. There is nothing in the nature of the fossil cones of this genus, so far as I am able to judge from the published figures, and an examination of fairly well-preserved English specimens, to stand in the way of a comparison with these two living genera. As regards the leaf form and arrangement, and the general habit of the fossil species, there is a very close

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[1] Palæontographica, vol. xix. p. 243.
[2] Zittel (A.), p. 304.
[3] Fossil Botany, p. 71.

resemblance between *Sphenolepidium Kurrianum* (Dunk.) and species of *Athrotaxis*, e.g. *A. laxifolia*, Hook, and *A. cupressoides*, Don.[1] Both *Athrotaxis* and *Sequoia* are placed by Eichler[2] in the section *Pinoideæ-Abietineæ-Taxodiinæ*, and it would seem highly probable that the Wealden form bears a close relationship to these recent genera, especially to Don's genus *Athrotaxis*.

We may define *Sphenolepidium* as follows: Branches alternate, with spirally disposed and decurrent leaves, cones small, oblong and spherical, borne on short lateral branches.

Sphenolepidium Kurrianum (Dunk.).

[Pl. XVII. Figs. 7 and 8; Pl. XVIII. Fig. 1.]

1839. ? *Muscites imbricatus*, Römer, Verstein. Ool. Geb. p. 9, pl. xvii. fig. 1*c*.
1846. *Thuites* (*Cupressites*?) *Kurrianus*, Dunker, Wealdenbildung, p. 20, pl. vii. fig. 8.
? *Lycopodites*, Dunker, *loc. cit.* p. 20, pl. viii. fig. 8.
Thuites Germari, Dunker, *loc. cit.* p. 19, pl. ix. fig. 10.
1847. *Widdringtonites Kurrianus*, Endlicher, Synopsis, p. 272.
1848. *Thuites Kurrianus*, Bronn, Index nomencl. p. 1271.
1849. *Brachyphyllum Kurrianum*, Brongniart, Tableau, p. 107.
1849. *Brachyphyllum Germari*, Brongniart, *loc. cit.* p. 107.
1850. *Widdringtonites Kurrianus*, Göppert, Foss. Conif. p. 176.
1850. *Widdringtonites Kurrianus*, Unger, Gen. spec. plant. foss. p. 342.
Thuites Germari, Unger, *loc. cit.* p. 348.
1851. *Widdringtonites Kurrianus*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 25.
Widdringtonites Haidingeri, Ettingshausen, *loc. cit.* p. 26.
Araucarites Dunkeri, Ettingshausen, *loc. cit.* pl. ii. fig. 10; pl. ii. fig. 1.
1854. *Thuites Kurrianus*, Morris, Brit. foss. p. 24.
1861. *Widdringtonites Kurrianus*, Hildebrand, Verbreit. Conif. p. 296.
Widdringtonites Haidingeri, Hildebrand, *loc. cit.* p. 296.
1870. *Widdringtonites Kurrianus*, Schimper, Trait. pal. vég. vol. ii. p. 329.
1870. ? *Araucarites hamatus*, Trautschold, Nouv. Mém. Soc. Nat. Moscou, vol. xiii. p. 37, pl. xxi. fig. 3.
1871. *Sphenolepis Kurriana*, Schenk, Palæontographica, vol. xix. p. 243, pl. xxxvii. figs. 5–8; pl. xxxviii. fig. 1.

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[1] Don.

[2] Engler and Prantl (*Coniferæ*), p. 84.

1875. *Thuites (Cupressites) Kurrianus*, Topley, Weald, p. 409.
1881. *Sphenolepidium Kurrianum*, Heer, Secc. Trab. Geol. Portugal, p. 19, pl. xii. fig. 1*b*; pl. xiii. figs. 1*b* and 8*b*; pl. xviii. figs. 1–8.
1881. ? *Thuites Choffati*, Heer, *loc. cit.* p. 11, pl. x. fig. 8.
1884. *Sphenolepidium Kurrianum*, Schenk in Zittel's Handbuch, p. 304, fig. 210.
1885. ? *Sphenolepis Kurriana*, Hosius and Von der Marck, Palæontographica, vol. xxvi. p. 216, pl. xliv. fig. 209.
1889. *Sphenolepidium Kurrianum*, Fontaine, Potomac Flora, p. 260, ? pl. cxxvi. figs. 1–6; pl. cxxviii. figs. 1 and 7; pl. cxxix. figs. 1, 2, 4, 6, and 8; ? pl. cxxx. fig. 11; pl. cxxxi. fig. 4; pl. clxvii. fig. 2.
? *Sphenolepidium Virginicum*, Fontaine, *loc. cit.* p. 259, pl. cxxv. fig. 4, and pl. clxvi. fig. 6.
? *Athrotaxopsis expansa*, Fontaine, *loc. cit.* p. 241, pl. cxxxv. figs. 15, 18, and 22.
1894. *Sphenolepidium Kurrianum*, Saporta, Flor. foss. Port. p. 115, pl. xxii. figs. 3–5.
1895. ? *Sphenolepidium Kurrianum*, Kerner, Jahrb. k.-k. geol. Reichs. vol. xlv. Heft i. p. 51, pl. iv. fig. 2.

Type. Vegetative branch. ? Berlin Museum.

Dunker thus defines the species:—

"Thuites ramulis erectis irregulariter pinnatis, compressiusculis utrimque subcarinatis, foliolis crassiusculis imbricatis irregulariter dispositis elongatis subflexuosis apice acutis dorso carinatis subdistantibus."

The small fragment figured by Römer as *Muscites imbricatus*, Röm., is probably identical with *Sphenolepidium Kurrianum* (Dunk.); Schenk calls attention to this resemblance, but, not having seen the type specimen, hesitates to express any decided opinion. Although there is a strong probability of Römer's specimen being a leafy twig of the present species, it would hardly be wise to enforce the rule of priority as regards the specific designation without more trustworthy data. The other fragment figured by Römer[1] as *Muscites falcifolius*, Röm., and compared by Dunker with *Sphenolepidium Kurrianum*, is too small to identify with certainty, and does not bear such a strong resemblance to Dunker's species as does *M. imbricatus*.

Ettinghausen's species *Widdringtonites Haidingeri* is no doubt correctly included by Schenk in the present species. The specimens figured by Ettingshausen as *Araucarites curvifolius* agree so closely

[1] Römer, F. A. (A.), Verstein. Ool. Geb. pl. xvii. fig. 1*e*.

with *S. Kurrianum* that there cannot be much doubt as to their specific identity. It has already been pointed out,[1] that one of the specimens referred by Schenk to this species is no doubt a fertile frond of *Onychiopsis Mantelli* (Brong.). Some of the numerous fragments figured by Fontaine from the Potomac beds, as examples of *S. Kurrianum*, suggest a plant with a habit somewhat different to that of Dunker's species. Without attempting to discuss the exact nature of all Fontaine's fragments, it is probably safe to assert that the present species is represented in the *Potomac Flora*. Fontaine's specimens are all without cones, but the small cones figured by him as *Athrotaxopsis expansa*, Font., may in all probability be referred to *S. Kurrianum*. The specimen figured by this author as *Sequoia gracilis*, Heer,[2] bears a decided resemblance to the present species. The fragments of cone-bearing twigs figured by Fontaine as a new species, *S. Virginicum*, are compared by him with *S. Kurrianum*. I have included these specimens in the synonomy as probably identical with the present species. Saporta's Portuguese examples of the species are for the most part small fragments of twigs; but there can be little or no doubt as to their specific identity with the English plant.

The numerous specimens figured by Heer from the Lower Cretaceous rocks of Greenland as *Cyparassidium gracile*, Heer,[3] agree so closely with *S. Kurrianum*, that one feels tempted to regard the two as identical. Heer notes the resemblance as regards leaf form and disposition between *Cyparissidium*, *Widdringtonites*, *Glyptostrobus*, *Athrotaxis*, and *Sequoia*; but adds that the form of the cones in *Cyparissidium* is quite distinct from that in the other genera, and more allied to *Cunninghamia*. Although there are some slight differences between the cones figured by Heer and those of *Sphenolepidium*, the points of difference do not appear to be very wide. Ettingshausen figures some specimens from Niederschoena under the name of *Frenelites Reichii*, Ett.;[4] these bear a strong resemblance to the present species, and it is difficult to determine on what grounds the

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[1] Vol. I. p. 44.

[2] Fontaine, Potomac Flora, pl. cxxvi.

[3] Heer (A. 3), Fl. foss. Arct. vol. vi. pl. i., and Fl. foss. Arct. vol. iii. (2) pl. xix. etc.

[4] Ettingshausen (A. 8), p. 246, pl. i. fig. 10.

comparison with *Frenela* is made. Possibly Yokoyama's Japanese species, *Cyparissidium* (?) *Japonicum*,[1] may be closely allied to *S. Kurrianum*, but the preservation of the specimens is too imperfect to allow of any satisfactory comparison. We may define the species as follows:—

Branching alternate; leaves ovate, acuminate, or triangular; keeled dorsally; cones small, borne on clusters of short slender branches, globose or oblong; scales broad and short, thick, with an elongated lozenge-shaped depression at the apex.

V. 2313. Pl. XVII. Figs. 8 and 8*a*.

This specimen appears to be practically identical with that figured by Schenk in his pl. xxxviii. figs. 10 and 11.[2] The oblong cone and the broad scales with the elliptical transversely elongated scars are well shown. The leaves of the fertile branches have an elongated oval form, with acute tips, and are closely adpressed to the stem. The cone is similar to that figured by Heer in pl. xiv.,[3] but in his specimen the leaves are less adpressed to the branch. Compare also Fontaine's *S. Virginicum*; this species may, however, be identical with *S. Sternbergianum*. Ecclesbourne. *Rufford Coll.*

V. 2316*d*. Pl. XVIII. Fig. 1.

This specimen shows very clearly the connection between the thicker and more slender branches. Compare the thicker portion with **V. 2316*b*.** Ecclesbourne. *Rufford Coll.*

V. 2316. Pl. XVII. Fig. 7.

The clustered fertile branches and small cones represent a characteristic feature of the species, and may be compared with those of such a recent plant as *Athrotaxis laxifolia*. *Cf.* **V. 2313*a***, etc.

V. 2313*b*, V. 2316*a*, V. 2316*b*. Cones; some with fairly well-preserved scales.

V. 2316*c*. Part of a thicker unbranched stem with clearly preserved leaves. This specimen, if examined without reference

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[1] Yokoyama, p. 229, pl. xx. figs. 3, 6, and 13, and pl. xxiv. fig. 4.

[2] Palæontographica, vol. xix.

[3] Secc. Trab. Geol. Port. 1881.

to the more slender branches of *S. Kurrianum*, would probably be referred to *Brachyphyllum*, and it serves to illustrate the great difficulty in attempting to discriminate between the various provisional genera of fossil conifers.

V. 2316*e*. Fragment of a thick axis. Cf. *Brachyphyllum obesum*, Heer. Ecclesbourne. *Rufford Coll.*

V. 2303. The adpressed leaves very clearly defined. The smaller branches appear to be identical with the fertile branch of **V. 2313** (Pl. XVII. Fig. 8). The long unbranched axis of this and other specimens suggests an open habit of branching.

V. 2303*a*. Probably the same species, but the leaves are rather less closely adpressed to the stem. *Cf.* Schenk, pl. xxxvii. fig. 5.[1]

V. 2303*b*. A much branched specimen. Towards the lower part of the thickest branch the leaves are seen to be shorter and more crowded. *Cf.* also **V. 2303**, and *Widdringtonites Haidingeri*, Ett., which Schenk has referred to *S. Kurrianum*.

V. 2303*c*. Long branches with the leaves less clearly preserved. Ecclesbourne. *Rufford Coll.*

V. 2253. Portions of branches. The leaves showing longitudinal striations, as in **V. 2750** (Pl. XVII. Fig. 5). Ecclesbourne. *Rufford Coll.*

V. 2285. Probably *S. Kurrianum*. Ecclesbourne. *Rufford Coll.*

V. 2286. Cones with open scales, probably belonging to this species. **V. 718.** Fragments of branches. Ecclesbourne. *Rufford Coll.*

V. 2303*a*. Slender branches with leaves rather less adpressed to the stem than in some examples of the species. This form suggests a passage to the more open leaves of *S. Sternbergianum*. *Cf.* **V. 2139***a* (Pl. XVI. Fig. 5). Ecclesbourne. *Rufford Coll.*

? *Sphenolepidium Kurrianum.*

V. 3343. Two large specimens. Slender branches given off from an axis 3 cm. in diameter.

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[1] Schenk, *loc. cit.*

Sphenolepidium Sternbergianum (Dunk.).

[Pl. XVI. Figs. 4–6.]

1846. *Muscites Sternbergianus*, Dunker, Wealdenbildung, p. 20, pl. vii. fig. 10.
1848. *Muscites Sternbergianus*, Bronn, Index nomencl. p. 759.
1849. *Juniperites Sternbergianus*, Brongniart, Tableau, p. 108.
1850. *Muscites Sternbergianus*, Unger, Gen. spec. plant. foss. p. 42.
1851. *Araucarites Dunkeri*, Ettingshausen, Abh. k.-k. geol. Reichs. vol. i. Abth. iii. No. 2, p. 27, pl. ii. figs. 2, 3, 7, and 8.
Araucarites curvifolius, Ettingshausen, *loc. cit.* p. 28, pl. ii. figs. 11, 13, 14, 17–21.
1861. *Araucarites Dunkeri*, Hildebrand, Verbreit. Conif. p. 276.
Araucarites curvifolius, Hildebrand, *ibid.* p. 276.
1870. *Widdringtonites Dunkeri*, Schimper, Trait. pal. vég. vol. ii. p. 329.
Widdringtonites curvifolius, Schimper, *ibid.* p. 329.
1871. *Sphenolepis Sternbergiana*, Schenk, Palæontographica, vol. xix. p. 243, pl. xxxvii. figs. 3 and 4; pl. xxxviii. figs. 3–13.
1881. *Sphenolepidium Sternbergianum*, Heer, Secc. Trab. Geol. Portugal, p. 19, pl. xiii. fig. 1*a*; pl. xiv. figs. 2–8.
1884. *Sphenolepidium Sternbergianum*, Schenk in Zittel's Handbuch, p. 304, fig. 210*a*, *b*, and *c*.
1885. *Sphenolepis Sternbergiana*, Hosius and Von der Marck, Palæontographica, vol. xxvi. p. 215, pl. xliv. figs. 206–208.[1]
1889. *Sphenolepidium Sternbergianum*, Fontaine, Potomac Flora, p. 261, ? pl. cxxi. figs. 8, 10, and 11; pl. cxxx. fig. 9.
1894. *Sphenolepidium Sternbergianum*, Saporta, Flor. foss. Port. p. 114, pl. xxii. figs. 1 and 2; p. 139, pl. xxvii. fig. 14; p. 193, pl. xxxiii. fig. 13.

Type. Fragments of small twigs.

Dunker gives the following definition of the species:—

"Muscites caule virgato subflexuoso, foliis bifariis imbricatis patentibus ovato-lanceolatis subfalcatis."

Brongniart substituted *Juniperites* as a more appropriate generic name than *Muscites*; and Ettingshausen renamed Dunker's plant *Araucarites Dunkeri*. The specimen figured in Ettingshausen's

[1] These fragments, from the Neocomian of Tönsberg, are very small and imperfect; fig. 206 is probably a fragment of *S. Sternbergianum*, but it would be unwise to make any definite statements on such slender evidence.

pl. ii. fig. x. seems to be identical with what he called *Widdringtonites Haidingeri*, and which we have included, following Schenk's example, as a synonym of *S. Sternbergianum*. Most of the specimens figured by Ettingshausen as *Araucarites curvifolius* (Dunk.), must no doubt be included in the present species, and are not identical with Dunker's *Lycopodites curvifolius*. Some of the species, on the other hand, are the same as Dunker's type, and do not appear to belong to *Sphenolepidium Sternbergianum*. Fontaine's small specimens agree with this species, but it is impossible to discriminate with any degree of certainty between the numerous and very similar twigs, which he figures from the Potomac beds under different specific names.

If we compare the figures of *Sequoia ambigua*, Heer,[1] with *Sphenolepidium Sternbergianum* (Dunk.), we find a striking resemblance; *e.g.*, Heer, pl. xxi. fig. 3, and Schenk, pl. xvi. figs. 3 and 4. It is exceedingly difficult to come to any satisfactory conclusion as to the specific identity of these various coniferous twigs; and the striking resemblance between the branches of certain recent forms, should sufficiently demonstrate the futility of attempting to carry our comparisons too far in the case of fossil fragments. It would seem, however, that if Heer's Greenland plant is not identical with the present species, it is closely allied to it. *S. Sternbergianum* differs from the preceding species chiefly in the more open and linear leaves. As regards the cones of the two species, it is not quite clear how far Schenk's description of a specific difference holds good; the material from the English beds is hardly sufficiently well preserved to enable us to give any satisfactory detailed diagnosis.

V. 2311. Pl. XVI. Fig. 4.

An imperfectly preserved specimen showing two cones attached to short branches. The difference in the leaf form from that of *S. Kurrianum* is clearly shown. Ecclesbourne. *Rufford Coll.*

V. 2144. Pl. XVI. Fig. 6.

Well-preserved branches with spreading and falcate leaves. Ecclesbourne. *Rufford Coll.*

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[1] Heer, Fl. foss. Arct. vol. iii. (2) pl. xxi. etc.

V. 2139*a*. Pl. XVI. Fig. 5.

Smaller specimen, with more crowded leaves, leaf form distinctly preserved. Compare with the upper part of **V. 2139**, in which the leaves are less closely arranged. Very similar to the specimens figured by Schenk[1] in pl. xxxvii. figs. 3 and 4.

V. 2139. 20 cm. in length. No doubt the same form as *Muscites Sternbergianus*, Dunk. The thicker branch well preserved, showing clearly defined leaves, with the distal end free, and the broader basal portion adpressed to the axis. Several delicate branches shown at the upper end. *Cf.* Schenk,[1] pl. xxxviii. fig. 3. Ecclesbourne. *Rufford Coll.*

V. 2141. Probably the same species. *Cf.* **V. 2144**, also Ettingshausen's figures of *Araucarites curvifolius*,[2] some of which Schenk refers to *S. Sternbergianum*. Ecclesbourne. *Rufford Coll.*

V. 2289, V. 2289*b*. Larger examples with imperfect fragments of cones.

V. 2289*c*. Imperfectly preserved, probably specifically identical with the above specimens. Compare the finer branches with Dunker's *Lycopodites*, pl. viii. fig. 8.[3]

V. 2289*d*. Imperfect fragment showing the leaves in side and surface view. Ecclesbourne. *Rufford Coll.*

V. 2290, V. 2315. Small curved and closely crowded leaves, probably identical with the form represented in Ettingshausen's figures of *Araucarites Dunkeri*. *Cf.* also **V. 2139***a*, etc. Possibly this form should be regarded as a distinct species, but the evidence is hardly sufficient to justify a separation from *S. Sternbergianum*. Ecclesbourne. *Rufford Coll.*

V. 2311*a*. Cone; fairly well preserved.

V. 2919. The leaves show very clearly the single median vein. Ecclesbourne. *Rufford Coll.*

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[1] *Loc. cit.*

[2] Ettingshausen (A. 4).

