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PART VI.

CATALOGUE

OF THE

MESOZOIC PLANTS

IN THE

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Vol. 6.

THE CRETACEOUS FLORA.

PART II.—LOWER GREENSAND (APTIAN) PLANTS OF BRITAIN.

BY

MARIE C. STOPES, D.Sc. (Lond.), PH.D. (Munich), F.L.S.,
FELLOW OF UNIVERSITY COLLEGE; LECTURER IN PALÆOBOTANY AT UNIVERSITY COLLEGE, LONDON UNIVERSITY.

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PREFACE.

THE second part of the Catalogue of the Cretaceous Flora deals with the remains of plants from the English Lower Greensand, and shows the importance of a careful study of even the most unpromising fossils. Most of the specimens described are merely fragments of wood, but their microscopical structure proves to be so well preserved that their organisation can be clearly determined. Some agree sufficiently well with corresponding structures in existing plants to be referred approximately to their true systematic position; but others appear to be more or less anomalous, and are not comparable with any stems in the existing flora of which the histological structure is known. The Catalogue, indeed, emphasises the necessity for a more extended and exhaustive study of the vegetative structures of the plants which are now living.

The general results of the detailed descriptions in the Catalogue are summarised in the Introduction, to which reference should be made especially for important observations on the climate of the Lower Cretaceous period.

The dates in round brackets after authors' names refer to the Bibliography at the end of the volume.

A. SMITH WOODWARD.

DEPARTMENT OF GEOLOGY,
April, 1915.

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INTRODUCTION

For the first time the Flora of the Lower Greensand (Aptian age) of Britain is considered as a unit. Hitherto the fossils which represent it have been dismissed as insignificant, and, with the exception of *Bennettites Gibsonianus* and *Cupressinoxylon vectense*, their anatomy has remained undescribed. In addition to the two plants just named, a few gymnospermic cones and undetermined "woods" are all that have been noticed. It is not surprising, therefore, that one of the most recent references to the Lower Greensand vegetation should state this general impression as follows:—"The land of Vectian [*i. e.* Lower Greensand] time was doubtless similar in aspect and climate to that of Wealden time, and the plants and creatures which inhabited the country were the same" (Jukes-Browne, 1911, p. 306).

In reality, the flora of the English Lower Greensand is rich, not only in species, but in interest, and it offers a startling contrast to the flora of the preceding Wealden. Furthermore, while the fossils which represent the Lower Greensand flora have generally been neglected as poorly preserved and fragmentary, the actual fact is that petrifactions of the internal anatomy of this age are surprisingly excellent, and the microscopic details of many of the Lower Greensand species are not surpassed by the most beautiful of the Coal-Measure petrifactions.

The plants of the Lower Greensand in this country are found under very favourable conditions: occurring in a well-defined and well-known marine deposit, their exact geological position is clear. Had this not been the case, there must have been much doubt regarding the age of the flora, for it is so unlike any other previously known.

The following species are present in the English Lower Greensand and are now described:—

THALLOPHYTA.	*Chondrites Targionii* (see Vol. I.).
FILICALES.	*Weichselia reticulata* (Stokes & Webb), Ward.
	Tempskya erosa, Stokes, Webb & Mantell sp.
CYCADOPHYTA.	*Bennettites Gibsonianus*, Carr.
	B. maximus, Carr.
	B. Allchini, sp. nov.
	B. inclusus (Carr. sp.). [Potton.]
	Cycadeoidea Yatesii, Carr. [Potton.]
	C. buzzardensis, sp. nov. [Potton.]
	Colymbetes Edwardsi, sp. nov.
	Cycadeomyelon sp.
	Cycadeorachis sp.
CONIFERALES.	*Sequoia giganteoides*, sp. nov.
	Protopiceoxylon Edwardsi, sp. nov.
	Pityoxylon Sewardi, sp. nov.
	P. Benstedi, sp. nov.
	P. Woodwardi, sp. nov.
	Pinostrobus sussexiensis (Mantell sp.).
	P. Benstedi (Mantell sp.).
	P. oblongus (Lindl. & Hutt. sp.).
	P. patens (Carr. sp.).
	P. cylindroides (Gard. sp.).
	P. sp., cf. *P. longissima*, Vel.
	Cedrostrobus Leckenbyi (Carr. sp.).
	C. Mantellii (Carr. sp.).
	Cedroxylon maidstonense, sp. nov.
	C. pottoniense, sp. nov.
	cf. *Abietites Solmsi* (Seward sp.).
	Abietites sp.
	Cupressinoxylon vectense, Barber.
	C. luccombense, sp. nov.
	C. cryptomerioides, sp. nov.
	C. Hortii, sp. nov.
	Taxoxylon anglicum, sp. nov.
	Podocarpoxylon woburnense, sp. nov.
	P. bedfordense, sp. nov.
	P. Gothani, sp. nov.
	P. Solmsi, sp. nov.
	Vectia luccombensis, sp. nov.
ANGIOSPERMÆ.	
MONOCOTYLEDONS.	Very doubtful palm.
DICOTYLEDONS.	*Cantia arborescens*, sp. nov.
	Woburnia porosa, Stopes.
	Sabulia Scottii, Stopes.
	Hythia Elgari, sp. nov.
	Aptiana radiata, Stopes.