[3] Dunker, Wealdenbildung.

Cf. **Sphenolepidium (Sequoia) subulatum** (Heer).

[Pl. XVI. Fig. 3.]

There are a few specimens in the Rufford Collection which differ from the typical *S. Sternbergianum* (Dunk.), in having more closely arranged, longer and narrower leaves; they agree very well with Heer's Greenland species *Sequoia subulata*,[1] and are probably identical with this form, and with the specimens described by Saporta from Portugal as *Sequoia subulata* var. *Lusitanica*.[2] Saporta's variety appears to be hardly justified by the very small differences which he notes between the Portuguese and Arctic forms. There would seem to be no satisfactory evidence to warrant the use of the generic name of *Sequoia*.

Ettingshausen's fig. 18, pl. ii.[3] [*Araucarites curvifolius* (Dunk.)] bears a strong likeness to the specimen represented in our Pl. XVI. Fig. 3 (**V. 2140**). It is not improbable that some of the specimens figured by Fontaine as *Sequoia Reichenbachii*, Heer,[4] are identical with the present species. Possibly the following specimens might reasonably be referred to as constituting a variety of *Sphenolepidium Sternbergianum*.

V. 2140. Pl. XVI. Fig. 3.

Branches fairly closely set. Leaves narrow, linear and keeled, slightly curved or almost straight. At first sight the branches appear to have a bilateral form as regards the leaf arrangement, but this may be simply due to manner of preservation. Ecclesbourne. *Rufford Coll.*

V. 2093. Broken fragments. Leaves fairly distinct. Cf. *S. Sternbergianum* and Ettingshausen's pl. ii. fig. 18. Ecclesbourne. *Rufford Coll.*

V. 1069. Smaller specimen. Ecclesbourne. *Rufford Coll.*

Sphenolepidium, sp.

V. 2281, V. 2283. Specimens of cones which cannot be referred with any certainty to a particular species of the genus.

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[1] Heer, Fl. foss. Arct. vol. iii. (2) p. 102, pls. xxvii.–xxix.

[2] Saporta (1), p. 177, pl. xxxiii. figs. 7–12.

[3] Ettingshausen, *loc. cit.*

[4] Fontaine, Potomac Flora, pl. cxviii. etc.

Genus **THUITES,** Brongniart.

[Tableau, 1849, p. 71.]

Thuites valdensis, sp. nov.

[Pl. XX. Fig. 6.]

Type. Single specimen of a leafy twig. British Museum.

Although it is impossible to give a complete or entirely satisfactory definition of this species from the single specimen in the Rufford Collection, it may be convenient to adopt a new specific term, as there seems to be little doubt that we have to do with fragments of a conifer different from any known species. The characters may be summarized as follows:—

Branching opposite, leaves in whorls, adpressed to the stem, two in each whorl, keeled dorsally and with comparatively blunt apices.

Some of the specimens referred by Ettingshausen to *Frenelopsis Hoheneggeri* (Ett.), and, in a less degree, a few of those figured by Schenk under Ettingshausen's specific name, show a distinct resemblance to the present specimen.

V. 2138. Pl. XX. Fig. 6.

Preservation good. The leaves and opposite branching are clearly seen. Cf. *Frenelopsis ramosissima,* Font., *Potomac Flora,* pl. xcv.,[1] etc., also *F. Hoheneggeri* (Ett.).[2] In describing the specimens subsequently referred by Schenk to the genus *Frenelopsis,* Ettingshausen adopts the generic name *Thuites* in the wide sense, as including various forms of *Cupressineæ*; it would probably be wiser to retain *Thuites* for such examples as those figured by Ettingshausen. In instituting the species *T. Hoheneggeri,* Ettingshausen speaks of the branching as alternate, and the leaves as "quadrifariam imbricatis"; but the specimen shown in his pl. i. fig. 7 has clearly only two leaves in some of the verticils; indeed, there is a striking similarity between this German specimen and the single example from the English

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[1] Fontaine (A. 2), Potomac Flora.

[2] Ettingshausen (A. 4), Abh. k.-k. geol. Reichs. vol. i. Abth. iii. 1852, pl. i. figs. 6 and 7.

beds. Turning to Schenk's description, we find that he notes the presence of rows of small tubercles on the branches as an additional character, and describes the leaves as decussate and opposite, and not four in each whorl as stated by Ettingshausen. It may be that under *Frenelopsis Hoheneggeri* (Ett.) we have more than one species; the younger fragments, such as those figured by Ettingshausen, and a few of those described by Schenk, agree very closely with the English specimen of *Thuites*, but the larger branches of Schenk may perhaps belong to another plant. Ecclesbourne. *Rufford Coll.*

Genus **NAGEIOPSIS**, Fontaine.

[Potomac Flora, 1889, p. 194.]

Fontaine proposes this generic title for one of the most largely developed and characteristic Potomac plants. He compares the leaves with those of *Podozamites*, but is enabled by the large and numerous specimens at his disposal to recognize distinct coniferous features. He defines the genus as follows:—

"Trees or shrubs with leaves and branches spreading in one plane; leaves varying much in size and shape, those towards the base of the twigs sometimes smaller than those higher up, distichous mostly, or rarely subdistichous, opposite and persistent, attached by a short, slightly twisted foot-stalk, usually to the side of the twig, more rarely slightly within the margin on the upper or under surface of the stem, either attenuated towards the base or abruptly rounded off there, at their ends acute or sub-acute; nerves several, coalescing at base to form a foot-stalk, forking immediately at the base or a short distance above, then approximately parallel to near the tips of the leaves, where they are somewhat crowded together, but do not converge to a union, ending in or near the extremity."

The genus *Podocarpus* is divided by Eichler[1] into four sections, of which section i. is *Nageia*, formerly regarded as a distinct genus.[2] In this form of *Podocarpus* the leaves have numerous veins, and not a single midrib as in other species of the same genus.

[1] Engler and Prantl, p. 104.

[2] E. G. Gordon, The Pinetum, p. 135 (1858).

Nageiopsis *cf.* N. heterophylla, Font.[1]

[Pl. XII. Fig. 3.]

The few small fragments from the English beds bear a strong resemblance to the specimen figured by Fontaine as *Nageiopsis heterophylla*, and most probably belong to this species.

V. 3190. Pl. XII. Fig. 3.

Compare Fontaine, pl. lxxxvi. figs. 6 and 7, etc. There are several equal veins in each leaf which converge somewhat towards the apex; the leaves are gradually tapered distally, and towards the point of attachment. The actual manner of attachment to the branch is not clearly shown. Near Hastings. *Rufford Coll.*

V. 2123, V. 2362.

Probably the same species, but much more imperfect. Eccles-bourne. *Rufford Coll.*

Coniferæ incertæ sedis.

Genus PAGIOPHYLLUM, Heer.

[Secc. Trab. Geol. Portugal, 1881, p. 11.]

Saporta[2] includes in the tribe *Araucarineæ* two genera, *Pachyphyllum* and *Araucaria*; the former representing the extinct types, the latter the living species. *Pachyphyllum* was first instituted by Pomel[3] as a section of his genus *Moreania*, including *M. brevifolia*, Pom., as the typical species.

Saporta figures some examples of the genus in which portions of cones are preserved, and is thus able to give a fairly detailed diagnosis. He places *Pachyphyllum* close to *Araucaria* (*Eutacta*), *Agathis*, and *Cunninghamia*. The general appearance of the

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[1] Potomac Flora, p. 201, pls. lxxxiv.-lxxxvi.

[2] Pal. Franç. vol. iii. p. 372.

[3] Pomel, p. 21.

branches referred to this genus suggests an araucarian habit, and there is a decided probability that we may consider the fossil forms as closely allied to the recent genus. As regards the English specimens, in the absence of fossil cones we have no very satisfactory evidence as to the relationship to modern forms. Heer substituted *Pagiophyllum* for *Pachyphyllum*, on the ground that the latter name had already been assigned to a genus of orchids. The following concise definition is given in Zittel's *Handbuch*[1]: "Leaves spirally arranged, leathery, thick, triangular, lanceolate; spreading or closely imbricate; decurrent at the base." Solms-Laubach[2] justly considers *Pagiophyllum* a purely artificial and provisional genus.

Pagiophyllum crassifolium (Schenk).

[Pl. XVI. Figs. 1 and 2.]

1871. *Pachyphyllum crassifolium*, Schenk, Palæontographica, vol. xix. p. 240, pl. xl. fig. 8.
1874. *Pachyphyllum crassifolium*, Schimper, Trait. pal. vég. vol. iii. p. 570.
1884. ? *Pachyphyllum crassifolium*, Saporta, Pal. Franç. vol. iii. p. 655, pl. ccxxvi. fig. 1.
1884. *Pagiophyllum crassifolium*, Schenk in Zittel's Handbuch, p. 276.

Type. Small and imperfect fragment of a branch. Göttingen Museum.

Schenk defines the species as follows:—

"Folia in ramulo spiraliter disposita, trigona crassa conica falcata basi sessilia decurrentia."

The specimens referred by Saporta to Schenk's species were obtained from some limestone rocks of Upper Jurassic age, in the neighbourhood of Grenoble; it is by no means certain that they are specifically identical with the Wealden type.

We may slightly extend Schenk's diagnosis:—

Leaves spirally arranged; sessile, with broad base, triangular, somewhat falcate, keeled on the dorsal surface; the leaf lamina marked by fine parallel lines. Branching alternate.

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[1] p. 275.

[2] Fossil Botany, p. 77.

V. 2803. Pl. XVI. Fig. 1.

Well-preserved specimen; the thick, falcate, and keeled leaves are closely arranged on the branches, reminding one of *Cryptomeria Japonica.* This form is very similar to the smaller specimens, compared with *Lycopodites curvifolius*, Dunk., and referred to *Sphenolepidium Sternbergianum.* Ecclesbourne. *Rufford Coll.*

V. 2142*a*. Pl. XVI. Fig. 2.

The left-hand fragment agrees closely with *Sphenolepidium Sternbergianum*; the leaves seen edgewise appear to be narrow, and show traces of a median keel. *Cf.* **V. 2289.**

Towards the upper end of the large branch the tips of the falcate leaves are distinctly preserved; in the lower part they are seen in side view, and present a broader triangular appearance.

V. 2142 and **V. 2142***b*. Here the leaves appear to be narrower, but this is largely due to the fact that they are seen edgewise, and not so directly as in **V. 2747.** Ecclesbourne. *Rufford Coll.*

V. 2747. *Cf.* **V. 2142***a* (Pl. XVI. Fig. 2). The flattened leaves seen in this view do not show the falcate form so distinctly in other specimens. Ecclesbourne. *Rufford Coll.*

Pagiophyllum, sp.

[Pl. XX. Fig. 3.]

V. 2288. Pl. XX. Fig. 3.

In this specimen the leaves are fairly well preserved; they appear to be broader than those of the specimens referred to *P. crassifolium.* The fragment is, however, too small and imperfect to admit of more exact determination. Ecclesbourne.

Rufford Coll.

V. 2143, V. 2317, V. 2931.

These fragments may possibly be portions of branches of the preceding species, but they are too fragmentary to determine with any accuracy.

Genus **BRACHYPHYLLUM**, Brongniart.

[Tableau, 1849, p. 69.]

Brongniart proposed this name for conifers with alternate leaves disposed in a spiral, short, fleshy, and inserted by a broad and rhomboidal base. Schimper[1] extends this definition, and speaks of the genus as differing in its characters from all living forms; he points out the striking resemblance between old branches of *Brachyphyllum*, with the leaves in the form of hexagonal or pentagonal cushions, and certain strobili of cycads and conifers. The surface features of a branch from which the leaves have fallen resemble those of *Lepidodendron*. Saporta[2] further extends Brongniart's definition; and remarks that probably no genus of conifers has given rise to more confusion and uncertainty than the present genus. It has been compared with several recent genera, but we cannot regard *Brachyphyllum*, with its numerous species from various geological horizons, as more than a purely provisional genus, the actual botanical position of which is very uncertain; probably more than one family of *Coniferæ* being represented by the forms referred to under this generic name. Schenk[3] has drawn attention to the too comprehensive nature of the genus as used by Saporta, Heer, and others, but does not suggest any more precise definition of the generic characters.

As Fontaine remarks, there is a striking resemblance between some forms of *Echinostrobus*, *Brachyphyllum*, and *Palæocyparis*. Saporta, in describing the characteristics of *Echinostrobus*, points out that it differs from *Brachyphyllum* in having the leaves less thick, more pointed, and less completely adnate to the stem. We may compare both of these fossil genera with certain species of the recent genus *Athrotaxis*. The thick fleshy leaves, with their broad rhomboidal bases and spiral arrangement, constitute the leading features of this artificial genus of fossil conifers.

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[1] Trait. pal. vég. vol. ii. p. 334.

[2] Pal. Franç. vol. iii. p. 310.

[3] Zittel's Handbuch, p. 301.

Brachyphyllum spinosum, sp. nov.

[Pl. XVII. Figs. 1–6.]

Type. Large specimens from Ecclesbourne, near Hastings. British Museum.

This specific term is proposed as a convenient designation for what is probably a new species of *Brachyphyllum.* It is possible that some of the Wealden specimens previously recorded from other localities, and referred to this genus, may be fragments of the present species; but of this there is no proof. Seeing that no fossils have been, so far, described in which the characters of the large branches in the Rufford Collection are represented, we must institute a new term. The species may be defined as follows:—

Leaves fleshy, with a median keel on the convex surface; the surface may be finely striated; leaf-scars rhomboidal, contiguous, and spirally arranged. Some of the short lateral branches have a pointed thorn-like form, and are clothed with the characteristic fleshy leaves with pointed apices. Two or three of the spiny branches arise approximately at the same level from the parent axis.

The short, stiff, leaf-bearing thorns or pointed branches constitute the most prominent feature of the species. One may compare the thicker branches, with their large rhomboidal leaf bases, with small cycadean stems or twigs of *Lepidodendron.* In the absence of any reproductive organs, it is impossible to assign the species to any definite position among the *Coniferæ.* It is no easy task to determine the connection, if any, between such large specimens as that represented in Pl. XVII. Fig. 1, and the numerous smaller portions of branches. The specimen shown in Pl. XVII. Fig. 6 (**V. 2135**)[1] is regarded as specifically identical with Pl. XVII. Fig. 1 (**V. 2746**), the striking difference being probably due to the destruction of the cortical tissues in the former case. The small piece of branch represented in Fig. 5 (**V. 2750**), shows very clearly the woody axis detached in the lower part of the specimen from the cortical tissues and leaves.

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[1] Represented in the figure one-third natural size.

This form of *Brachyphyllum* does not appear to have been hitherto recorded from rocks of Upper Jurassic or Lower Cretaceous age, unless we may refer to this species some of the small twigs described by Saporta, Heer, Fontaine, and others from Wealden strata. The spinous branches and general habit of *B. spinosum* distinguish it from previously figured examples with similar leaves and leaf cushions. Velenovský[1] figures some specimens from the Perucer beds of Bohemia under the name of *Echinostrobus squamosus*, Vel.: these have similar leaves to those of *B. spinosum*; but coniferous branches with this form of leaf are too abundant in Jurassic and Cretaceous rocks to admit of any strict comparison. *Brachyphyllum crassicaule*, Font.,[2] *B. obesum*, Heer,[3] and others may be referred to as similar in leaf form to the present species. Among the numerous conifers figured by Saporta from Jurassic strata, we have such species as *B. nepos*, Sap.,[4] and *B. Desnoyersii*[5] (Brong.), and other forms which resemble the Wealden species in a greater or less degree. We may compare also *Pagiophyllum cirinicum*,[6] Sap. Possibly the latter genus might be a suitable designation for the English specimens, but the distinction between *Brachyphyllum* and *Pagiophyllum* is in many cases by no means well marked, and neither term is more than a convenient generic name which does not imply any precise botanical affinity.

V. 2746. Pl. XVII. Fig. 1.

The main axis of this large specimen has a breadth of 2 cm., and is covered with polygonal areas representing the impressions of large scale leaves, very similar to those in thicker branches of species of *Athrotaxis*, *Thujopsis*, etc., among recent genera. These are the remains of short and broad leaves preserved in the form of carbonaceous impressions on the matrix, immediately in contact with the thick axis. The two lowest branches are 4 cm. apart; their surface markings are identical with those on the main branch; from each of the lateral branches there are given off short tapered stiff branches covered with similar leaf impressions. Each of

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[1] (A. 1) Gym. böhm. Kreid. p. 16, pl. vi. figs. 3, 6, 7, 8.

[2] Potomac Flora, p. 221, pl. 100, fig. 4, pl. cix. etc.

[3] Heer (A. 6), Secc. Trab. Geol. Portugal, 1881, p. 20, pl. xvii. figs. 1–4.

[4] Pal. Franç. vol. iii. p. 356, pl. clxviii. etc.

[5] *Ibid.* p. 331, pl. clxiii. etc.

[6] *Ibid.* p. 402, pl. clxxx. etc.

these small branches ends in a distinct spinous apex, and in the axils of some of them are seen the indistinct impressions of smaller leafy twigs. A still larger specimen, very similar to the above, is in the possession of Mr. Rufford; it shows two branches, the longest of which has a length of 42 cm., and gives off numerous stiff, pointed branches like those shown in **V. 2746**. These spinous branches appear to be given off approximately at the same level, and probably there were three in each pseudo-whorl. Some of the large leaves in these specimens show fine longitudinal striations. Ecclesbourne. *Rufford Coll.*

V. 2135. Pl. XVII. Fig. 6. ($\frac{1}{3}$ nat. size.)

This long and narrow branched axis I have referred to *Brachyphyllum spinosum*, on the grounds that it represents a decorticated specimen of the same plant which is more perfectly preserved in **V. 2746** (Pl. XVII. Fig. 1). The breadth is fairly uniform, about 5–6 mm.; the numerous short spinous branches are clearly marked, and appear to have been given off in groups of twos or threes; one sees in some cases two branches lying lengthwise in the sandstone, and the base of a third in the form of a round scar in the substance of the main branch. There are no signs of any leaf bases or leaves in this example, the exposed surface of which probably represents the face of the woody axis. In specimen **V. 2750** (Pl. XVII. Fig. 5) we have a good example of the marked difference in breadth and surface characters between the leafy branch and the decorticated woody axis. The thorn-like processes in this specimen are regarded as the decorticated spinous branches of **V. 2746** (Pl. XVII. Fig. 1). Ecclesbourne. *Rufford Coll.*

V. 2240. Pl. XVII. Fig. 4. (A portion of the specimen shown in the figure.)

At the upper end of the specimen we have what appears to be a pith cast, surrounded by a woody cylinder, in the form of a dusty substance, representing the remains of wood tissue. The figured portion shows two spinous branches and the base of a third; probably there may have been four such branches in each pseudo-whorl. It may be noted that the spinous appendages in this specimen and in **V. 2135** (Pl. XVII. Fig. 6), are more nearly at right angles to the larger axis than in **V. 2746** (Pl. XVII. Fig. 1). Ecclesbourne. *Rufford Coll.*

V. 3180. Pl. XVII. Fig. 3.

This thicker branch resembles a small cycadean axis with well-marked bases of petioles. Probably it is a portion of *B. spinosum.* At the edges of the cast there are here and there the impressions of the narrow distal ends of scale leaves; also at one place there is shown the point of attachment of a lateral branch. Length 15 cm.; diameter 1·5 cm. Ecclesbourne. *Rufford Coll.*

V. 2750. Pl. XVII. Figs. 5 and *5a.*

A small piece of a branch, showing clearly preserved leaves with longitudinal striations (*5a*). At each end there projects the impression of the woody axis, or possibly of a large pith-cavity, such as one finds in the genus *Araucaria.* It is difficult, not to say impossible, to distinguish between fragments of this species and those of *B. obesum.*

V. 2746*a*. Axis 13 cm. long, showing the clearly defined outlines of short and broad leaves. Immediately above and below the point of attachment of a spinous branch, there are impressions of much more slender leafy twigs. Ecclesbourne. *Rufford Coll.*

? Brachyphyllum spinosum.

V. 2296. Pl. XVII. Fig. 2.

The broad leaves of this specimen show very clearly the fine striations similar to those already noted, and identical with the surface characters represented by Saporta in species of *Pagiophyllum* and *Brachyphyllum.*

V. 2750*a*, V. 2751. Fragments. Ecclesbourne. *Rufford Coll.*

Brachyphyllum obesum, Heer.

1881. *Brachyphyllum obesum*, Heer, Secc. Trab. Geol. Portugal, p. 20, pl. xvii. figs. 1–4.

1889. ? *Brachyphyllum crassicaule*, Fontaine, Potomac Flora, p. 221, pl. 100, fig. 4; pl. cix. figs. 1–7.

1894. *Brachyphyllum obesum*, Saporta, Flor. foss. Port. pp. 112, 138, pl. xxi. figs. 1–7; pl. xxvii. figs. 7 and 8.

Brachyphyllum obesiforme, Saporta, *loc. cit.* p. 176, pl. xxxi. figs. 12 and 13.

Brachyphyllum obesiforme var. *elongatum*, Saporta, *loc. cit.* p. 176, pl. xxxi. fig. 14.

Type. Portions of vegetative branches.

Heer instituted this species from some fragments of coniferous branches from the Lower Cretaceous rocks of Almargem, Portugal; and defined it as follows :—

"Br. ramis alternis, ramulis numerosis, aggregatis, crassis, brevibus, apice obtusis, foliis rhombeis, dense imbricatis, dorso leviter striatis."

In his recent monograph on the Portuguese flora, Saporta proposes a new specific name, *obesiforme*, for some examples of *Brachyphyllum*, which he considers may be distinguished from Heer's species by their more slender branches, which are less thick-set, more elongated, and subdivided. He speaks of the difference between the two forms as slight, and admits that one may be merely a variety of the other. If we compare Saporta's figures with those of *B. obesum* given by Heer, it must be admitted that the grounds for a specific distinction are extremely slight, and we may not unreasonably regard the two sets of specimens as specifically identical. Another specimen figured by Saporta is spoken of as *B. obesiforme* var. *elongatum*; this, again, appears to be too closely allied to such examples of *B. obesiforme* as are figured on pl. xxxi. figs. 12 and 13 to be entitled to a separate designation. The new specific term instituted by Fontaine for some Potomac specimens is perhaps a somewhat unnecessary addition to specific nomenclature; the author of the species does not, apparently, draw attention to the very close resemblance between the fossils he describes as *B. crassicaule* and those already figured by Heer and Saporta as *B. obesum*. The figures in Fontaine's pl. cix. may include more than one specific form, but the evidence is too meagre to admit of exact determination; figs. 4 and 5 resemble the form named by Saporta *B. confusum*,[1] but the difference between this species and *B. obesum* is very small. The agreement between Fontaine's pl. cix. fig. 1 (*B. crassicaule*) and Heer's pl. xvii. fig. 2, is very striking: compare also Fontaine, pl. cix. fig. 2, Heer, pl. xvii. fig. 3, and Saporta, pl. xxxi. fig. 12. Fontaine's species, *B. parceramosum*,[2] comes very near to the specimen figured by Saporta as *B. obesiforme* var. *elongatum*.

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[1] Flor. foss. Portugal, p. 112, pl. xxi. fig. 8.
[2] Potomac Flora, pl. cx. fig. 4.

I believe we cannot sufficiently discriminate between the several specimens figured by the above authors, and the similar fragments from the English Wealden strata, to arrive at any trustworthy specific distinctions or diagnoses of well-marked specific types. To group together all these forms may be unwise, and it has already been pointed out that we find certain points of difference between some of the specimens, which suggest either specific distinctions or varieties of the same type. I venture, therefore, to make use of Heer's specific name *B. obesum* in a somewhat more comprehensive sense than has been adopted by Saporta.

Among recent conifers, e.g. *Cupressus Lawsoniana*, Parl., etc., we find a considerable difference in the appearance of the branches depending on the development of numerous or few lateral branches in the axils of the leaves; we have the closely set lateral branches as in some forms of *B. crassicaule*, as figured by Fontaine, and the more elongated branches without the closely set lateral shoots, as in *B. obesiforme* var. *elongatum*, Sap. To unite such forms under one name, especially in the absence of cone-bearing branches, can hardly be regarded as an unwarranted extension of the limits of a fossil species of which our accurate knowledge is extremely small. The Jurassic species *Brachyphyllum gracile*, Brong.,[1] appears almost identical with some forms of *B. obesum*; such comparisons might, however, be considerably increased, but without leading to any satisfactory conclusions.

Many of the specimens referred to *B. obesum* agree very closely with *B. spinosum*, sp. nov., and it is, I believe, almost impossible to feel much confidence in our attempts to distinguish between small specimens of plants of this particular form. Possibly it would have been better to make use of Fontaine's specific term *crassicaule* for some of the following examples, and to have included others under *B. obesum*; but if we examine such a series as is represented by the following specimens, the difficulty of accurate determination becomes apparent: **V. 3348** (Pl. XVII. Fig. 9), **V. 2137** (Pl. XX. Fig. 1), **V. 2137***a* (Pl. XX. Fig. 2), **V. 2337** (Pl. XX. Fig. 4).

V. 2137. Pl. XX. Fig. 1.

Cf. *Brachyphyllum obesiforme* var. *elongatum*, Saporta, pl. xxxi.

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[1] Saporta, Pal. Franç. vol. iv. p. 365, pl. clxviii., clxx., and clxxi.

fig. 14; also Fontaine's *Athrotaxopsis expansa*, pl. cxiii. figs. 5 and 6, and *A. grandis*, Font., pl. cxvi. figs. 1–4. This specimen does not show the leaf form very clearly, but the manner of branching is well illustrated; similar to the smaller example (**V. 3348**) figured in Pl. XVII. Fig. 9. Ecclesbourne. *Rufford Coll.*

V. 2137*a*. Pl. XX. Fig. 2.

Leaves distinct; the habit agrees with that of the smaller specimen (**V. 3348**) shown in Pl. XVII. Fig. 9. *Cf.* Saporta, pl. xxxi. fig. 14, and Fontaine, pl. cxi. fig. 7.

V. 3348. Pl. XVII. Fig. 9.

Leaves very indistinct. Cf. *Brachyphyllum obesum*, Heer, pl. xvii. fig. 2, and Saporta, pl. xxxiv. fig. 8; also *B. crassicaule*, Font., pl. cxii. fig. 6. Ecclesbourne. *Rufford Coll.*

V. 2337. Pl. XX. Fig. 4.

Leaves well shown, with faint indications of longitudinal striations. Similar to **V. 2316***a*, etc. Ecclesbourne. *Rufford Coll.*

V. 2316*a*. Leaves agree closely with those of *Sphenolepidium Kurrianum* (Dunk.), but the branching is apparently different. *Cf.* **V. 2316***e* (*S. Kurrianum*). Ecclesbourne. *Rufford Coll.*

V. 2137*a*. *Cf.* Saporta, pl. xxxi. fig. 14, and Fontaine's *B. crassicaule*, pl. cxi. fig. 7. Ecclesbourne. *Rufford Coll.*

V. 2292*a*. *Cf.* Saporta, pl. xxxiv. fig. 8. Branches in this specimen closer together and thicker. Similar habit to **V. 2292.** Ecclesbourne. *Rufford Coll.*

V. 2307. Similar to **V. 2316***a*, etc. Branch 18 cm. long; imperfectly preserved.

V. 3312. Broad axis with two small branches; similar habit to that of **V. 2292***a*. *Cf.* Fontaine, pl. cxi. fig. 7. Ecclesbourne. *Rufford Coll.*

Other specimens of branches or leaves referred to this species: **V. 2257**, **V. 2303**, **V. 2303***a*, **V. 2310**, **V. 2883**, **V. 3183**, **V. 3192.** Ecclesbourne. *Rufford Coll.*

Genus **CONITES**, Sternberg.

On page 113 of the present volume I have suggested the revival of Sternberg's genus *Conites* for cones of doubtful position, and have included under this generic name two species previously described by Carruthers as examples of cycadean strobili. From an examination of additional specimens in the Rufford Collection, it would seem that the species *Conites elegans* should be referred to the genus *Araucarites*, as being, in all probability, a female araucarian cone. Owing to the different manner of preservation of the Rufford specimens, it would, perhaps, be somewhat rash to speak of them as specifically identical with Carruthers' cones from the Isle of Wight, but there is a strong likelihood of their close relationship, if not specific identity. Possibly the institution of a new species of *Araucarites* would be the most convenient course to adopt in dealing with these new Wealden specimens; but the various strobili hitherto described as species of *Cycadeostrobus*, *Araucarites*, and *Kaidocarpon* require careful revision, and I prefer, therefore, to refrain from adding a new specific name until the several forms have been more thoroughly examined.

Conites armatus, sp. nov.

[Pl. IX. Fig. 7.]

Type. Imperfectly preserved impression of flattened cone. British Museum.

The single specimen to which I have assigned the above specific name is too imperfect to admit of any complete diagnosis, but the very distinctly marked and characteristic spinous processes render it convenient to have some descriptive designation, even in the absence of those more important characters on which a satisfactory specific definition could be founded.

V. 2338. Details very obscure; the long recurved spines are in all probability the apical prolongation of the cone scales, similar to those in the cones of such recent species as *Araucaria Bidwilli*, Hook., *A. Cooki*, Brown, *Pinus Coulteri*, Don, *P. Sabiniana*, Dougl., etc. Ecclesbourne. *Rufford Coll.*

CONIFEROUS WOOD.

The occurrence of coniferous wood of Wealden age has long been known in the case of the so-called Pine-raft of Brook Point, in the Isle of Wight. This seems to have been first observed by Webster in 1811,[1] and was afterwards described by Mantell in 1846[2]; the latter writer compares the numerous coniferous trunks and associated fossils, with the rafts of drifted trees carried down by the waters of the Mississippi. In addition to the fossil wood, with its tissues more or less perfectly preserved in carbonate of lime, there are numerous deposits of lignite at various horizons in the Wealden strata, in which the lignitic material obviously consists of the wood of coniferous trees. In the *Medals of Creation*, Mantell writes:[3] "In the Wealden deposits of Sussex, Kent, and Surrey, I have not observed a single fragment of coniferous wood." More recently, in Dixon's *Geology of Sussex*, we find that the occurrence of wood similar to that of the recent genus *Pinus* is recorded, both in the form of brittle jet and as mineralized fossil wood.[4]

In the British Museum Collection, there are several good specimens of lignite in which the characters of coniferous wood are clearly seen, and numerous examples of wood with the tissues for the most part imperfectly preserved.

By far the most perfectly preserved specimen of coniferous wood is that previously mentioned as *Pinites Ruffordi*, sp. nov., and which I hope to describe in detail elsewhere. In addition to this, the following specimens may be mentioned:—

V. 701. Specimens of lignite, or perhaps more accurately described as jet; the annual rings clearly seen at one end of the large block. Hastings. *Dawson Coll.*

V. 704. Lignite. Hastings. *Dawson Coll.*

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[1] Bristow (A), Geol. I. Wight, pp. 6 and 252.
[2] Mantell (2), p. 92.
[3] *Ibid.* (1), vol. i. p. 165.
[4] Dixon (A.), p. 279.

V. 706. A fairly large piece of wood with patches of resinous material or amber traversing the mass longitudinally; some of these suggest the presence in the wood of large groups of parenchymatous tissue, such as Conwentz has described as "abnormes Holz-parenchym" in the case of *Pinus succinifera* (Göpp.)[1] from the North German amber beds. The microscopic structure is very imperfectly preserved. Ecclesbourne.

Rufford Coll.

V. 707. Wood partially converted into lignite. Ecclesbourne.

Dawson Coll.

V. 713 (*Dawson Coll.*), **V. 2233**, **V. 2237**.

Specimens of wood showing little or no internal structure. Ecclesbourne. *Rufford Coll.*

V. 2247 and **V. 2247***a*. In the latter specimen the structure is fairly well preserved; annual rings are distinct, but less so than in **V. 2304** (*Pinites Ruffordi*).

V. 2326. A specimen of wood which has undergone comparatively little alteration. Ecclesbourne. *Rufford Coll.*

38374. Small piece of lignite. Fairlight. *Mantell Coll.*

[**Spirangium Jugleri** (Ett.). In the Rufford Collection there are several exceedingly well-preserved specimens of this fossil which merit careful examination; but if we accept the view that they are the eggs of fishes and not plant structures, this is not the place for any descriptive account of them. For information as to the nature of *Spirangium* reference may be made to the following sources:—Ettingshausen, Ueber *Palæobromelia*, ein neues Fossiles Pflanzengeschlecht, *Abh. k.-k. geol Reichs.*, vol. i. Abth. iii. p. 1; Schenk, *Palæontographica*, vol. xix. 1871, p. 247; Schenk, *Die fossilen Pflanzenreste* (Schenk's *Handbuch*, vol. iv. 1888), p. 186; Nathorst, *Öfvers. kongl. Vetensk.-Akad. Förhand.* 1879, No. 3; Renault and Zeiller, *Compt. Rend.* vol. cvii. 1888, p. 1022; Saporta, *Pal. Franç.* vol. iv. 1891, p. 38; Seward, A new British Carboniferous fossil, *Naturalist*, 1894, p. 233; A. Hollick, Remarks on a paper by Dean in the *Trans. New York Acad. Sci.* vol. xiii. 1893, p. 115, etc.]

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[1] Conwentz, p. 51.

ADDENDA TO VOL. I.

Nathorstia valdensis (= *Leckenbya valdensis*), gen. et sp. nov. Vol. I. p. 145, Pl. VII. Fig. 5, and Pl. IX. Figs. 2 and 2*a*.

After the publication of the first volume of the *Wealden Catalogue*, it was pointed out to me by Prof. Nathorst that his name had been previously made use of by Heer for certain marattiaceous ferns from the Cretaceous strata of Pattorfik, in Greenland.[1] This oversight on my part was corrected in a short note published in the *Geological Magazine* for 1894,[2] and the generic name *Leckenbya* suggested as a substitute for *Nathorstia*.

Phyllopteris acutifolia (= *Sagenopteris acutifolia*). Vol. I. p. 143, Pl. IX. Fig. 6.

The generic name *Phyllopteris* was chosen for certain small isolated leaflets, on account of the apparent absence of any anastomosis of the lateral veins. The examination of more perfect specimens has enabled me to detect true reticulate venation, and to confirm Mr. Rufford's opinion that the leaflets should be included in the genus *Sagenopteris*.

Weichselia Mantelli (Brong.). Vol. I. p. 114.

In the synonymy of this species, I included a plant named by Nathorst *Weichselia erratica*, as probably identical with the English Wealden form. Prof. Nathorst[3] has expressed some doubt as to the correctness of this suggestion, his species being found in a deposit which is probably of Upper Cretaceous age; he adds that there are no Wealden strata in Sweden.

Sagenopteris Mantelli (Dunk.). Vol. I. p. 132.

In speaking of this species I referred to a plant described by Velenovský under the name of *Thinnfeldia variabilis* as probably identical with *S. Mantelli*, and added, with regard to his use of the

[1] Fl. foss. Arct. vol. vi. 1882.
[2] Geol. Mag. 1894, p. 384.
[3] Letter, June 25, 1894.

genus *Thinnfeldia*, that he made no reference to the resemblance of the leaves to the genus *Sagenopteris*. Velenovský's error was pointed out to him by Nathorst,[1] with the result that he afterwards acknowledged his mistake,[2] a correction which I unfortunately overlooked.

CANADA.

Sir William Dawson has pointed out to me, that I appear to have done injustice to Canadian geologists in the brief notice of the Kootanie plant beds in Vol. I. p. xxxi.[3] It was not my intention to give a complete historical sketch of these Cretaceous deposits, but I am glad to take the opportunity of calling attention to a paper by Dawson *On the Correlation of early Cretaceous Floras in Canada and the United States, and on some new plants of this period*. In this contribution we have a summary of the work of Richardson, G. M. Dawson, and others, and a description of some new plants from the Kootanie formation of the Rocky Mountains. After giving a list of Kootanie species, Dawson discusses the age of the flora, and points out that while some of the plants must be regarded as Jurassic, the majority have a Lower Cretaceous facies. On the whole, he concludes that "the Kootanie flora belongs to the lowest portion of the Cretaceous, and may be a little older than that of the main part of the Potomac formation."[4]

Among the plants described by Dawson we find the following Wealden forms: *Equisetites Lyelli*, Mant., *Pecopteris Browniana*, Dunk., *Sphenolepidium*, sp. The pinna figured as *Pecopteris Browniana* is very imperfectly preserved, and does not afford very satisfactory proof of the occurrence of Dunker's Wealden species in the Kootanie flora. In another form, *Cladophlebis falcata*, Font., we have one of those ferns which it is very difficult to separate from the widely distributed *C. Whitbyensis* (Brong.) and *C. Albertsii* (Dunk.). The fragment figured as

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[1] Letter, June 25, 1894.

[2] Velenovský (A. 2), Abh. k. böhm. Ges. Wiss. vol. ii. 1888, p. 5.

[3] Letter, Oct. 17, 1894.

[4] Dawson (2), p. 93.

Sphenopteris latiloba ? Font., I am disposed to regard as identical with *S. Fittoni*, Sew.: *cf.* Vol. I. p. 111, Fig. 11, and Pl. VI. Fig. 2. The specimens figured by Dawson are for the most part very small and imperfectly preserved, and the task of determination has necessarily been extremely difficult.

AMERICA.