This makes a total of 45 forms, of which the numbers in the respective groups are as follows:—1 Thallophyte; 2 Filicales; 9 Cycadophyta; 27 Conifers; 5 Angiosperms. The proportions of the representatives of the different groups are noticeably different from those in most described floras: the extreme scarcity of ferns and the overwhelming preponderance of Conifers being unusual features in Mesozoic floras; while, in those vegetations which contain authentic Angiosperms, they generally bulk more largely in the lists than in the present case.

As the Lower Greensand flora has hitherto been merged with that of the Wealden, it must first be compared with it.

The recent additions to the Wealden Flora are included in a complete summary by Prof. Seward (1913), and the total flora brings the number of species up to 68 (with one or two other fragments and *incertæ sedis*). Of these a total of 32 are Thallophyta to Pteridophyta, which include 23 species of ferns, as against the two species of ferns in the Lower Greensand. There are also 19 species of Cycadophyta, the rest of the flora being composed of Conifers and gymnospermic *incertæ sedis*.

Among the Conifers, 4 species represent the Araucarineæ, 1 the Cupressineæ, 5 the Abietineæ, and the rest are uncertain.

Not only is it true, as Seward (1895, p. 240) says, that "we search in vain among the abundant samples of the Wealden vegetation for any fragments of monocotyledonous or dicotyledonous plants," while in the Lower Greensand the dicotyledons are represented by five distinct and well-preserved genera; but "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."

Berry (1911, p. 101) writes: "As transitional deposits the Wealden may well be partly of Jurassic age, but of late years it has come to be accepted as a non-marine facies of the Neocomian, since, where it is present, the lowest marine beds of the Neocomian are said to be absent. That the flora (Seward, Ward) and fauna (Smith Woodward, Marsh) are Jurassic in type is not to be wondered at, indeed, it would be remarkable

b 2

if it were otherwise, since Nature knows no units, and boundary lines in conformable deposits are purely utilitarian or academic."

Nevertheless, the academic boundary is well indicated in the contrast between the Lower Greensand and the Wealden floras of this country. In 1913 Halle wrote, in relation to the Mesozoic flora of Patagonia: "It must be stated at once that it is not possible, with the present state of the knowledge of fossil floras, to establish any accurate subdivision, on a palæobotanical basis, of the time from the close of the Jurassic to the Lower Albian. The Wealden flora, as understood by palæobotanists, embraces more or less the whole of this time, several of the characteristic Wealden species being found as high as in the Albian of Portugal (Saporta, 1894)." The present work on the Aptian affords great hope that, as the structures of plants of this age are discovered in various localities, the palæobotanical divisions between the Jurassic and the Lower Albian will be established.

To the Jurassic, our Aptian flora, with its preponderance of Conifers and its Dicotyledons, offers a contrast indicative of the passage from one major life-sequence to another. Nevertheless, some of the differences in composition between the Wealden and the Lower Greensand floras are due to the different physical circumstances of their deposition. For instance, the absence of fern-foliage in the Lower Greensand must be due simply to the destruction of the leaves before they reached a position in which they could be entombed.

Leaving the Coal-Measure flora out of consideration, as it is unique in many ways, it may generally be stated that the floras of which any considerable numbers of forms are known are preponderatingly composed of species based on fragments of *leaves*. The Lower Greensand flora, however, is preponderatingly composed of *woody stems*, with a fair sprinkling of gymnospermic cones. The reason for this is doubtless correlated with the palæogeography of the deposit. Everything points to the Aptian deposits of this country as representing a narrow arm of the sea, in which a coarse marine detritus was being laid down at no great distance from land. The plant-remains which were mingled with the coarse sandy matrix must have drifted for some time before they were entombed. While sea-water has proved to be an exceedingly good preservative (see Stopes & Watson, 1908) and, as is evidenced by the state of many of the Lower Greensand plants, must have been a perfect specific against the decay of even the finest details, yet the sea journey resulted in the elimination of all the soft leaves, which probably formed attractive food for fishes and molluscs. It is noteworthy that in the list of species, there are only two based on leaf-impressions, and these are both very scanty and incomplete. The one well-preserved leaf is the minute twig of *Sequoia* which was completely sheltered, and must have travelled concealed in the larger mass of secondary tissues of another plant (see pp. 70, 247).