Prof. Lester Ward writes to me as follows in reference to the geological age of the Potomac formation[1]:—

"As you may know, I have been engaged for several years on our Potomac formation, and I have established the fact that it is by no means so simple a group as might be supposed from what has been thus far said about it. I have been able to subdivide it into no less than six somewhat distinct horizons, each of which is fairly well marked off stratigraphically, and has its own peculiar flora. The uppermost of these subdivisions embraces the well-known Amboy clays of New Jersey, which have yielded a very rich flora, a monograph of which had been nearly completed by Dr. Newberry at the time of his death, and has been edited by Dr. Arthur Hollick, and has now gone to press to be published by the U.S. Geological Survey. The difference between the lowest and highest of these beds is very great, and the flora is correspondingly different. I suppose that the series as a whole includes nearly the entire Lower Cretaceous.

"It is only with the older Potomac that your Wealden of England can properly be compared. It is in that that we have the remarkable cycad trunks, so much like those of the Isle of Purbeck, which I suppose are really Jurassic; although, as you show, they are most intimately connected with the overlying Wealden."

PORTUGAL.

Reference was made in Volume I. (p. xxiii.), to Saporta's important work on the fossil flora of Portugal, and a few notes were added with regard to some of the more interesting species.

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[1] Letter, July 3, 1894.

Since this was written a large monograph[1] has been published, in which the Portuguese floras receive a full and careful treatment; this work is of considerable scientific importance, and its value is enhanced by the fact of its being the last important contribution to palæobotany by that indefatigable worker whose loss is so deeply deplored.

Beginning with strata of infra-Liassic age, Saporta describes a number of plants from beds referred to the following geological horizons: Niveau de Sinémurien (Couches à *Gryphæa obliqua*), Niveau du lusitanien, Niveaux du néo-jurassique (Couches à *Lima alternicostata*, ptérocérien et portlandien), Niveaux infra-crétaciques (du valanginien à l'aptien et de l'urgonien à l'albien). In summing up the characteristics and affinities of the neo-Jurassic floras, Saporta draws attention to the occurrence of species characteristic of the Corallian and Kimmeridgian, and associated with these he recognizes various Wealden types such as occur in Northern Germany, the Carpathians, and in North America. To discuss at length the numerous points suggested by this extremely valuable memoir, would take us far beyond the limits of the present work, but some portions of the monograph more immediately germane to our present subject must be briefly dealt with. In looking through the excellent plates, we find a large number of very small specimens referred to a great variety of species, and on examining the evidence on which many of the determinations are based, it would seem that the number of specific names might well be considerably reduced.

NEO-JURASSIC SPECIES.

Sphenopteris dissectifolia, Sap., p. 19, pl. iii. fig. 9; pl. viii. fig. 2; and pl. x. fig. 9.

Saporta notes a resemblance to the Wealden species *Ruffordia Göpperti* (Dunk.); we may also draw attention to a resemblance with *Onychiopsis elongata* (Geyl.).

S. marginata, Sap., p. 20, pl. viii. fig. 6. While recognizing the striking agreement of this fern with *Onychiopsis Mantelli* (Brong.), Saporta prefers to consider it a distinct type. It is impossible to be quite certain as to the precise nature of the

[1] Saporta (1).

specimen, but it is difficult to understand on what grounds it can be separated from such a form as *O. Mantelli*.

S. Mantelli neojurassica, p. 21, pl. vii. etc.

S. (*Davallia*) *Mantelli*, Brong., p. 72, pls. xv. and xviii.

After referring to the wide range and distribution of this fern, Saporta describes specimens of fertile fronds, which he compares with those of the recent species *Davallia gibberosa*, Sw., and *D. concinna*, Schrad. The agreement of the fossil and recent specimens, leads the author to refer the Wealden fern to the genus *Davallia*, or at least to a sub-genus of the *Davallieæ*. The figured examples of fertile pinnæ are less perfect than those which I have described in Volume I. (p. 50, Pl. III. Figs. 2–4); and the comparison made by Yokoyama in the case of *Onychiopsis elongata*, and by myself as regards *O. Mantelli*, with the recent genus *Onychium*, is, I believe, a much nearer approach to the truth than if we adopt the conclusions of Saporta.

The following are a few of the numerous instances in which mere fragments are referred to specific types, or on which new species are founded:—*Sphenopteris trifida*, Sap., p. 26, pl. x. fig. 20; *S. pedicellata*, Sap., p. 26, pl. x. fig. 21; *S. minima*, Sap., p. 26, pl. xiv. fig. 16; *S. trapezoidea*, Sap., p. 27, pl. xi. fig. 1*a*; *S. acutidens*, Sap., p. 27, pl. x. fig. 14; *Cladophlebis minor*, Sap., p. 30, pl. iv. fig. 14; *C. obtusiloba*, Sap., p. 30, pl. xiv. fig. 15. To carry the niceties of determination so far, and to institute new species on almost microscopic fragments of pinnæ or pinnules, is, I venture to think, a retrograde rather than a progressive method in palæobotany. A large number of other cases might be cited illustrating this method of determination, but the above may serve as examples of this dangerous practice. The specimens named *S. microclada*, Sap., p. 23, pl. vi., may be compared with *S. Fontainei*, Sew., and those described as *Scleropteris sinuata*, Sap. (p. 45, pls. vii. and viii.), with *Sphenopteris Fittoni*, Sew.

Any traces of angiospermous plants in strata of Jurassic age are of special interest. Saporta, in speaking of fossil angiosperms, writes: "En dépit du nombre restreint des espèces et de l'extrême rareté des échantillons, la présence de végétaux angiospermiques dans la flore portugaise néo-jurassique est cependant certaine."[1]

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[1] Saporta, *loc. cit.* p. 56.

The fragment referred to as *Rhizocaulon vetus*, Sap. (p. 57, pl. x. fig. 22), is very small, and in itself hardly satisfactory as an example of a monocotyledonous species. Other fragments of parallel-veined leaves are referred to five species of *Poacites*; it may be that we have in them portions of monocotyledonous leaves, but the specimens are so small and fragmentary, that one cannot feel much confidence in them as trustworthy evidence in so important a matter.

INFRA-CRETACEOUS (Valanginian to Aptian).

Adiantum aneimiæfolium, Sap., p. 82, pl. xv. fig. 21.

There is apparently no evidence that this fragment belongs to the genus *Adiantum*: cf. *Ruffordia Göpperti* var. *latifolia* (Vol. I. Pl. VI. Figs. 1 and 1*a*). Similarly there does not appear to be sufficient reason for naming the fragment represented in pl. xvi. fig. 14 *Marattia minor*, Sap. *Oleandridium tenerum*, Sap., p. 85, pl. xv. fig. 3; pl. xvi. fig. 18, as Saporta points out, closely resembles *Tæniopteris Beyrichii* (Schenk). The leaf figured as *Glossozamites brevior*, Sap., pl. xvi. fig. 32, may be a pinna of *Otozamites Klipsteinii* (Dunk.).

Saporta has drawn my attention to the resemblance of *Cyclopitys Delgadoi*, Sap. (p. 91), to the specimen figured by me in Vol. I. (p. 19, Pl. I. Fig. 7) as probably an equisetaceous sheath.

From these infra-Cretaceous strata we have several specimens referred to *Rhizocaulon* and *Poacites*, which may be portions of monocotyledonous leaves, but the leaf fragment spoken of as *Yuccites fractifolius*, Sap., p. 110, pl. xix. fig. 20*a*, cannot be accepted as a certain monocotyledon. A few specimens are described as probably dicotyledons, but the existence of such plants at this horizon is considered as still problematical.

INFRA-CRETACEOUS (Urgonian to Albian).

Sphenopteris circalensis, Sap., p. 126, pls. xxiv. and xxv.: cf. *Onychiopsis elongata* (Geyl.). *S. cuneifida*, Sap., p. 127, pl. xxiii. fig. 5. This closely resembles the finely divided form of *Ruffordia Göpperti* (Vol. I. Pl. IV.).

An interesting series of specimens is described and figured under the name of *Isoetes Choffati*, Sap., p. 134, pls. xxiv., xxv., and xxvii.; these fossils show a striking resemblance to this recent genus of vascular cryptogams. Among the specimens figured as *Protorrhipis Choffati*, Sap., p. 144, pls. xxii., xxvi., and xxvii., there are some which suggest leaves very similar to those described by Bartholin from Bornholm under the name of *Hausmannia Forchhammeri*, Barth.

Sphenopteris tenuifissa, Sap., p. 161, pl. xxviii. fig. 4. In all probability this is identical with *Ruffordia Göpperti* (Dunk.). Saporta himself noted the close agreement; but he does not accept my determination of the broad-leaved fronds figured in Vol. I. Pl. VI. as a variety of Dunker's species.

Adiantum eximium, Sap., p. 164, pl. xxviii. fig. 18; pl. xxxi. fig. 6. Probably identical with *R. Göpperti* var. *latifolia*.

In speaking of *Cycadites Saportæ*, sp. nov. (p. 30), I have drawn attention to the very close similarity of the Portuguese specimens named by Saporta *Cycadites tenuisectus*. The numerous dicotyledonous leaves described by Saporta are of considerable interest, but need not be dealt with here, as we have no trace of angiospermous fossils in our Wealden strata, which occupy a lower horizon than the beds from which Saporta's specimens were obtained.

In taking a review of the whole flora described in his monograph, Saporta calls attention to the remarkable series of types which are represented in the plant-bearing beds ranging from the Corallian to the Cenomanian; the series is practically continuous, and without any distinct break or hiatus in the succession of genera and species. The flora is compared with that of the Potomac beds of America; a close comparison of the two sets of plants[1] has also been recently instituted by Prof. Lester Ward.

JAPAN.

Yokoyama followed up his account of the Jurassic plants from Kaga, Hida, and Echizen, by a memoir on the Mesozoic plants from Kotzuke, Kii, Awa, and Tosa.[2] Nathorst[3] had previously described several species from some of these localities, and concluded that the plant-bearing strata should be classed as transition

[1] Science, March 29, 1895.

[2] Yokoyama.

[3] Nathorst (A. 3), Denkschr. k. Ak. Wiss. vol. lvii. 1890, p. 43.

beds between the Jurassic and Cretaceous systems. Yokoyama supports Nathorst's view, but prefers to regard the Japanese beds as corresponding to the whole Neocomian series, and to the Potomac of America. The following species are mentioned in Yokoyama's paper:—

Thyrsopteris, sp.
Dicksonia Tosana, Yok.
Dicksoniopteris Naumanni, Nath.
Onychiopsis elongata (Geyl.).
O. elegans, Yok.
Adiantites Yuasensis, Yok.
Pteris (?), sp.
Sphenopteris tenuicula, Yok.
Pecopteris Browniana, Dunk.
P. Geyleriana, Nath.
P. cf. *virginiensis*, Font.
Cladophlebis Nathorsti, Yok.
Macrotæniopteris (?) *marginata*, Nath.
Lycopodites, sp.
Podozamites, sp.
Podozamites lanceolatus, L. and H., var. *minor*, Heer.
P. lanceolatus var. *latifolia*, Nath.
P. pusillus, Velen.
Zamiophyllum Buchianum (Ett.).
Z. Buchianum var. *angustifolia*, Font.
Z. Naumanni, Nath.
Glossozamites parvifolius, Yok.
Nilssonia Johnstrupi, Heer.
N. Schaumburgensis, Dunk.
N. pterophylloides, Yok.
Ptilophyllum cf. *Cutchense*, Morr.
Cyparissidium (?) *Japonicum*, Yok.
Torreya venusta, Yok.

Some of the specimens described as *Podozamites* show a strong resemblance to Fontaine's *Nageiopsis*; but it is no easy matter to decide between these two genera when we have to deal with small specimens.

AUSTRIA.

Fritz Von Kerner[1] has recently described some fossil plants from the Island of Lesina, off the Austrian coast, in the Adriatic Sea; the flora is regarded as Lower Cretaceous in age. Among the species recorded from these beds we have *Dioonites* cf. *Saxonicus* (Reich.), p. 49, pl. iv. fig. 6: this species I have included as a synonym of *Zamites Buchianus* (Ett.); but it is difficult to decide from the indistinct photograph of Kerner's fragment how far his specimen may be regarded as identical with the Wealden species. A coniferous twig figured by Kerner as *Pagiophyllum rigidum*, Sap., resembles fairly closely some of the English specimens of *P. crassifolium*, Schenk: *cf.* Kerner's figure, pl. iv. fig. 3, and my Pl. XVI. Fig. 2.

[1] Kerner.

A very small and imperfect specimen is figured as a piece of *Sphenolepidium Kurrianum* (Dunk.), (pl. iv. fig. 2); this does not seem to be a typical example of the species, but it is impossible to accurately determine so small a fragment.

SPITZBERGEN.

In 1883 Nathorst[1] published a short account of some plant-bearing beds in Spitzbergen, which had formerly been classed as Cretaceous, but which he preferred to consider as uppermost Jurassic in age. Having lately had an opportunity, through the kindness of Professor Nathorst, of examining the Spitzbergen fossils, I am disposed to think that we shall find in his forthcoming monograph on this flora a certain amount of evidence in favour of its being regarded as Wealden.

CONCLUSIONS.

Prior to the acquisition of the Rufford Collection by the British Museum, the following plants had been recorded from the Wealden strata of England. Such alteration as I have suggested with regard to any of the species are noted in brackets.

Chara (= *C. Knowltoni*, sp. nov.).
Equisetites Lyelli, S. and W.
E. Burchardti, Dunk.
Onychiopsis Mantelli (Brong.).
Sphenopteris Fittoni, sp. nov. (= *S. Mantelli*, Brong.).
Tempskya Schimperi, Corda.
Tæniopteris Beyrichii (Schenk).
Weichselia Mantelli (Brong.).
Sphenolepidium Kurrianum (Dunk.).
Araucarites Pippingfordensis (Ung.).
Pinites Dunkeri, Mant.
P. Carruthersi, Gard.
P. valdensis, Gard.
Pinites Mantelli, Carr.
P. patens, Carr.
Cycadeostrobus elegans, Carr. } [= *Conites elegans* (Carr.)].
C. ovatus, Carr. }
C. tumidus, Carr. [= *Conites tumidus*, (Carr.)].
Bucklandia anomala (S. and W.).
Fittonia squamata, Carr.
Yatesia Morrisii, Carr.
Bennettites Saxbyanus (Brown).
Dioonites Brongniarti (Mant.) (= *Cycadites Brongniarti*, Mant.).
Nilssonia Schaumburgensis (Dunk.).

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[1] Nathorst (6).

The following list includes the species described in Volume I., with the addition of those dealt with in Volume II.

† SPECIES CONFINED TO ENGLAND.

THALLOPHYTA.

† *Algites valdensis*, Sew.
† *A. catenelloides*, Sew.

CHAROPHYTA.

† *Chara Knowltoni*, Sew.

BRYOPHYTA.

† *Marchantites Zeilleri*, Sew.

PTERIDOPHYTA.

Equisetites Lyelli, Mant.
E. Burchardti, Dunk.
E. Yokoyamæ, Sew.
Onychiopsis Mantelli (Brong.).
O. elongata (Geyl.).
† *Acrostichopteris Ruffordi*, Sew.
Matonidium Göpperti (Ett.).
Protopteris Witteana, Schenk.
Ruffordia Göpperti (Dunk.).
R. Göpperti var. *latifolia*, Sew.
† *Cladophlebis longipennis*, Sew.
C. Albertsii (Dunk.).
C. Browniana (Dunk.).
Cladophlebis Dunkeri (Schimp.).
Sphenopteris Fontainei, Sew.
S. Fittoni, Sew.
Weichselia Mantelli (Brong.).
Tæniopteris Beyrichii (Schenk).
† *T. Beyrichii* var. *superba*, Sew.
† *T. Dawsoni*, Sew.
Sagenopteris Mantelli (Dunk.).
† *S. acutifolia*, Sew.
Microdictyon Dunkeri (Schenk).
Dictyophyllum Römeri, Schenk.
† *Leckenbya valdensis*, Sew.
Tempskya Schimperi, Cord.

GYMNOSPERMÆ.

Cycadites Römeri, Schenk.
† *C. Saportæ*, Sew.
Dioonites Dunkerianus (Göpp.).
D. Brongniarti (Mant.).
Nilssonia Schaumburgensis (Dunk.).
Otozamites Klipsteinii (Dunk.).
† *O. Klipsteinii* var. *superbus*, Sew.
† *O. Klipsteinii* var. *longifolius*, Sew.
Otozamites, sp. Cf. *O. Reibeiroanus*, Heer.
O. Göppertianus (Dunk.).
Zamites Buchianus (Ett.).
† *Z. Carruthersi*, Sew.
Z. Carruthersi var. *latifolius*, Sew.
Anomozamites Lyellianus (Dunk.).
Cycadolepis (*Dory-Cycadolepis* and *Eury-Cycadolepis*).
Carpolithes, sp.
† *Androstrobus Nathorsti*, Sew.
Bucklandia anomala (S. and W.).
† *Fittonia Ruffordia*, Sew.
† *Bennettites Saxbyanus* (Brown).
† *B. Gibsonianus*, Carr.
Bennettites, sp.
† *B.* (*Williamsonia*) *Carruthersi*, Sew.
† *B.* (*Williamsonia*) *Carruthersi* var. *latifolius*, Sew.
† *Yatesia Morrisii*, Carr.

Sphenolepidium Kurrianum (Dunk.).
S. Sternbergianum (Dunk.).
Cf. *S.* (*Sequoia*) *subulatum*, Heer.
Sphenolepidium, sp.
Pagiophyllum crassifolium (Schenk).
Pagiophyllum, sp.
† *Brachyphyllum spinosum*, Sew.
B. obesum, Heer.
† *Pinites Dunkeri*, Carr.
† *P. Carruthersi*, Gard.
† *P. Solmsi*, Sew.
† *P. Ruffordi*, Sew.
Cf. *Nageiopsis heterophylla*, Font.
† *Thuites valdensis*, Sew.
Conites (*Araucarites*), sp.
† *C. armatus*, Sew.

PLANTÆ INCERTÆ SEDIS.

Specimen A. (Vol. I. p. xxxv. Pl. I. Fig. 7).
Specimen B. (Vol. I. p. xxxv. Pl. I. Figs. 8 and 9).
† *Withamia Saportæ*, Sew.
† *Becklesia anomala*, Sew.
Cf. *Dichopteris lævigata* (Phill.).

In the accompanying table an attempt is made to show the geographical range of such species as are not confined to the Wealden rocks of England. The occurrence of the same species in different regions is not regarded as necessarily proving homotaxial strata. A more detailed consideration of the geological correlation of the plant-bearing strata, in which Wealden types occur, will be undertaken elsewhere, as there are still a few species to be described from the English beds. Such plants as *Onychiopsis Mantelli* (Brong.), *Matonidium Göpperti*, Schenk, *Ruffordia Göpperti* (Dunk.), are by no means confined to one geological horizon; and it is possible that we have other species, the range of which is not strictly limited to true Wealden strata.

In the following list are added the chief districts or localities in each country from which the plants have been obtained. The names of the principal authors of the several Wealden floras (or floras containing Wealden species), are given below, with numbers referring to the bibliographies at the end of Part I. and Part II.; those in the former being printed with A. after the author's name, those in the latter with B.

List of Species.	England.	Portugal.	France.	Belgium.	Germany.	Austria.	Russia.	Sweden and Bornholm.	America.	Canada.	Greenland.	Japan.	Africa.	Australia.	New Zealand.
Equisetites Lyelli, Mant. ...	x	...	...	...	...	...	...	...	x	x	...	...	...	...	...
Equisetites Burchardti, Dunk.	x	x	...	...	x	x	...	...	...	...	...	...	...	...	...
Equisetites Yokoyamæ, sp. nov.	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
Onychiopsis Mantelli (Brong.)	x	x	...	x	x	x	...	...	x	...	...	...	x	x	...
Onychiopsis elongata (Geyl.)	x	x	...	...	...	...	...	...	...	...	...	x	...	...	...
Matonidium Göpperti (Ett.)	x	x	...	x	x	x	x	...	...	...	...	...	...	...	..
Protopteris Witteana, Schenk	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
Rufordia Göpperti (Dunk.)	x	x	...	x	x	x	x	...	...	...	...	x	...	...	...
Cladophlebis Albertsii (Dunk.)	x	? x	...	...	x	x	x	x	...	...	x	...	...	x	...
Cladophlebis Browniana (Dunk.)	x	x	...	...	x	x	...	...	...	...	...	x	...	...	...
Cladophlebis Dunkeri (Schimp.)	x	x	..	x	x	x	...	x	x	...	...	x	...	...	...
Sphenopteris Fittoni, sp. nov.	x	x	x	...	x	...	...	...	...	x	...	...	...	...	x
Weichselia Mantelli (Brong.)	x	...	x	...	x	x	x	x	...	...	...	x	...	...	...
Tæniopteris Beyrichii (Schenk)	x	? x	...	...	x	...	...	...	...	...	...	...	...	...	...
Sagenopteris Mantelli (Dunk.)	x	...	...	...	x	x	...	x	...	...	...	x	...	...	...
Microdictyon Dunkeri (Schenk)	x	...	...	...	x	x	x	x	...	...	...	...	...	...	...
Dictyophyllum Römeri, Schenk	x	...	...	...	x	...	...	x	...	...	...	...	...	...	..
Leckenbya valdensis, gen. et sp. nov.	x	...	...	...	? x	...	...	...	...	...	...	...	...	...	...
Tempskya Schimperi, Corda	x	...	...	...	x	x	...	...	...	...	...	...	...	...	...
Sphenolepidium Kurrianum (Dunk.)	x	x	...	...	x	? x	? x	...	x	...	? x	...	...	...	...
Sphenolepidium Sternbergianum (Dunk.) ...	x	x	...	...	x	x	? x	...	x	...	...	...	...	...	...
Brachyphyllum obesum, Heer	x	x	...	...	x	...	...	...	x	...	...	...	...	...	...
Pagiophyllum crassifolium, Schenk	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
? *Nageiopsis heterophylla*, Font.	x	...	...	...	...	...	...	...	? x	...	...	...	...	...	...
Cycadites Römeri, Schenk	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
Cycadites Saportæ, sp. nov.	x	? x	...	...	...	...	...	...	...	...	...	...	...	...	...
Dioonites Dunkerianus, Göpp.	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
Dioonites Brongniarti (Mant.)	x	...	x	...	x	...	...	...	...	...	...	x	...	...	...
Nilssonia Schaumburgensis (Dunk.)	x	...	...	...	x	...	...	...	...	...	...	x	...	...	...
Otozamites Klipsteinii (Dunk.)	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
Otozamites Göppertianus (Dunk.)	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
? *Otozamites Reibeiroanus*, Heer	x	? x	...	...	...	...	...	...	...	...	...	...	...	...	...
Zamites Buchianus (Ett.)	x	...	...	...	x	x	...	...	x	...	...	x	...	...	...
Anomozamites Lyellianus (Dunk.)	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...
Bucklandia anomala (Stokes and Webb) ...	x	...	...	...	x	...	...	...	...	...	...	...	...	...	...

ENGLAND.	Isle of Wight, Kent, Surrey, Sussex, and Bedfordshire. [Stokes and Webb (A.), Mantell (A. 1-7), Carruthers (A. 3 and 4), (B. 1, 3, 6, and 8), Topley (A. 1.), Gardner (A. 1 and 2), Bristow (A.), Peyton (A.), etc.]
PORTUGAL.	Cercal, Bellas, Torres-Vedras, etc. [Heer (A. 6), Saporta (B. 1).]
FRANCE.	Beauvais. [Brongniart (A. 4).]
BELGIUM.	Hainaut. [Coemans (A.), Bommer (B. 1 and 2).]
GERMANY.	Deister, Quedlinburg, Teutoburgerwald, and other localities in N.W. Germany. [Dunker (A. 2), Schenk (A. 2 and 4), Hosius and Von der Marck (A. 1 and 2).]
AUSTRIA.	North Carpathians. [Ettingshausen (A. 4), Schenk (A. 3).]—Lesina I. [Kerner (B.).]
RUSSIA.	Klin. [Trautschold (A. 3).]
BORNHOLM.	[Bartholin (A.) and (B.).]
SWEDEN.	Hör (Scania). [Nathorst (A. 4).]
AMERICA.	Virginia, Maryland, Montana. [Fontaine (A. 2 and 3), Newberry (A. 1), Knowlton (A. 2).]
CANADA.	Rocky Mountains (Kootanie R.). [Dawson (B. 2).]
GREENLAND.	Kome (Nugsuaks Peninsula). [Heer (B.).]
JAPAN.	Kaga, Hida, Echizen, Kü, etc. [Yokoyama (A. 2) and (B.), Nathorst (A. 3).]
AFRICA.	Geelhoutboon (South Africa). [Tate (A.).]
AUSTRALIA.	[Tenison-Woods (A.).]
NEW ZEALAND.	Prov. Auckland. [Unger (A. 3).]

The questions of geological age suggested by the above table, will be discussed in a subsequent communication on the Wealden floras, which it is intended to lay before the Geological Society at an early date. With a view to discover if the manner of occurrence of the fossil plants, or the association of different genera and species, would afford any evidence as to the relative positions of growth of the various floral types, I wrote to Mr. Rufford asking him to give me such information as his accurate knowledge of the Hastings district[1] enabled him to contribute with regard to this question. I cannot do better than reproduce the main facts which he communicated to me. He writes that he is unable to discover any reliable data as to the relative altitudes at which the plants grew, but adds the following useful information as to the occurrence of some of the characteristic species in the different beds :—

[1] For a geological section of this district see Vol. I. p. xvii.

FAIRLIGHT CLAYS.

(*a*) Fine clay ironstone; ferns well preserved, no cycads or conifers. This bed occupies about the same geological position as (*b*), although separated from it horizontally; it contains *Marchantites*, *Equisetites Burchardti*, *Onychiopsis Mantelli*, *Ruffordia Göpperti*, *Sphenopteris Fittoni*, and other ferns.

(*b*) Fine blue clay. The "cycad bed," containing *Zamites*, *Anomozamites*, *Otozamites*, *Fittonia*, etc.; ferns rare. A few yards farther on, and about the same horizon, there have been found coniferous twigs, etc.

(*c*) Porous sandstone, with *Pinites*; no cycads or ferns. This bed occupies a lower horizon than (*a*) and (*b*).

(*d*) Blue clays, sometimes sandy. "Fern bed"; no cycads; occasionally leaves of *Pinites*, also *Onychiopsis Mantelli*, *Ruffordia*, *Sphenopteris Fittoni*, *Cladophlebis*, etc.

(*e*) For the most part reddish ironstone, with some grey sandstone merging into sandy clay. About the same horizon as (*d*); plants very abundant—*Onychiopsis*, *Ruffordia*, *Sphenopteris*, *Cladophlebis*, *Tæniopteris*, *Protopteris*; also *Dioonites Brongniarti*, *Zamites*, *Otozamites*, *Bennettites* (*Williamsonia*), *Pagiophyllum*, and other conifers, etc. This bed is of somewhat coarser material than the others, and contains a greater mixture of plants; *Pagiophyllum crassifolium* and other conifers are very abundant.

In reading the above notes by Mr. Rufford, we find that with the exception of bed (*e*), in which the various classes of plants are well represented, the ferns, cycads, and conifers are not usually intermixed. The partial or complete separation of ferns, cycads, and conifers, may be due either to the nature of the plant material, which might be sorted by the water by reason of some differences in weight, or to the relative adaptability to longer or shorter transport by water; or the result of the plants growing in different districts and at different elevations. The more delicate fern fronds would probably be carried to a greater distance than the heavier and larger pieces of cycadean or coniferous plants. On the other hand, the gymnosperms may well have been more abundant on higher ground and in drier situations than the *Filicinæ*. Assuming the bed (*e*) to occupy the lowest horizon in the series, it would appear that the material composing the sandstones and ironstones was laid down in somewhat shallow water, and the fossils embedded in the strata were derived from a wide area, embracing localities rich in both ferns and gymnosperms. The petrological nature of (*d*) and the absence of cycads suggest deeper water; while the fine blue clay of (*b*) may have been derived from rocks in an area characterized by the predominance of cycads. It would, however, be difficult to reconstruct the conditions of growth of the several plants without a very careful examination of the rocks and their fossil contents, and at best our conclusions would probably not possess any great scientific value.

In an old work by Unger,[1] we read that in the Wealden period there were "small wet islands, covered with forests, inhabited by the largest and most terrible monsters of the primitive world. The atmosphere was filled with moist vapour, and carbon dioxide exhalations favourable to the prodigious propagation of the amphibian race, and to the development of ferns, cycads, conifers, and some monocotyledons." He goes on to say that "La triste sauvagerie de cet intérieur de forêt est encore redoublée par celle de ses habitants, parmi lesquels le gigantesque *Iguanodon* à crêté osseuse et la monstreux *Hylæosaurus* tiennent la première place."

In a more recent monograph on the Wealden period, Schenk[2] confidently speaks of the climate as undoubtedly tropical, and refers to the occurrence of tree ferns, the abundance of cycads, and other facts in support of this conclusion. It would be extremely difficult, or indeed impossible, to give any approximate estimate of the temperature in Northern and Central Europe during the Wealden period. The general characters of the vegetation would certainly seem to point to a tropical climate, and there can be little doubt that the temperature was considerably higher than the Wealden districts enjoy at the present day.

In discussing the climate of a past age, in which no living species of plants existed, and in attempting to make use of fossil plants as indices of climatal conditions, we have to bear in mind the great danger of drawing conclusions from a comparison of extinct and living forms. It is superfluous to point out the lesson so clearly taught by recent plants, that closely allied species frequently

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[1] Unger, p. 29.

[2] Palæontographica, vol. xix. p. 256.

occur under very different conditions of temperature. In the present instance, the numerous species of cycads naturally suggest conditions similar to those most favourable or essential to the living representatives of the *Cycadaceæ*; but we must remember that the so-called cycadean fronds from Mesozoic rocks are nearly always found apart from the stems and reproductive structures, and we are still to a large extent in the dark as to the exact nature and structure of these extinct cycadean plants.

Looking at the Wealden plants collectively, we notice a very striking agreement with the flora of the underlying Jurassic strata, and it would be difficult to point to any well-marked or essential difference between the plant-life of the two periods. The evidence of palæobotany certainly favours the inclusion of the Wealden rocks in the Jurassic series.

One of the most attractive and difficult problems which is suggested to a botanist by such a flora as that of the Wealden period, is the evolution of angiospermous plants. A reviewer has happily expressed this in the following words[1]: "In the folds of the Wealden we imagine the secret of the evolution of angiosperms must be locked. It is as if we stood at the mouth of a great river flowing from an unexplored interior, whose flotsam we anxiously interrogated for clues as to the nature of the unknown Hinterland; yet nothing reaches us from beyond the coast-belt, which we have already explored." Among the English species there are none which can be regarded as the earliest angiosperms, and we search in vain among the abundant samples of the Wealden vegetation for any fragments of monocotyledonous or dicotyledonous plants. In the Potomac beds of America, which include strata of Jurassic and Lower Cretaceous age, we have several undoubted angiospermous species; and again, in the closely parallel series of Portuguese rocks, dicotyledons and monocotyledons are fairly abundant. The true Wealden vegetation would seem to have been without any examples of the highest class of plants, and may be looked upon as the last of the Mesozoic floras in which the gymnosperms represented the limit of plant development. One genus, however, carries us a few steps towards the next stage in botanical evolution; the inflorescence of *Bennettites* marks

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[1] Nature, July 26, 1894, p. 294.

a distinct advance in the differentiation of reproductive structures beyond the characteristic cycadean type. Were we in a position to speak of the anatomical structure, or to describe more fully the reproductive organs, of Wealden plants, it might be that we should be able to recognize a distinct foreshadowing of angiospermous characters; unfortunately, however, the extreme scarcity of mineralized plant tissues precludes any such treatment of plant types. In spite of the somewhat disappointing nature of the flora from the point of view of angiosperm development, we may reasonably hope that a more detailed comparison of floras possessing a Wealden facies will enable us to add something of value to the history of plant evolution, and to the facts of plant distribution.

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Lieferung	i. - -	pp.	1–152	-	1879.
,,	ii. - -	,,	153–232	-	1880.
,,	iii. - -	,,	233–332	-	1884.
,,	iv. - -	,,	333–396	-	1885.
,,	v. - -	,,	397–492	-	1887.
,,	vi. - -	,,	493–572	-	1888.
,,	vii. - -	,,	573–668	-	1889.
,,	viii. - -	,,	669–764	-	1889.
,,	ix. - -	,,	765–958	-	1890.

INDEX OF GENERA, SPECIES, ETC.

[Synonyms are printed in *italics*.]

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EXPLANATION OF PLATES.

All the figured specimens are preserved in the British Museum (Natural History), their registered numbers being quoted in square brackets. The figures are drawn natural size, except in a few cases where the enlargement is stated. With the exception of those represented on Plates XIII. and XIV., the figured specimens are from the *Rufford Collection*.

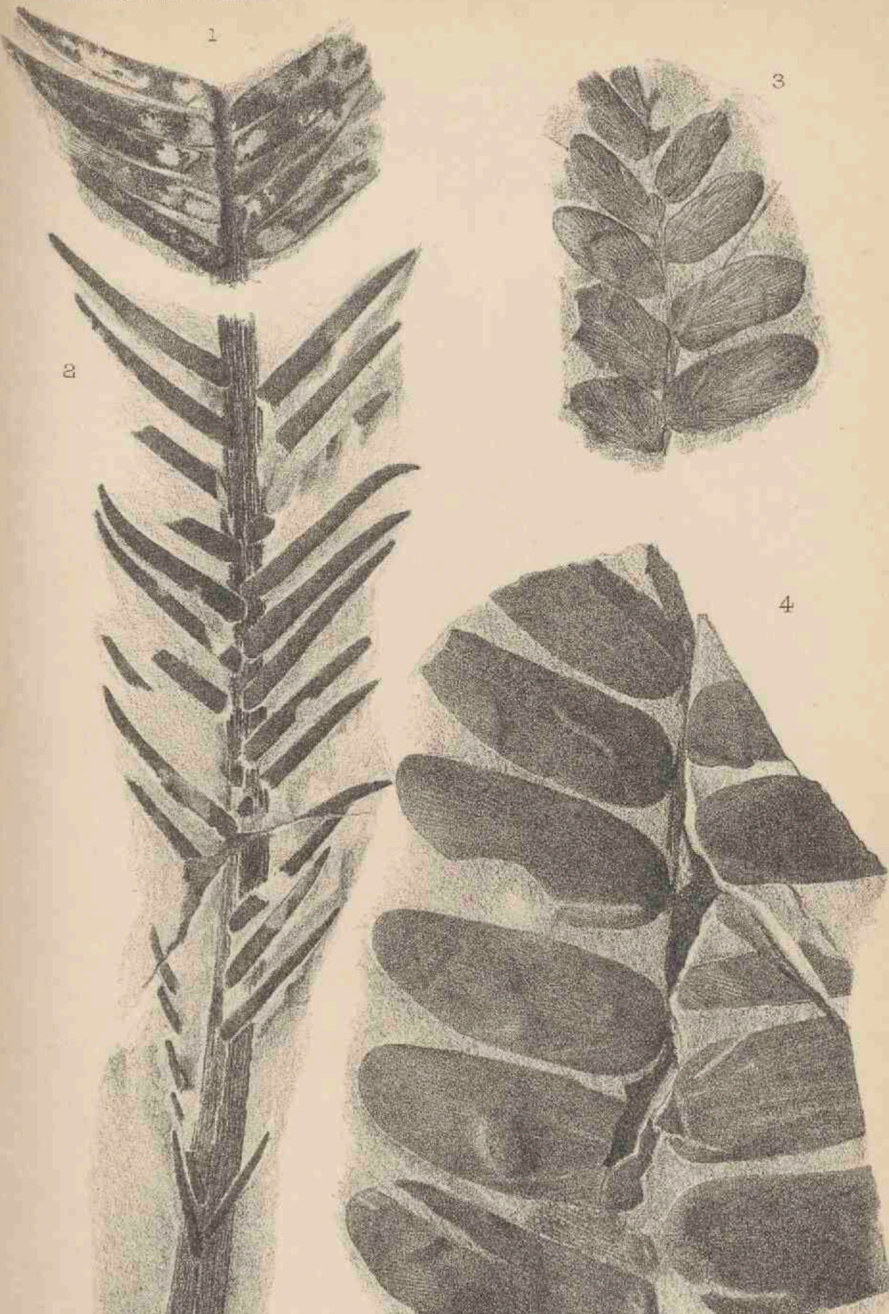
PLATE I.

Fig. 1. *Otozamites Göppertianus* (Dunk.). Portion of a frond. Page 70. [V. 2123.]

Fig. 2. *Otozamites Göppertianus* (Dunk.). The lower and middle portion of a frond. P. 70. [V. 2360.]

Fig. 3. *Otozamites Klipsteinii* (Dunk.). Terminal portion of a frond. P. 64. [V. 2336.]

Fig. 4. *Otozamites Klipsteinii* (Dunk.). P. 65. [V. 2745*a*.]



G.M.Woodward del.et lith.

West, Newman imp.

Otozamites

PLATE II.