The species now described, therefore, represent only the sturdier portions of the larger woody elements of the whole flora then living. Hence it must not be assumed that herbaceous plants were wanting, or even scanty at this time. Indeed, in the contemporaneous Lower Cretaceous floras of Portugal (Saporta, 1894) and North America, where the physical conditions of deposition were different, the various types of plants were in quite other proportions. Very useful summaries of the Lower Cretaceous floras from all parts of the world are given by Berry (1911) in his recent monograph, to which reference should be made.

As a consequence, in our deposit, the absence of herbaceous plants, and in particular of herbaceous Angiosperms, must not be taken to be of any phylogenetic significance. While it might at first sight appear to support the view (see Eames 1911, Sinnott & Bailey 1914, etc.) that the woody tree is the "primitive" type of Angiosperm, since the species described above are all woody; yet that deduction is an illegitimate one to draw from the data. This in reality only proves that the physical conditions of deposition were such as to prohibit the preservation of the herbaceous Angiosperms which I am sure were then living, and which, if I may express an unsupported opinion, were probably some of several "primitive" stocks of the profoundly polyphyletic Angiosperms.

As the Angiosperms described in the present volume are the earliest Dicotyledons recorded, not only for England but for the whole North of Europe, and are the earliest specimens of which the anatomy is known from any part of the world, some discussion of the vexed question of the origin of the Angiosperms might be deemed appropriate. Many leaf-impressions from deposits somewhat older than the Aptian (*e. g.* the 'Potomac" of America) have been described, but the exact correlation of these deposits with the European beds is still very uncertain. In those beds which are clearly older than Aptian, on the other hand, the records of reputed Dicotyledons, though numerous, are far from securely established (see p. 259). In the Kootanie and Horsetown beds, for instance, which are definitely older than the Aptian, the recorded Angiosperms are very doubtful. Similarly in Europe, the pre-Aptian Angiosperms and pro-Angiosperms of Saporta (1894) cannot be accepted unhesitatingly.

Nevertheless, it is certain that Angiosperms, to have spread so widely by Aptian times, must have existed either actually or potentially in some pro-angiospermic character, by the Jurassic, possibly even by Triassic times.

As will be seen in the descriptive part of this work (pp. 260–294), the Aptian stems were woody plants of a highly advanced and differentiated character, and there is nothing in their anatomy to indicate any more clearly their phylogenetic origin than there is in the stems of the still living genera. The origin of the Angiosperms remains the "abominable mystery" Darwin thought it. The solution *via* the Bennettitales has never commended itself to me, and the existence of such highly differentiated Angiosperms in the strata from which the typical *Bennettites Gibsonianus* and others were obtained, renders it still more incredible that there should be a Bennettitalean ancestry for the Angiosperms.

CLIMATE.

As geologists are at present almost without information regarding the land-conditions of the Aptian of Northern Europe, they may ask what evidence regarding the climate is given by the plants now described.

It is evident from their structure that these plants inhabited an ordinary dry, or comparatively high, land. As the fossils had all drifted in sea-water at least some short distance before they were petrified, we cannot be quite sure that they all lived close together. Their states of preservation and the amount of teredo-boring they endured, however, favour the view that they had not travelled far, but were petrified in water near the land on which they grew. This conclusion is also supported by the tendency to localisation of the types—for instance, *Cupressinoxylon vectense* is the commonest form in the Isle of Wight, while *Podocarpoxylon woburnense* is the preponderating form in Woburn. Both show annual rings and both lived in similar climates, and the prevalence of one or the other form probably depended on local distribution, which in its turn was correlated with ecological differences comparable with those which to-day determine one wood as being of beech, another of oak.

The presence of *Bennettites*, which occurs not only in the Isle of Wight, but also in Kent, has generally been held to indicate a tropical or subtropical climate. There is, however, no certainty that this was the case, and *Pseudocycas* (see Nathorst, 1907), a genus belonging to the same family *in sensu lato*, inhabited the Arctic at a time when, though the climate was warmer than at present, it could not have been tropical.