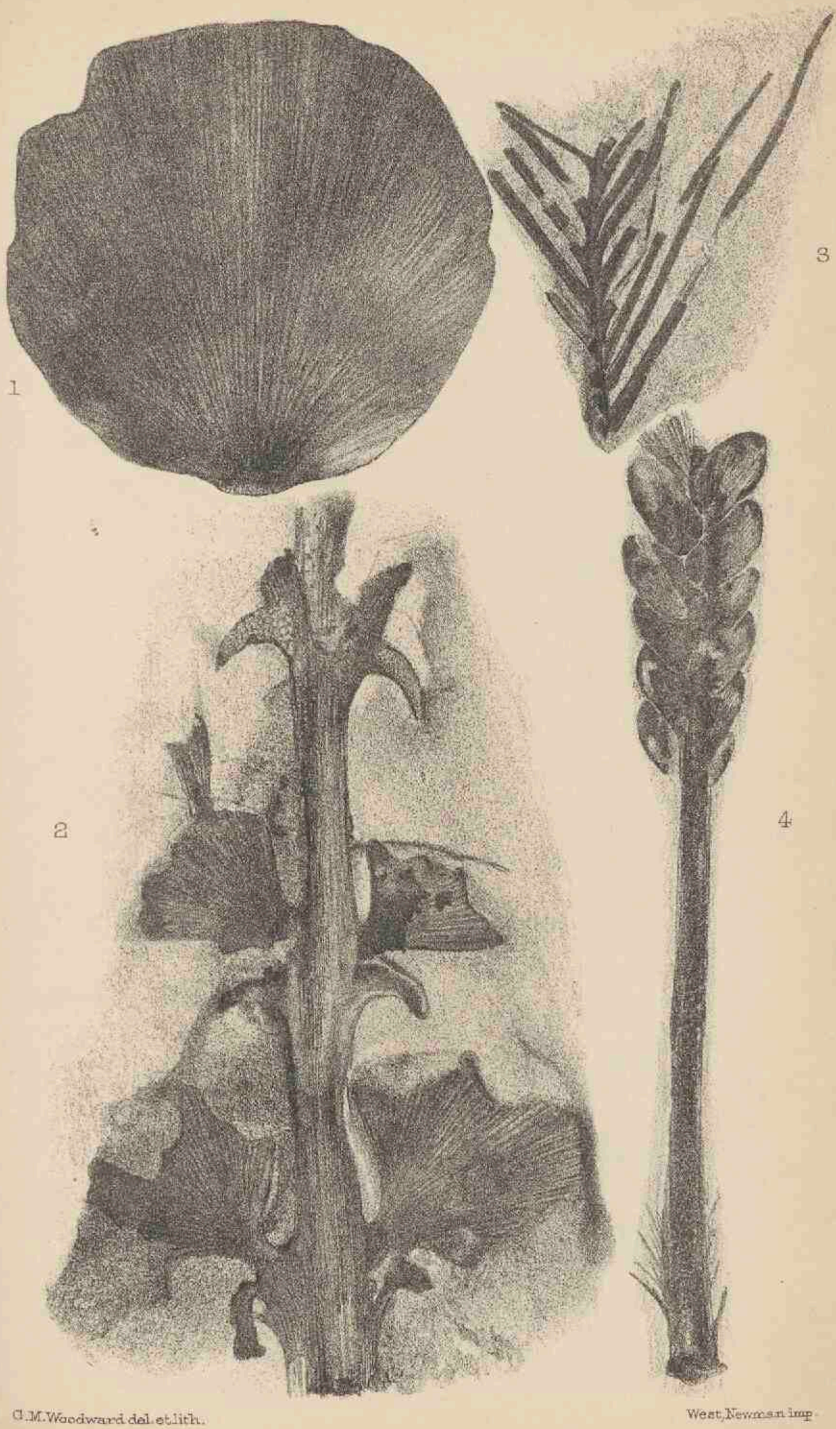
* Fig. 1. *Withamia armata*, gen. et sp. nov. Single detached leaf, showing well-marked flabellate venation. P. 177. [V. 2915.]

* Fig. 2. *Withamia armata*, gen. et sp. nov. Axis bearing recurved spines and imperfect leaves in their axils. P. 177. [V. 2134.]

Fig. 3. *Dioonites Dunkerianus* (Göpp.). Terminal portion of a frond. P. 46. [V. 2823.]

Fig. 4. *Otozamites*, sp. Cf. *O. Klipsteinii* (Dunk.). Basal portion of a young frond. P. 69. [V. 2734.]

* The name *Saportaia* was unfortunately printed on the plate before the previous use of *Saportæa* was discovered (p. 174).



G.M. Woodward del. et lith. West, Newman imp.

1. 2. Saportaia, 3. Dioonites. 4. Otozamites.

PLATE III.

FIG. 1. *Zamites Buchianus* (Ett.). Page 85. [V. 2262.]

FIG. 2. *Zamites Buchianus* (Ett.). Apex of a single pinna. P. 83. [V. 2363.]

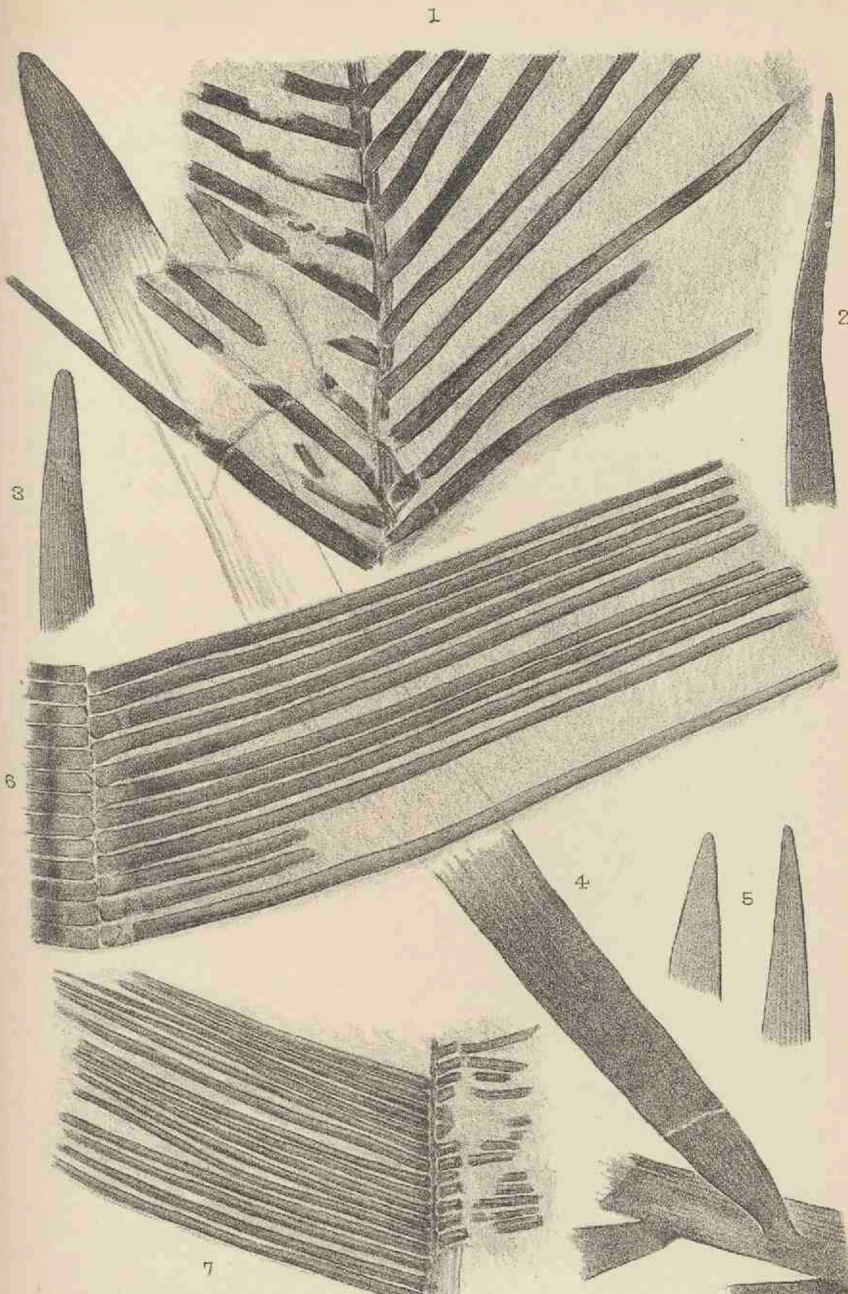
FIG. 3. *Zamites Buchianus* (Ett.). Apex of a single pinna. P. 84. [V. 2123*c*.]

FIG. 4. *Zamites Buchianus* (Ett.). Portion of a large frond, showing manner of attachment of a pinna. P. 83. [V. 2227.]

FIG. 5. *Zamites Buchianus* (Ett.). Apical portions of two pinnæ. P. 82. [V. 2120.]

FIG. 6. *Dioonites Dunkerianus* (Göpp.). Portion of a frond, showing the form and manner of attachment of the pinnæ. P. 45. [V. 3218.]

FIG. 7. *Cycadites Saportæ*, sp. nov. Portion of a frond, showing the venation and arrangement of the pinnæ. P. 34. [V. 2124*a*.]



G M Woodward del. et lith. West, Newman imp.

Figs. 1–5. Zamites. Fig. 6. Dioonites. Fig. 7. Cycadites.

PLATE IV.

Fig. 1. *Zamites Buchianus* (Ett.). Young frond. Page 84. [V. 2125*b*.]

Fig. 2. Portion of a large frond, showing the position of the pinnæ in the rachis. P. 84. [V. 2125*c*.]

Fig. 3. Terminal portion of a very small frond. P. 84. [V. 2925.]

Figs. 4 and 5. Portions of a large frond, showing manner of attachment of the pinnæ. P. 84. [V. 2123*a*.]

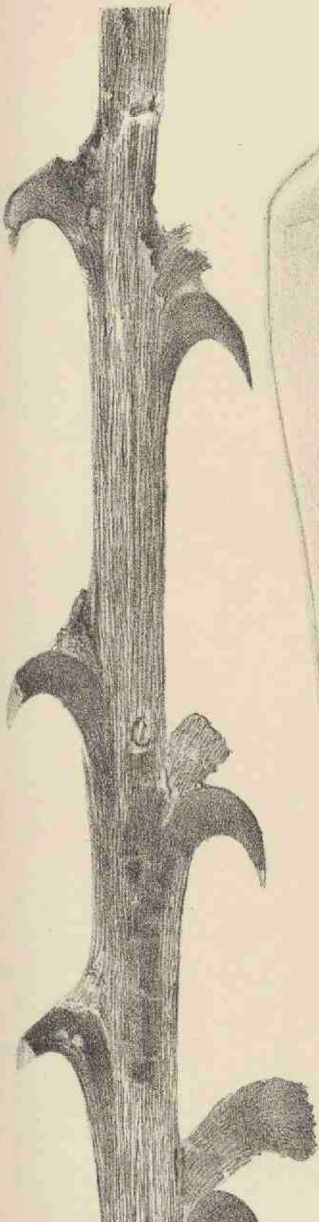
G.M.Woodward del.et lith. West, Newman imp.

Zamites.

PLATE V.

FIG. 1. *Withamia armata*, gen. et sp. nov. Axis with strongly recurved spines, with the basal portions of leaves in their axils. P. 178. [V. 2134*a*.]

FIG. 2. *Cycadolepis*. Single scale. P. 99. [V. 2929.]



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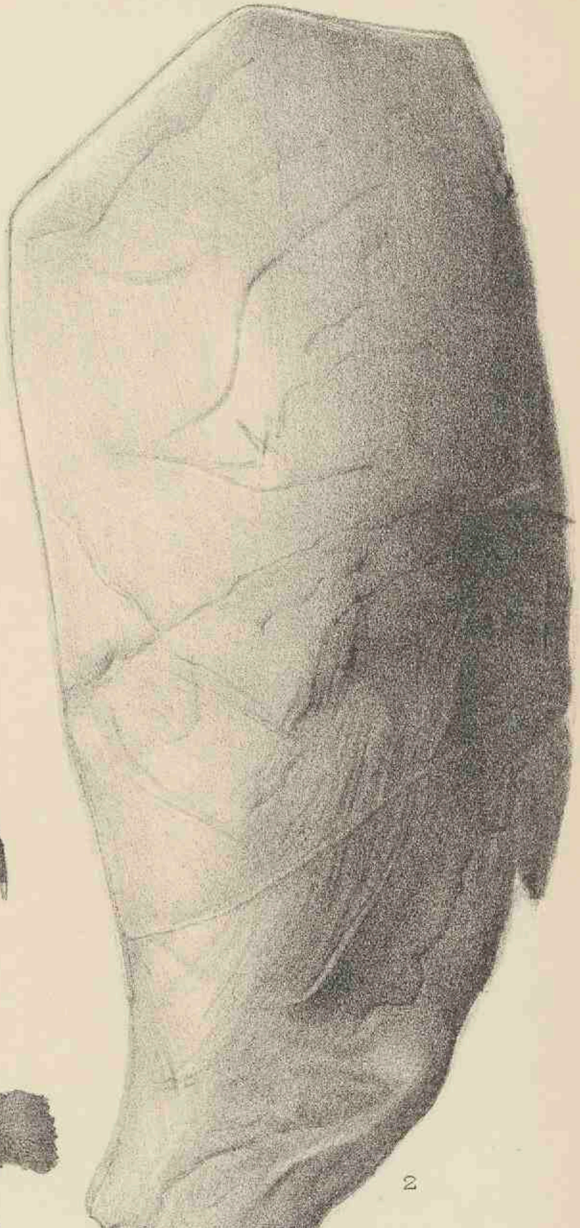

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G.M. Woodward del. et lith. West, Newman imp.

Saportaia. Cycadolepis.

PLATE VI.

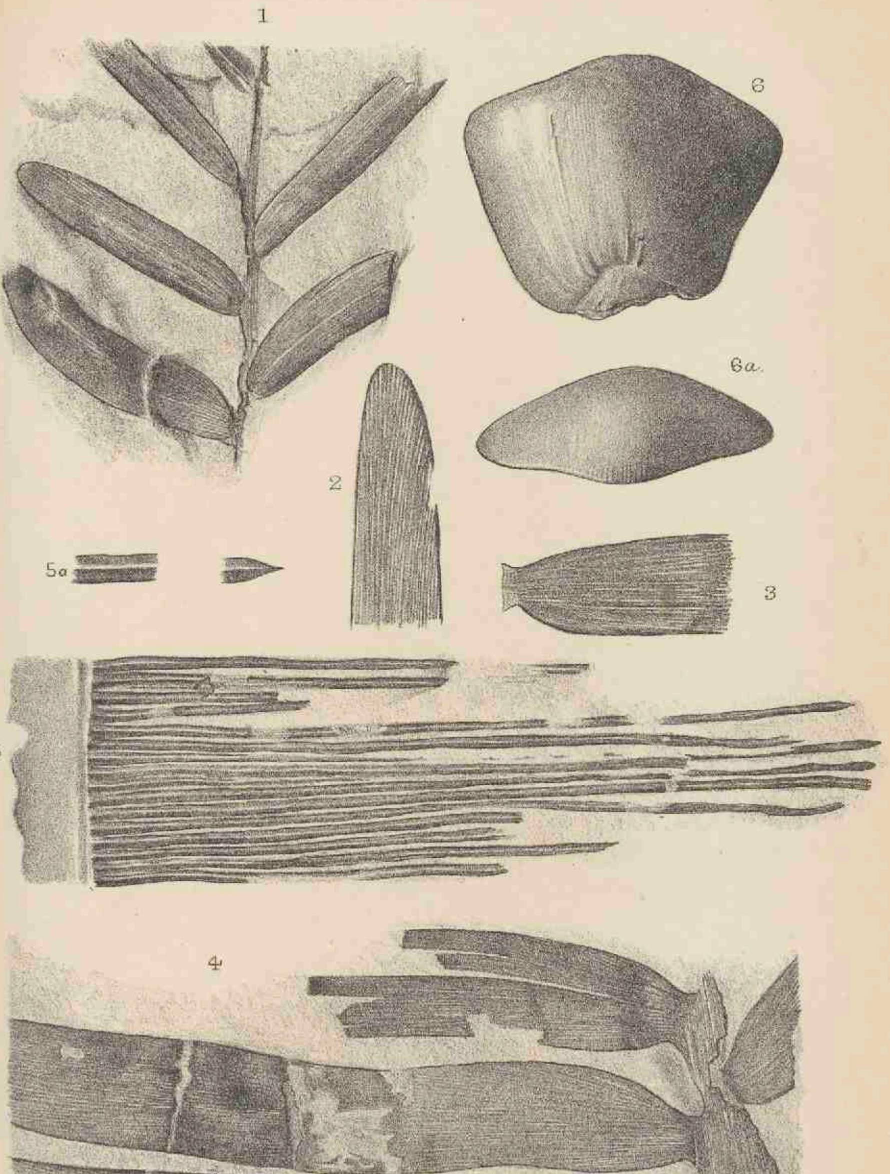
FIG. 1. *Zamites*, sp. P. 89. [V. 2743.]

FIGS. 2 and 3. *Zamites Carruthersi*, sp. nov. The apical and basal portions of a pinna. P. 88. [V. 2123*c*.]

FIG. 4. *Zamites Carruthersi*, sp. nov. Portion of a frond showing the manner of attachment and venation of the pinnæ. P. 88. [V. 2123*d*.]

FIGS. 5 and 5*a*. *Cycadites Saportæ*, sp. nov. Portion of a large frond. In 5*a* part of a single pinna is slightly enlarged, showing the apex and single vein. P. 34. [V. 2797.]

FIGS. 6 and 6*a*. *Cycadolepis*. A detached scale; in 6*a* the incurved distal margin is represented. P. 99. [V. 2699.]



G.M. Woodward del. et lith. West, Newman imp.

Figs. 1-4. Zamites. Figs. 5 & 5a. Cycadites. Fig. 6. Cycadolepis.

PLATE VII.

FIG. 1. *Otozamites Klipsteinii* (Dunk.), var. *longifolius.* Single pinna of the longer and narrower type. P. 68. (See also Fig. 6.) [V. 2122.]

FIG. 2. *O. Klipsteinii* (Dunk.), var. *superbus.* Single pinna of the shorter and broader type, with lobed margin. P. 66. [V. 2122*a*.]

FIG. 3. Single broad and short pinna. P. 67. [2912*a*.]

FIG. 4. Part of a frond with smaller pinnæ. *Cf.* Pl. I. Fig. 4. P. 66. [V. 2126*a*.]