The large number of Abietineæ in the Lower Greensand is highly suggestive of a cool, if not actually a cold climate (see Gothan 1908, among others, and note also the present distribution of the Abietineæ). This view is strongly supported by the remarkable and total absence of Araucarineæ, a group widely distributed in most European, and in the English deposits in particular, both of earlier and later periods, which are supposed to have been relatively warm. *Araucaria* itself is plentiful in the Jurassic, the Wealden, and the succeeding Upper Cretaceous and Tertiary of this geographical region: its remarkable absence from the English Lower Greensand, particularly in a flora represented so largely by petrified woods, among which its woody branches would so naturally have been preserved had they been present, appears to indicate clearly that the climate was temporarily too cool for it. Supporting this conclusion are the well-marked growth-rings, so regular and normal as to have every appearance of being *annual* rings (see, for example, Pl. III, fig. 1), which are present in nearly all the woods described. While growth-rings in Angiosperms do not necessarily indicate seasonal change of climate, in the ever-green Gymnosperms they do (see Gothan 1908, Stopes 1914, etc.).

The evidence from the plants, that Aptian times in this region were relatively cool, with well-marked seasons, seems indubitable; and if this is so, the climate must have been noticeably cooler than that of either the preceding or succeeding periods.

Regarding the preceding Wealden, Seward (1895, p. 239) writes: "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 to-day." The succeeding Gault and Upper Greensand create the general impression of having been warmer again, but I cannot express an opinion on this till I have completed my examination of the plants of these periods.

Published accounts of the fossil animals of the Lower Greensand of England do not support or supplement this conclusion from the plants, for there are remarkably few remains of the kind from which any evidence is deducible. There seems, however, to be a general impression among some geologists that the Cretaceous climate of England had begun to be cooler by Aptian times. In conversation Dr. Gregory pointed out to me the notable lack of large corals in the Greensand, even in the cherty deposits in which they might—lithologically—be expected to be prolific. Land-animals of the period are very few: the famous Maidstone Iguanodon, and two or three other species of reptiles, scantily represented, seem to be all the British records. Dr. Andrews kindly informs me that they afford little or no evidence regarding their habitat. The one specimen which suggests a rather warmth-loving habit is only represented by fragmentary bones, and these may well have drifted or been carried some distance.

Too little is known of the land-distribution and the direction of the currents, etc., of Aptian Britain to make a discussion of the causes of this cooling (so clearly indicated by the plant-structures) at all profitable. It is evident that the effect of a cooling-off from the warmth of the Wealden must have had a profound effect on the vegetation.

Previous Records of English Lower Greensand Plants.

In 1822 Mantell (p. 78) gives "wood" in the list of the "organic remains" from Willingdon, Selmeston, etc., again referring to them in 1828 (see 1835, p. 211) under the class Phanerogamia (Dicotyledonous) as "rolled fragments of wood at the junction of the sand with the galt." It should be noted that at this early date coniferous wood was described under the term "Dicotyledonous," so that this entry is not a record of angiospermic but of gymnospermic wood.

In the same year Martin (1828, p. 28) writes: "Its common iron-stone (car-stone) abounds most in the reddest beds of sand, and exists in balls." . . . "The nucleus of these balls is often pyrites, or a ball of chlorite sand, and sometimes wood." Such phrases are repeated in most of the works about this date (*e. g.*, Mantell, 1833, 1835, etc.).

Fitton, in 1836 (p. 131), published a very clear account of the three main divisions of the Lower Greensand, and, referring to the neighbourhood of Folkestone, makes the following remark: "*Wood.* Coniferous, silicified. Near Folkestone and Wilsborough. Rolled fragments are frequent at the junction of the Gault with the top of the sands." And in the list of fossils from the interior of Kent (p. 152) is the entry: "Wood, Dicotyledonous [see note above]. Boughton; and near Brasted, West Kent."

In 1847 Mantell, describing the Isle of Wight, gives the following classification of the beds (p. 64):—

"GALT.		
GREENSAND.	A triple alternation of sand, sandstones and limestones, with dark stiff clays. Layers and concretions of chert. Ironstone, fuller's-earth, sulphate of barytes, fibrous gypsum, etc.	Marine shells, many peculiar to this division of the Chalk. Fishes, crustaceans; bones of reptiles. Fuci; coniferous wood, and fruit.
WEALD CLAYS."		

In referring to the Greensand fossils (p. 229) he remarks: "The organic remains to be met with along this coast are almost exclusively shells; but few traces of the higher orders of animals, or of plants, have hitherto been observed. It should, however, be borne in mind, that remains of land reptiles, and trees, and plants, have been found in strata of this formation in Kent; similar relics may therefore occur in the same deposits in the Isle of Wight. Of the vegetable kingdom but few vestiges have been discovered. The laminæ of lignite in the upper ferruginous beds, and obscure traces of fuci in some of the lower sandstones, are the only indications of the flora of this geological epoch that have come under my notice. But remains of the foliage of a fern that abounds in the Wealden (*Lonchopteris Mantelli*) were discovered by Mr. Morris in many of the strata at Atherfield; and the Messrs. Gladstone have since found several leaflets of the same species associated with trigoniæ, etc., in the ironstone nodules at the foot of Shanklin Cliff."

In Lindley & Hutton's well-known 'Flora' (1837) there is only one Lower Greensand species, *Abies oblonga*, a cone, said to be washed out of the Lower Greensand of Lyme Regis.

Mantell (1839), referring to the fossils in Mr. Bensted's Iguanodon Quarry in Kent, says (p. 398): "Mr. Bensted has also discovered fossil wood perforated by lithodami, or boring shells; impressions of leaves, stems of trees, *ammonites*, etc."

In 1843 Mantell (p. 34) gives short preliminary accounts of two cones of Lower Greensand age, which he names respectively *Zamia Sussexiensis* and *Abies Benstedi*.

By 1843 Morris lists the following species of plants in the Lower Greensand:—

Abies Benstedi,	from	Maidstone.
A. oblonga,	,,	Lyme Regis.
Dracæna Benstedi,	,,	Maidstone.
Zamites Sussexiensis,	,,	Selmeston.

In the following year Mantell (1844) again refers to and gives a popular account of the fossil wood found near Maidstone and elsewhere, mentioning also the fossil cones.

The important and detailed work of Ibbetson & Forbes (1844, 1845) contains but little reference to fossil plants, though, in mentioning the changes of the shore-level (p. 193), they say that "lignites, indicating a shallow sea, become common, form belts in the ferruginous sand, and in one place a bed in the navy blue sand, at a time when much iron was deposited." In their detailed list of the beds they make the following note: "Bed 31. Thin, very wavy laminæ of black clay (or lignite) full of pyrites, with a layer of spongiform nodules near the bottom."

In 1846 Mantell's fuller paper describing the two Lower

Greensand cones, *Abies Bensteli* and *Zamia Sussexiensis*, appeared, with illustrations of the external aspects of the structures. Referring to *A. Bensteli*, he mentions the occurrence in the same [the Iguanodon] quarry of wood of various sorts, petrified as well as carbonised.

Fitton's detailed and exhaustive paper appeared in 1847, in which several references are made to plants. He says (p. 292) "remains of *Lonchopteris Mantellii*, a fossil fern hitherto found only in the Wealden group, have been detected by Mr. Morris in so many different places, that it may be regarded as diffused throughout the whole division." Of his series of beds 4–10, called the "Crackers," he writes (p. 297), "the upper nodules (5 *b*), about a foot below the top of the sand, consist of coarse sandy limestone or grit, including fossil coniferous wood, eroded by Teredoliths. I counted thirty-two of these masses in 100 paces, on a line descending from the cliffs to low-water mark; they were from three to five feet long, and about two feet thick, but very irregular in form and dimensions." (P. 308): "The vegetable remains in [beds] Nos. 36 and 37 have a glistening surface like that of plumbago. They were found by Mr. Morris to be distinctly portions of *Lonchopteris Mantellii*, a fern of the Wealden hitherto found in that deposit only, but which seems to be diffused in fragments nearly throughout the whole of the lower Greensand. Its occurrence amidst shells exclusively marine makes it probable that when these remains were deposited in the detritus which now forms the lower Greensand, some portion of the Wealden land was still above the sea; but the fragments of *Lonchopteris* found here are very small, and so confusedly mixed together, that they may have been transported from great distances. In [bed] No. 36 they are accompanied by *Inoceramus*."

In 1851 Mantell gave a detailed account of the Maidstone Iguanodon, followed by a description of the formation in which it was found (p. 302):—"Waterworn blocks of fossil wood perforated by boring-shells, fragments of stems, and branches of monocotyledonous and coniferous vegetables, are also occasionally found imbedded with the marine exuviæ, having evidently been transported by rivers or land-floods, and drifted into the bed of the chalk-ocean."

By 1854 the list of Lower Greensand plants in Morris' Catalogue contained the following:—

Abietites Benstedi,	from	Maidstone.
A. oblonga,	,,	Lyme Regis.
Chondrites fastigiatus,	,,	Maidstone.
Dracœna Benstedi,	,,	Maidstone.
Lonchopteris Mantelli,	,,	Isle of Wight.
Zamiostrobus Sussexiensis,	,,	Selmeston.

Mr. Bensted himself gave an account of the Geology round Maidstone (Bensted, 1862), in which he mentions the plants found there, but he adds nothing new to the subject.

In the same year Mackie (1862 B) described and figured the famous "Dragon-Tree" (see p. 159), which he took to be evidence of Monocotyledons at that date. From this time onward there are frequent references to this fossil, which will not be included here.