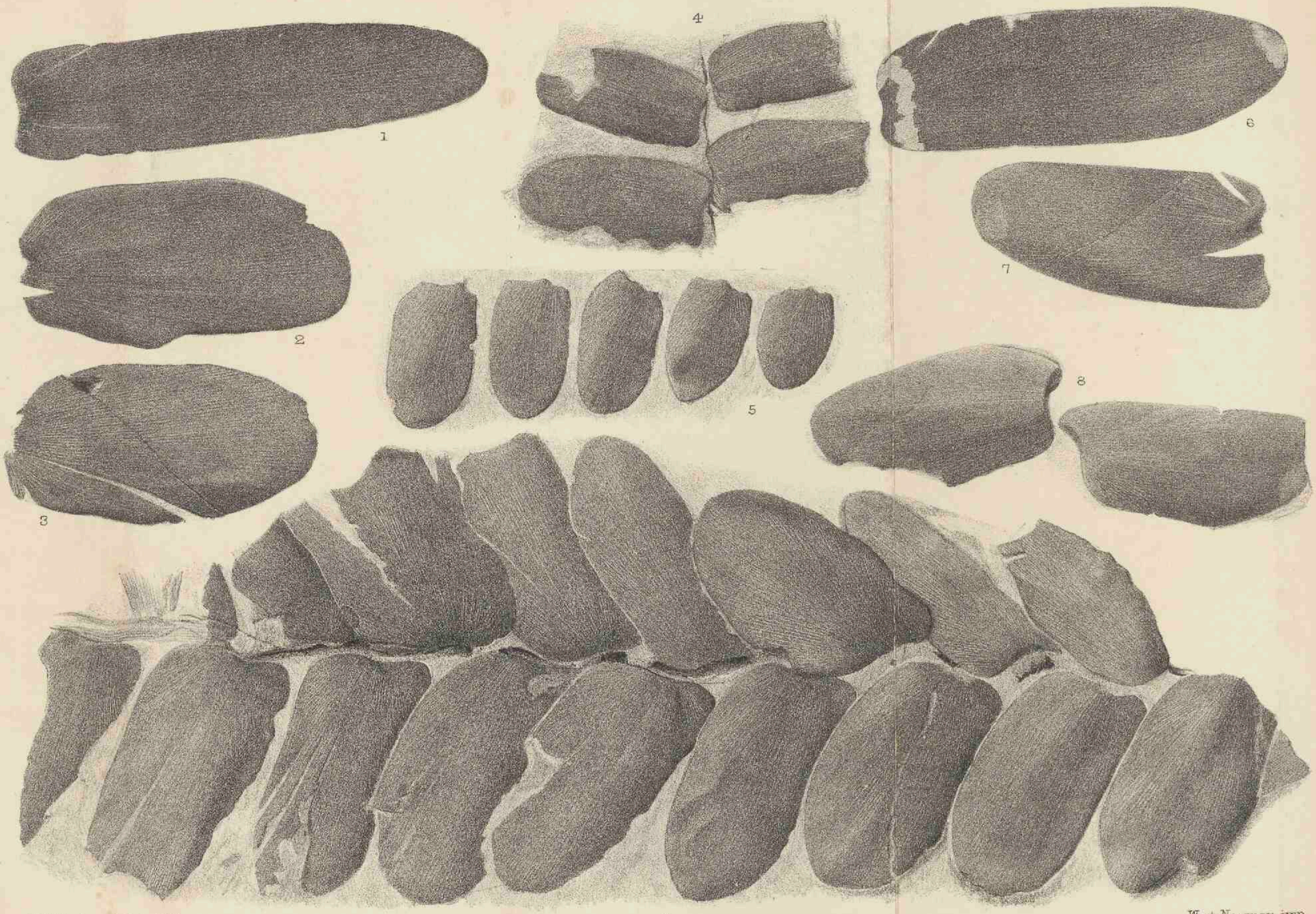
FIG. 5. Part of a frond showing smaller pinnæ. *Cf.* Pl. I. Fig. 4, and Pl. I. Fig. 3. P. 67. [V. 2745.]

FIG. 6. *O. Klipsteinii* var. *longifolius.* Single longer and narrower pinna. *Cf.* Fig. 1. P. 68. [V. 2122.]

FIG. 7. *O. Klipsteinii* var. *superbus.* Shorter pinna showing distinctly auriculate base. P. 67. [V. 2740.]

FIG. 8. Two pinnæ from a large frond. P. 66. [2126*a*.]

FIG. 9. Large frond, probably not fully expanded; venation and form of the pinna distinct. P. 65. [V. 2170.]



G.M.Woodward del. et lith.

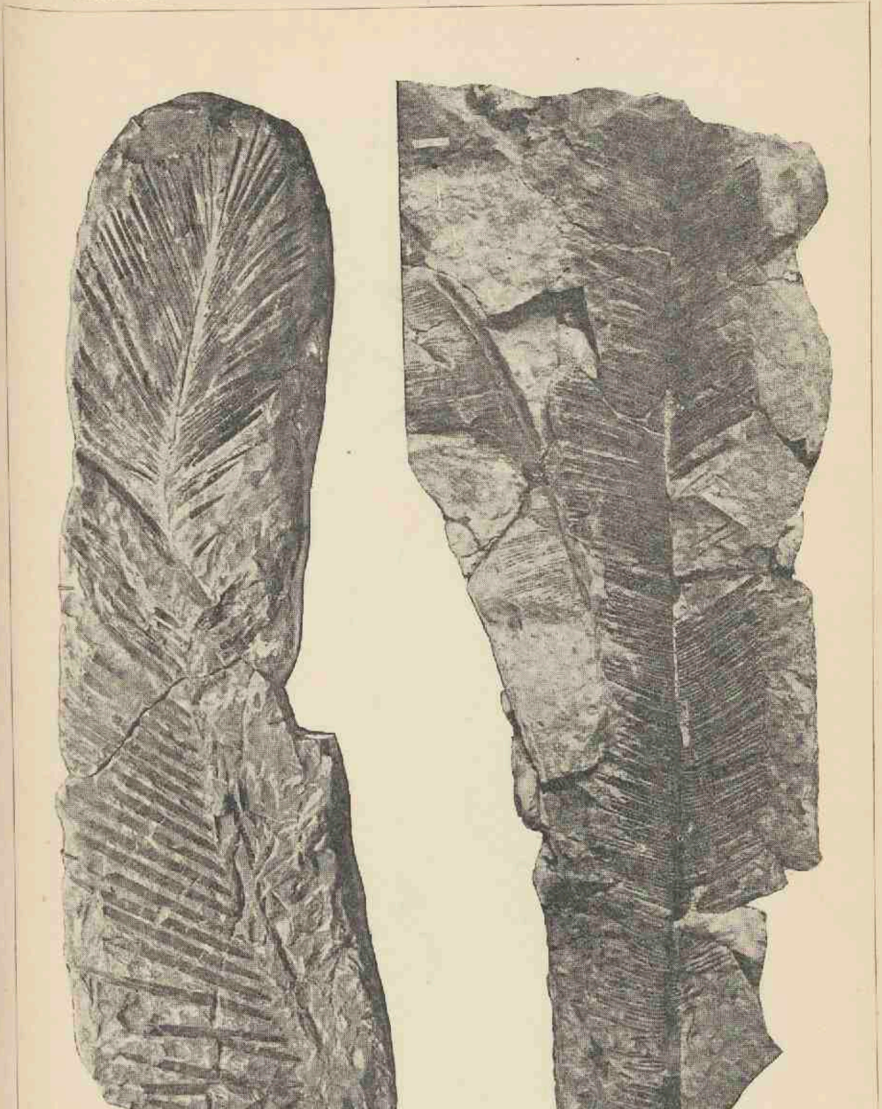
West, Newman imp.

Otozamites.

PLATE VIII.

Fig. 1. *Zamites Buchianus* (Ett.). Large frond, from a photograph by Mr. Gepp. One-sixth nat. size. P. 82. [V. 2120.]

Fig. 2. *Cycadites Saportæ*, sp. nov. From a photograph by Mr. Gepp. One-fourth nat. size. P. 33. [V. 2777.]



A. Gepp, phot. ad nat.

Fig. 1. Zamites. Fig. 2. Cycadites.

PLATE IX.

FIG. 1. *Androstrobus Nathorsti*, sp. nov. Showing central axis and flattened sporophylls. P. 111. [V. 2810.]

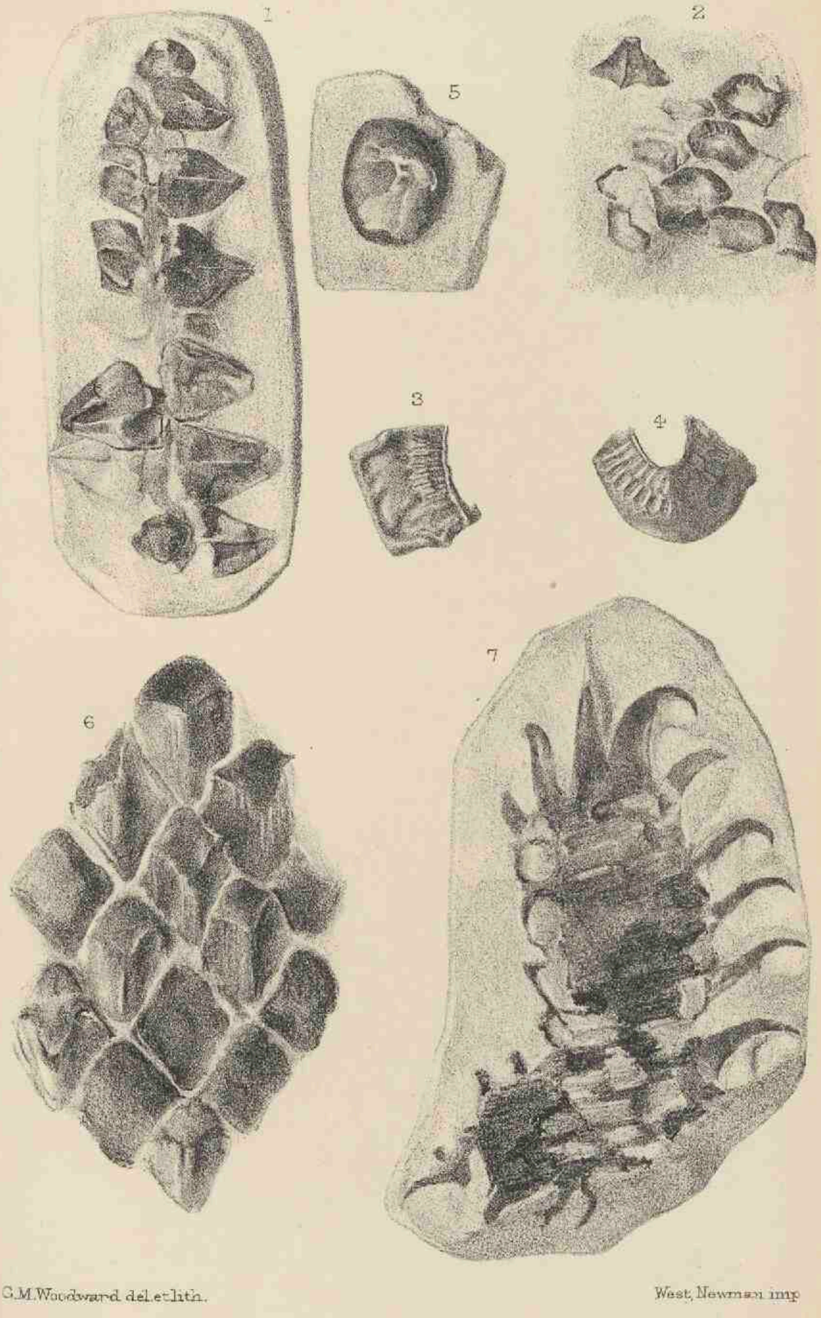
FIG. 2. *Androstrobus Nathorsti*, sp. nov. End view of sporophylls. P. 112. [V. 2811.]

FIGS. 3 and 4. Two sporophylls, slightly enlarged, showing pollen-sac impressions. P. 110. [V. 2701.]

FIG. 5. Seed-like body. Cf. *Oolithes*, Carruthers. P. 107. [V. 2796*a*.]

FIG. 6. *Fittonia Ruffordi*, sp. nov. Portion of a stem with well-preserved petiole bases. P. 133. [V. 2238.]

FIG. 7. *Conites armatus*, sp. nov. Badly preserved cone, showing the recurved spinous terminations of the scales. P. 222. [V. 2338.]



G.M.Woodward del.et lith. West, Newman imp

Figs. 1–4. Androstrobus. Fig. 6. Fittonia. Fig. 7. Conites

PLATE X.

Bennettites (*Williamsonia*) *Carruthersi*, sp. nov.

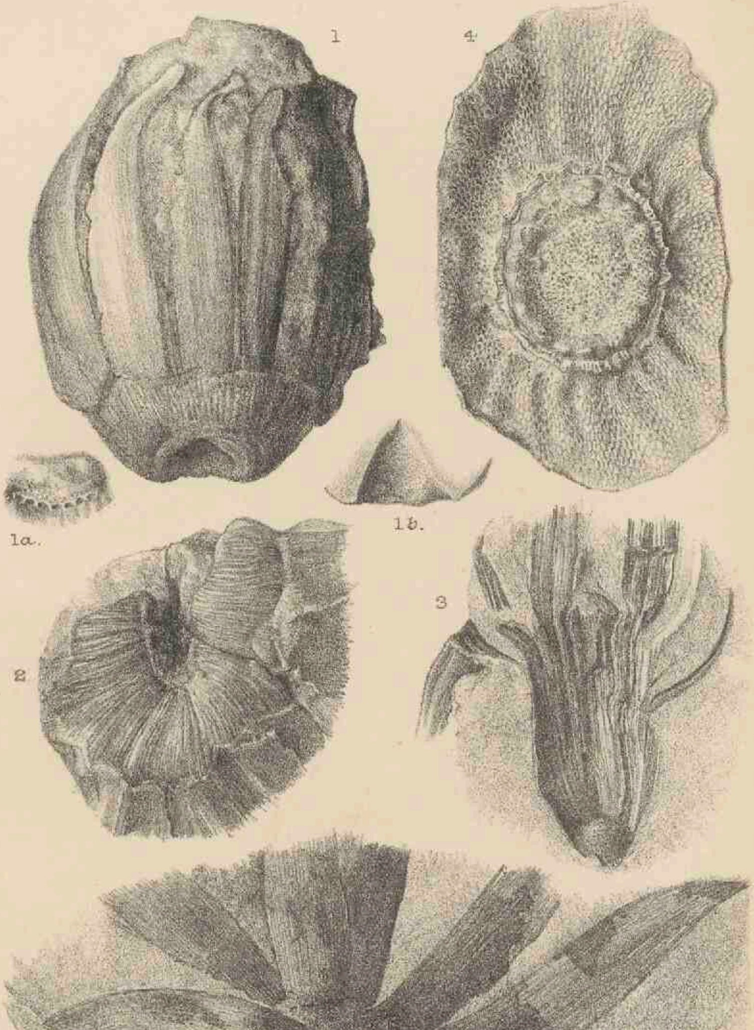
Fig. 1. Unexpanded fructification showing external bracts, and in Fig. 1*a* the reticulate lamellar projections from the inner face of a bract. Fig. 1*b* represents the conical basal cavity of the fructification. P. 157. [V. 3177.]

Fig. 2. Basal view of a slightly larger fructification. P. 159. [V. 3202.]

Fig. 3. A small fructification in longitudinal section, showing a spherical boss at the base, and a few involucral bracts with the thread-like interstitial organs internal to the bracts. P. 160. [V. 2129*b*.]

Fig. 4. The basal portion of a longer and expanded fructification, in the centre the base of the central boss, surrounded by the reticulately marked peripheral tissue. P. 159. [V. 3201.]

Fig. 5. Expanded bracts near the base of a fructification. P. 160. [V. 2129*c*.]



G.M.Woodward del.et lith. West,Newman imp.

Bennettites.

PLATE XI.

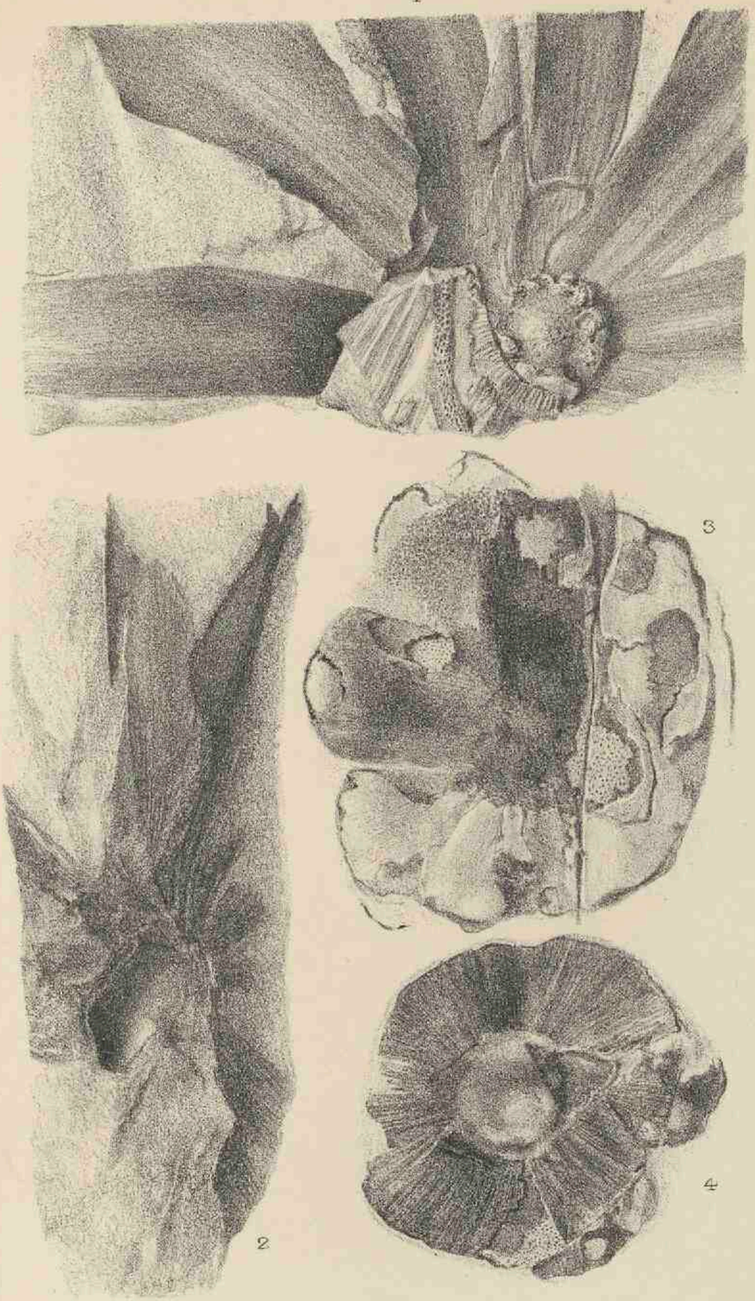
Bennettites (Williamsonia) Carruthersi, sp. nov.

Fig. 1. Large expanded bracts below the base of a fructification, the base of the central boss, traces of interstitial organs, and the reticulate peripheral tissue. P. 161. [V. 2793.]

Fig. 2. Bracts surrounding the conical cavity originally occupied by the central boss of a fructification. P. 161. [V. 2129*d*.]

Fig. 3. *Bennettites (Williamsonia) Carruthersi* var. *latifolius*. Short and broad bracts seen from the under-side; at a lower level portions of the reticulations are shown. P. 163. [V. 2129*f*.]

Fig. 4. The base of the central boss, surrounded by expanded interstitial organs, and below these, in one place, some of the reticulations are visible; and at a still lower level portions of short and broad bracts. P. 163. [V. 2129*e*.]



G. M. Woodward del. et lith.

West, Newman imp.

Bennettites.

PLATE XII.

FIG. 1. *Araucarites* (*Conites*), sp. Central axis of cone and imperfect scales. P. 191. [V. 2180*a*.]