The same year also saw the publication of Bristow's memoir on the Isle of Wight. In the lists of fossils the following Lower Greensand plants appear:—

Actinophyllum sp.
Lonchopteris Mantelli.
Abietites Benstedi.

He also quotes Paine & Way as saying (p. 15): "Amongst the fossils there are large quantities of black fossil wood, frequently encrusted with a grey cement of phosphate of lime and sand. This wood is very rich in phosphoric acid."

Carruthers began his series of papers on Lower Greensand fossils in 1866 with one on the fossil fruits, in which he shortly describes some previously known fossils, which he puts in the genus *Pinites*, viz. *P. oblongus*, *P. Benstedi*, *P. Sussexiensis*, *P. Mantellii*, and *P. patens*. In the following year he first described the interesting Potton-Sand stem, *Cycadeoidea Yatesii* (see p. 299), and in 1869 he again referred to *Pinites Sussexiensis*, and described and illustrated *Pinites Leckenbyi* (see p. 143), which he recognized as being very like *Cedrus*.

In 1870 Carruthers' most important work on the Lower Greensand plants appeared, in which he gives short accounts of *Yatesia Morrisii* (the same plant as *Cycadeoidea Yatesii*), *Bennettites maximus*, and *Mantellia inclusa*, as well as a long and fully illustrated account of *Bennettites Gibsonianus* and the new genus of which it is the type, showing well-petrified anatomical details of the stem and fructifications.

In the Survey memoir of 1875 Topley refers to some of the fossil plants found in the Lower Greensand (pp. 118, 127), but adds nothing new to the lists. This is also the case in the body of Dixon's (1878) work, though in this Carruthers has a special section on the Lower Cretaceous flora (p. 279), in which he unites the Wealden and the Lower Greensand plants already known.

By 1885 the different beds of the Lower Greensand are individually mentioned, and Etheridge (1885, p. 536) writes: "The so-called 'Iguanodon Quarry' at Maidstone exhibits the greater part of the Hythe beds, with *Trigonia caudata*, *Exogyra sinuata*, *Gervillia aviculoides*, coniferous wood, and *Pinites Mantellii*, *P. patens*, and *P. Benstedi*."

In 1886 the British Association Committee on the Mesozoic plants reported and recorded two further Lower Greensand cones from Potton, viz. *Pinites cylindroides* and *P. pottoniensis* (see Gardner, 1886).

In 1887, Williamson adds to Lindley & Hutton's meagre account of (*Abies*) *Pinites oblonga* some account of its internal structure, the relation of the seeds to the scales, etc., but does not give any account of the cellular anatomy.

In 1888 Prestwich, referring to the Lower Greensand, writes (p. 270): "The flora is very similar to that of the Wealden. The *Pinites Sussexiensis* is a true pine. The cones found in this formation are of much interest. Four of them, of which three are from the Kentish Rag of Maidstone, belong to the Cedar. A beautiful and perfect cone from Shanklin, the *Pinites Leckenbyi*, also resembles in size and form the cones of *Pinus cedrus*, L. At the present day the Cedar is represented by only two species—the Cedar of Lebanon and the Deodar of India. Some fine cones have also been found in the neighbourhood of Leighton in Buckingham. In the sands of Potton, a cylindrical stem (*Yatesia Morrisii*) covered with short tumid leaf-bases, and allied to the *Zamia* group of living Cycadeæ, has been found; with also a small species of *Mantellia* (*M. inclusa*, Carr.)."

Solms-Laubach in 1890 published a German paper, reprinted in the 'Annals of Botany' in 1891, in which he adds further details to Carruthers' account of *Bennettites Gibsonianus*. He mentions the occurrence of wood in nodules in the bed in which it was found (1891, p. 429): "If we break up the concretions we usually find at the centre of them a fragment of coniferous wood in good preservation, and sometimes covered only by a thin crust of stone. . . . The material of petrifaction is calcium carbonate and tricalcium phosphate."

Seward's account of the Wealden (1895) contains a short reference to *Bennettites Gibsonianus*; and in 1896 the "Dragon-Tree" is further illustrated by the same author.

The first of the oft-mentioned "coniferous woods" to receive detailed treatment was *Cupressinoxylon vectense*, which was illustrated and described with meticulous care by Barber (1898).

From this date onwards nothing further was added to the list of Lower Greensand plants, till Stopes in 1910 announced the discovery of petrified angiospermic woods of this age. In 1911 also Stopes demonstrated that the "Dragon-Tree" was only a badly-preserved conifer.

In the same year Berry (1911) published his important work on the Lower Cretaceous of America, in which he gives a summary of the described floras from all parts of the world. Under the heading "Barremian Stage" he lists the following remains from the Lower Greensand and Atherfield beds:—

"*Cycadeoidea Gibsoni* (Carr.), Ward.
Cycadeoidea inclusa (Carr.), Ward.
Cycadeoidea maxima (Carr.), Solms-Laubach.
Cycadeostrobus Walkeri, Carruthers.
Dracæna Benstedi, Koenig.
Fittonia squamata, Carruthers.
Fucoides bignoriensis, Mantell.
Fucoides sp.
Pinites Benstedi (Mantell), Endl.
Pinites cylindroidea, Gardner.
Pinites Leckenbyi, Carruthers.
Pinites Mantelli, Carruthers.
Pinites oblongus (L. & H.), Endl.
Pinites patens, Carruthers.
Pinites pottoniensis, Carruthers.
Pinites sussexiensis (Mantell), Brongn.
Weichselia reticulata (S. & W.), Ward."

This list, largely taken from Ward, is, as Berry indicates, not entirely to be relied on.

Jukes-Browne (1911, p. 306), in a general consideration of the deposits, expresses the view that the plants and animals of the Wealden and the Lower Greensand are the same.

In 1912 Stopes published a detailed and illustrated account of the anatomy of the three Lower Greensand Angiosperms, *Aptiana radiata*, *Woburnia porosa*, and *Sabulia Scottii*. In 1913, in the previous volume of this Catalogue, are included some Algæ from the Lower Greensand. In the present volume, not only are many new species of Lower Greensand plants described, but the anatomical details of some of the known species are given for the first time—as, for instance, in the case of *Pinostrobus sussexiensis*.

Geological Position of the British Lower Greensand.

With one very doubtful exception, all the plants of the Lower Greensand found in the British Isles are from the South-east of England. The principal localities are the coasts of the Isle of Wight, the quarries of North Kent in the neighbourhood of Maidstone and Ightham, in Bedfordshire near Woburn and Potton, and in Buckinghamshire near Leighton Buzzard.

The position of the British Lower Greensand in relation to the other Cretaceous rocks will be seen in the following table, which is taken from Jukes-Browne (1911):—

	British Northern Area.		*British Southern Area.*	*France and Switzerland.*
Upper Series.	8. (Wanting.)		(Wanting.)	Danian.
	7. Upper Chalk.		Upper Chalk.	Senonian.
	6. Middle Chalk.		Middle Chalk.	Turonian.
	5. Lower Chalk.		Lower Chalk.	Cenomanian.
	4. Red Chalk.		Selbornian.	Albian.
Lower Series.	3. Speeton Clay.	Upper.	Vectian (Lower Greensand).	Aptian.
	2. Speeton Clay.	Lower.	Wealden.	Barremian.
	1.			Neocomian.

The British Aptian (for the name Vectian has never been generally adopted for the Lower Greensand) consists of thick series of marine beds, chiefly sands and sandstones with numerous chert-bands. There is a sharp lithological break between them and the superimposed Gault clays, but, as Gregory (1895) points out, it is probable that the very top of the "Lower Greensand" sands represents the beginning of the Gault period.

The following are the principal local deposits to be included in the Lower Greensand (Gregory, 1895, p. 100):—

1. Upper Aptian, or Gargasian.	Including Folkestone Beds of Folkestone, *excl. mammillare* zone. Sandgate Beds. Phosphatic Beds of Great Chart. Bargate Beds of Guildford. Fuller's Earth Series of Nutfield. Faringdon Sponge Gravels. Lower Greensand of Upware and Bedfordshire.
2. Lower Aptian, or Bedoulian.	Hythe Beds, and Kentish Rag. Main Chert Series of Godalming, Hindhead, Ewhurst, and Leith Hill.
3. Rhodanian ...	Atherfield Clay.

The characteristic fossils of the above beds are given by Gregory (1895, p. 103) in the table copied on p. xxxiii.

Thus the Lower Greensand beds are all marine, and they represent the influx of the Aptian sea into the Wealden area. All the divisions of this series, according to Jukes-Browne (1911, p. 295), "are the deposits of a shallow sea, rather deep and muddy at first, but becoming shallower afterwards. These beds are thickest to the south, and thinnest to the north, and as an illustration of this it may be mentioned that they total about 270 ft. at Maidstone, while at Chatham, only 8 miles northward, they have shrunk to 40 ft."

The exact limits of land and sea at this time are very uncertain. That there was continental land to the north seems established, though its shore-limits cannot be exactly traced: also it appears evident that the arm of the sea of which the Lower Greensands represent the successive floors, was in connection with a long, south-easterly running gulf. Before the true marine conditions of the Aptian established themselves in the Wealden area, there must have been an intermediate period which, according to Judd (1871), is represented by the Punfield fluvio-marine series.