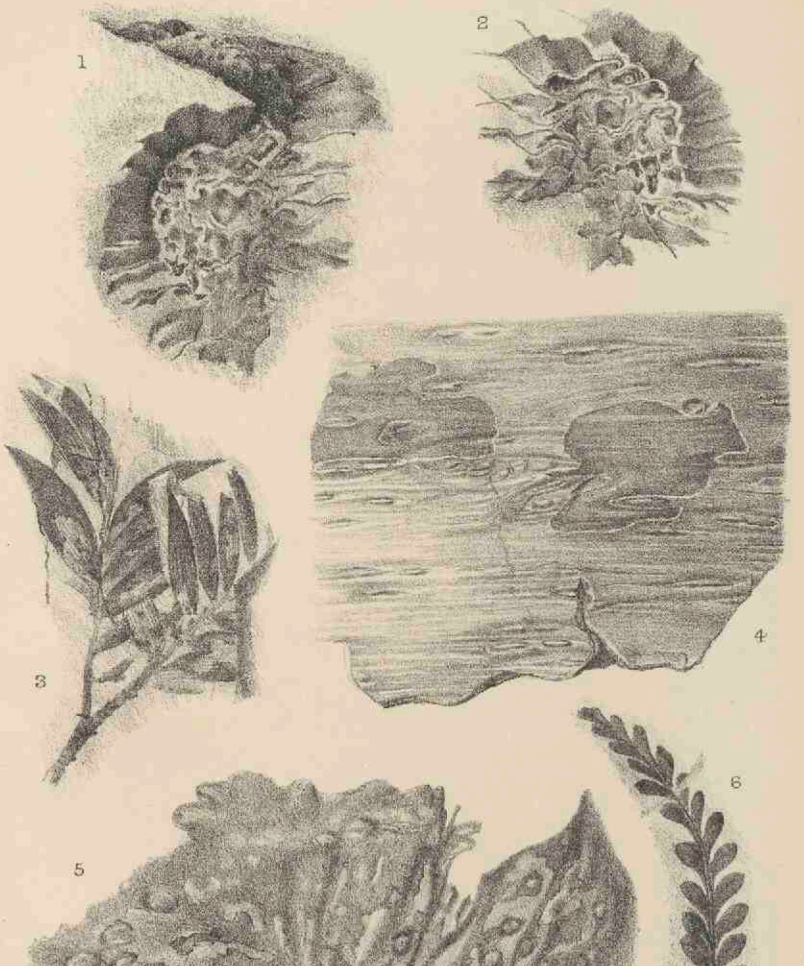
FIG. 2. *Araucarites* (*Conites*), sp. nov. Proximal ends of bracts. P. 191. [V. 2180.]

FIG. 3. *Nageiopsis*, sp. A branched specimen with well-preserved leaves. P. 211. [V. 3190.]

FIG. 4. Cycadean trunk. P. 171. [V. 2350.]

FIG. 5. Cycadean trunk showing branching. P. 171. [V. 3162.]

FIG. 6. *Dichopteris*, sp. P. 184. [V. 3145.]



G.M. Woodward del. et lith.

West, Newman imp.

Figs. 1–2, Conites. Fig. 3, Nageiopsis.
Fig. 6, Dichopteris. Figs 4–5, Trunci.

PLATE XIII.

Fig. 1. *Macrozamia heteromera*, Moore. Single branched pinna. P. 5. (Royal Gardens, Kew.)

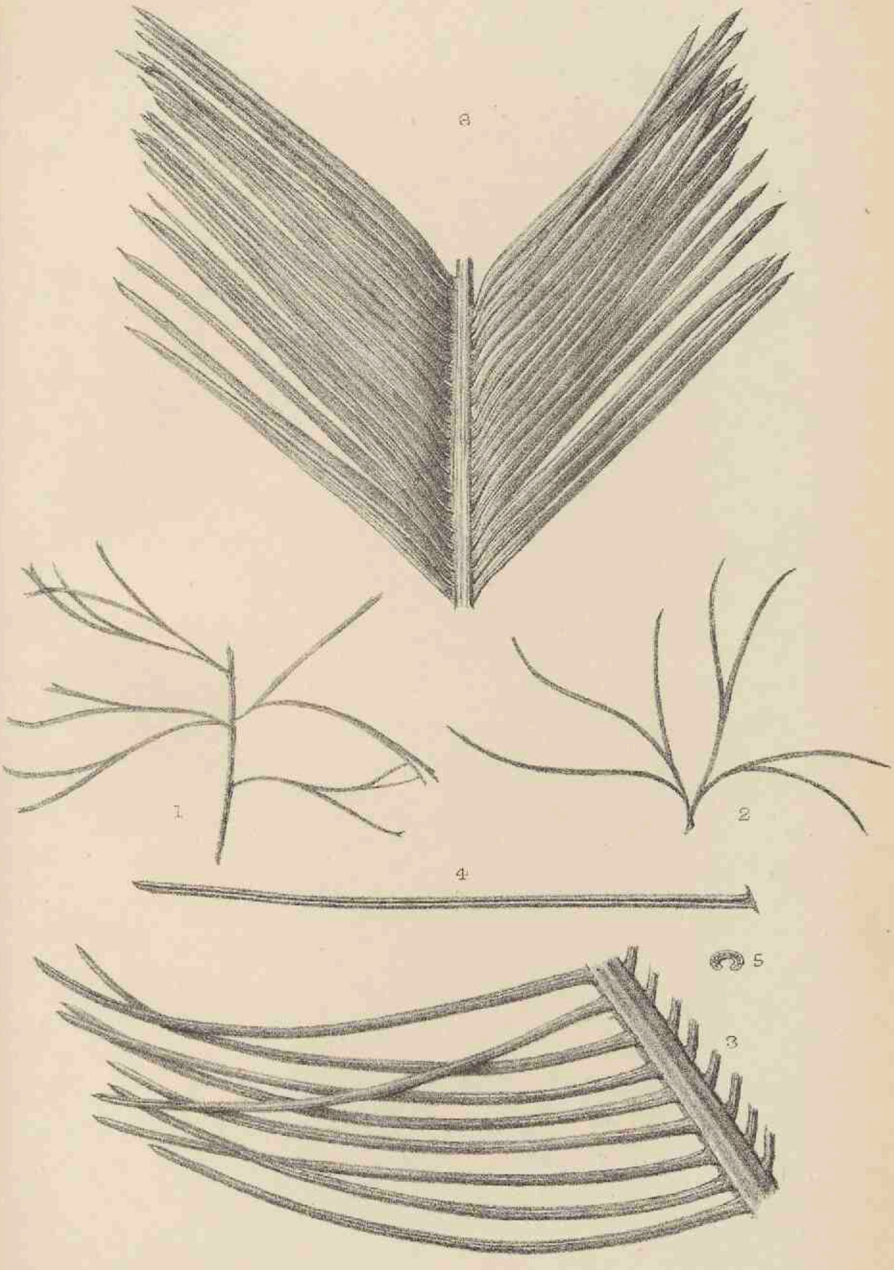
Fig. 2. *Macrozamia heteromera.* Single pinna. P. 5. (Royal Gardens, Kew.)

Fig. 3. *Encephalartos Ghellinckii*, Lem. Pp. 20, 22, 29, etc. (British Museum Herbarium.)

Fig. 4. *Encephalartos Ghellinckii*, Lem. Single pinna from the underside. P. 29.

Fig. 5. *Encephalartos Ghellinckii*, Lem. Cross section of a pinna, showing the revolute edges. P. 29.

Fig. 6. *Encephalartos cycadifolius*, Lehm. Portion of frond. P. 22. (Kew.)



G.M. Woodward del. et lith. West, Newman imp.

Figs. 3–6, Encephalartos. Figs. 1–2, Macrozamia.

PLATE XIV.

FIG. 1. Cf. *Becklesia anomala*, gen. et sp. nov. P. 182. [V. 2608.]
(*Beckles Coll.*)

FIG. 2. *Becklesia anomala*, gen. et sp. nov. P. 179. [V. 2361*a*.]

FIG. 3. *Becklesia anomala*, gen. et sp. nov. P. 179. [V. 2361*b*.]

G.M. Woodward del. et lith.

West, Newman imp.

Becklesia.

PLATE XV.

Bennettites, sp.

P. 144. [V. 3177.]

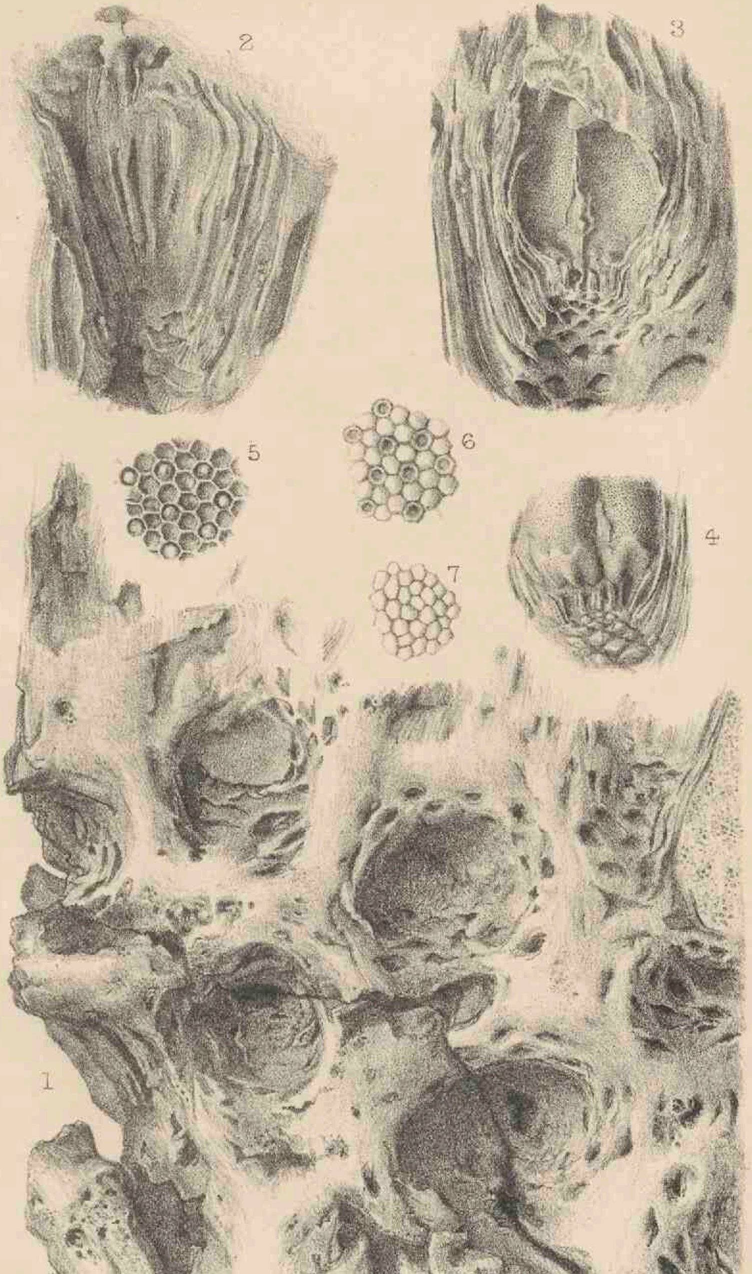
FIG. 1. Surface view of stem, showing position of the inflorescences.

FIG. 2. Bracts of a single inflorescence.

FIG. 3. Involucral bracts, and the central cavity with reticulate markings.

FIG. 4. Wax cast of Fig. 3.

FIGS. 5–7. Enlarged portions of the surface shown in Fig. 3. P. 145.



G.M. Woodward & J. Cameron del. et lith. West, Newman imp.

Bennettites.

PLATE XVI.

Fig. 1. *Pagiophyllum crassifolium* (Schenk). Branch with leaves well preserved. P. 213. [V. 2803.]

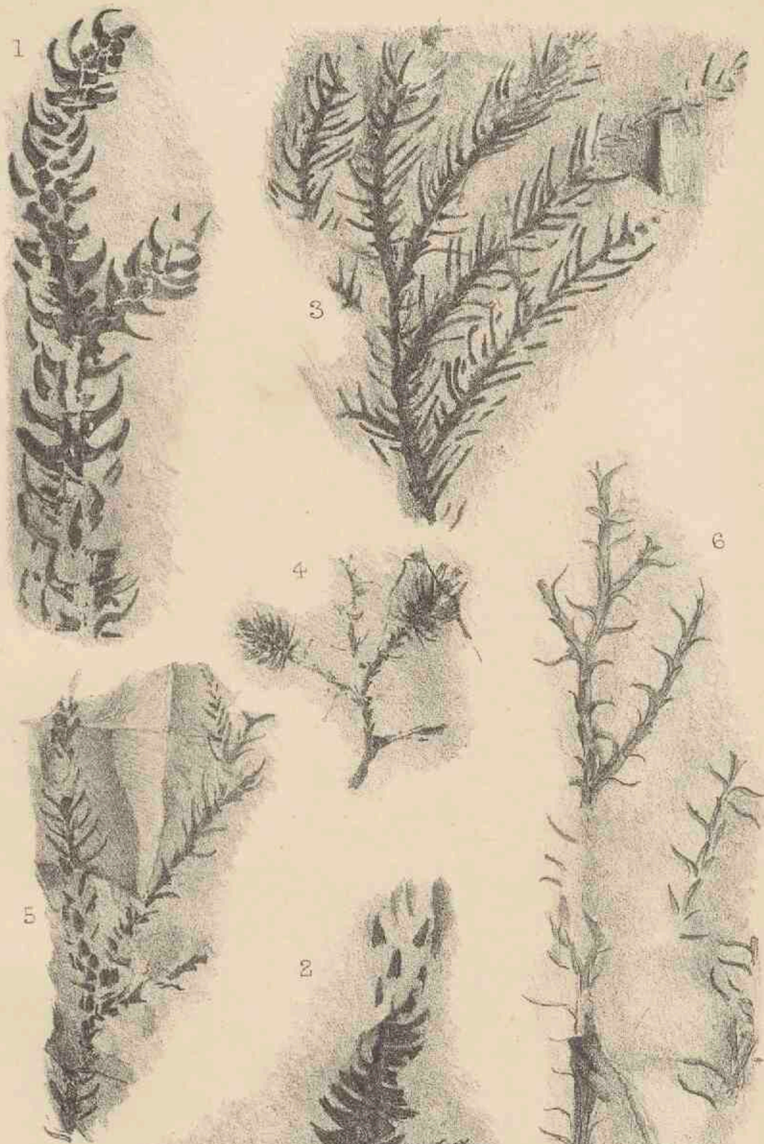
Fig. 2. *Pagiophyllum crassifolium* (Schenk). Preservation less perfect, and leaves more indistinct than in Fig. 1. P. 213. [V. 2142*a*.]

Fig. 3. Cf. *Sphenolepidium subulatum* (Heer). P. 208. [V. 2140.]

Fig. 4. *Sphenolepidium Sternbergianum* (Dunk.). Imperfect female cones, with expanded scales. P. 206. [V. 2311.]

Fig. 5. *Sphenolepidium Sternbergianum* (Dunk.). Branches showing spreading leaves. P. 207. [V. 2139*a*.]

Fig. 6. *Sphenolepidium Sternbergianum* (Dunk.). Leaves and leaf bases clearly shown. P. 206. [V. 2144.]



G.M. Woodward & J. Cameron del. et lith.　　West, Newman imp.

Figs. 1–2, Pagiophyllum. Figs 3–6, Sphenolepidium.

X

PLATE XVII.

FIG. 1. *Brachyphyllum spinosum*, sp. nov. Large branched specimen with leaves, leaf-scars, and thorn-like branches. P. 216. [V. 2746.]

FIG. 2. ? *Brachyphyllum spinosum*. Leaves slightly enlarged, showing the form and striate structure. P. 218. [V. 2296.]

FIG. 3. *Brachyphyllum spinosum*. Portion of a thick branch with leaf bases. P. 218. [V. 3180.]

FIG. 4. *Brachyphyllum spinosum*. Portion of a decorticated axis with three branches. P. 217. [V. 2240.]

FIGS. 5 and 5*a*. *Brachyphyllum spinosum*. Branch showing decorticated axis. P. 218. [V. 2750.]

FIG. 6. *Brachyphyllum spinosum*. One-third nat. size. Decorticated specimen showing the spinous branches. P. 217. [V. 2135.]

FIG. 7. *Sphenolepidium Kurrianum* (Schenk). Cluster of female cones. P. 203. [V. 2316.]

FIGS. 8 and 8*a*. *Sphenolepidium Kurrianum* (Schenk). Single cone more perfectly preserved. P. 203. [V. 2213.]

FIG. 9. *Brachyphyllum obesum*, Heer. Small twig. P. 221. [V. 3348.]

G.M. Woodward del.et lith. West, Newman imp.

Figs.1–6 & 9. Brachyphyllum. Figs.7 & 8. Sphenolepidium.

PLATE XVIII.

FIG. 1. *Sphenolepidium Kurrianum* (Schenk). Large specimen with well-preserved leaves. P. 203. [V. 2316*d*.]

FIG. 2. *Pinites Solmsi*, sp. nov. Branches with leaf bases and long needles. P. 197. [V. 2169.]

FIG. 3. *Pinites Solmsi*, sp. nov. Female cone with short branch and narrower needles. P. 197. [V. 2255.]

G. M. Woodward del et lith. West, Newman imp.

Fig. 1. Sphenolepidium. Figs. 2 & 3. Pinites

G. M. Woodward del. et lith.

West, Newman imp.

Pinites.

PLATE XX.

FIG. 1. *Brachyphyllum obesum*, Heer. Twig showing manner of branching. P. 220. [V. 2137.]

FIG. 2. *Brachyphyllum obesum*. Stouter branch with well-preserved leaves. P. 221. [V. 2137*a*.]

FIG. 3. *Pagiophyllum*, sp. Twig with broad leaves. P. 213. [V. 2288.]

FIG. 4. *Brachyphyllum obesum*. Comparatively thick branch. P. 221. [V. 2337.]

FIG. 5. *Pinites Carruthersi*, Gard. Detached female cone. P. 195. [V. 2611.]

FIG. 6. *Thuites valdensis*, sp. nov. Twig with distinctly preserved branches and leaves. P. 209. [V. 2138.]

G.M. Woodward & J. Cameron del et lith.

West, Newman imp.

Figs. 1, 2 & 4. Brachyphyllum. Fig. 3. Pagiophyllum.
„ 5. Pinites. „ 6. Thuites.

PLATE XIX.

Pinites Solmsi, sp. nov.

FIG. 1. Branch with well-preserved leaf bases, and cones with unexpanded scales. P. 196. [V. 2146.]

FIG. 2. Branch and cone with partially expanded scales. P. 198. [V. 2147.]

FIG. 3. Branch bearing two female cones, and in the upper portion small indistinct structures. P. 197. [V. 2146*a*.]

FIG. 4. Cone with partially expanded scales. P. 197. [V. 2147*a*.]