Time-Divisions.	*Representatives in East Kent.*	*Representatives in Surrey.*	*Characteristic Species.*
ALBIAN.	Gault: Upper Zones Nos. 4 ?–9. Gault: Lower Zones Nos. 1–3 (+x?). Folkestone Beds: *Ac. mammillare* Zone.	Gault. "Folkestone Sands" or "Upper Ferruginous Sands."	*Hoplites splendens*, etc. *Hoplites interruptus*, etc. *Acanth. mammillare.*
UPPER APTIAN.	Folkestone Beds (Divisions I.–III. Sandgate Beds and Phosphate Bed of Great Chart).	Bargate Stone. Nutfield Fuller's Earth Beds, etc.	*Waldheimia Wanklyni.* *Terebratella Fittoni.* *Rhynchonella sulcata.* *Avicula pectinata.*
LOWER APTIAN.	Hythe Beds (Kentish Rag, etc.).	Main Chert Series. Lower Ferruginous Sands.	*Waldheimia tamarindus.* *Acanth. Cornuelianum.* *Acanth. Martini.* *Hoplites furcatus*, etc.
RHODANIAN.	Atherfield Clay.	Atherfield Clay.	*Aporrhais Robinaldina.*
NEOCOMIAN.	Weald Clay, etc.	Weald Clay, etc.	

In 1903 Geikie writes: "Of the total assemblage of fossils in the 'Lower Greensand,' only a small proportion passes up into the Upper Cretaceous formations, except among foraminifera. . . . .This marked palæontological break, taken in conjunction with a great lithological change, and with an unconformability which in Dorset brings the Gault directly upon the Kimeridge Clay, shows that a definite boundary line can be drawn between the lower and the upper parts of the Cretaceous system in the south of England."

This is in agreement with the more recent and exhaustive classification of Haug (1910), who divides the Cretaceous system into three main divisions, as follows—in which the APTIAN (our Lower Greensand) comes in the EOCRETACEOUS :—

Néocrétacé.	Danien. Maestrichtien. Campanien. Santonien. Coniacien.
Mésocrétacé.	Turonien. Cénomanien. Albien.
Éocrétacé.	APTIEN. Barrémien. Hauterivien. Valanginien.

Historical accounts of the English Lower Greensand will be found in Holloway 1724, who describes the Fuller's Earth of Woburn, Mantell 1822, Conybeare & Phillips 1822, Fitton 1827, Mantell 1828 (35), Martin 1828, Mantell 1833, Fitton 1836, Mantell 1839, 1844, 1847, Ibbetson & Forbes 1844, 1845. In the last-named papers the authors gave an exceedingly detailed account of the beds of the Lower Greensand, which remained the standard for many years.

In 1845 Fitton proposed the term Vectine for the Lower Greensand beds, because of their special development in the Isle of Wight. In 1847 he published a detailed and exhaustive paper on the subject.

Further accounts of the Lower Greensand will be found in Dixon 1850, Mantell 1851, Bensted 1862, Bristow 1862, Judd 1871, Topley 1875, Dixon 1878, and Etheridge 1885. Jukes-

Browne (1886) discusses the loose and rather incorrect use of the term Neocomian in Britain, and points out that the Lower Greensand, as represented by the Folkestone, Sandgate, and Hythe beds, is the equivalent of the French Aptien, and he proposes to change Fitton's name to Vectian. The Atherfield Clay he shows to be the equivalent of the Rhodanien. A very similar classification was proposed by Gregory in 1895.

H. B. Woodward 1887, Jukes-Browne & Topley 1888, Prestwich 1888, Lamplugh 1889, Pavlov 1889, Jukes-Browne 1891, Pavlov & Lamplugh 1892, Gregory 1895, Lamplugh 1896, Jukes-Browne 1902, Geikie 1903, Lamplugh & Walker 1903, Whitaker 1908, and Jukes-Browne 1911, have all contributed to our knowledge of the English Lower Greensand.

In conclusion, I have pleasure in recording thanks for much valuable help received during the progress of this work. I am especially indebted to Mr. J. H. Allchin, Curator of the Maidstone Museum, who has charge of so many interesting fossils from the Lower Greensand, and has arranged with the Committee of the Maidstone Museum both for the loan of specimens and for the gift of some portions and microscope-slides of new type-specimens to the British Museum (Nat. Hist.). To his assistant, Mr. Elgar, I owe several photographs noted in the descriptions, which they are used to illustrate. During visits to Maidstone I received much help from Mr. Allchin and Mr. Elgar; and I also had the pleasure of seeing the quarries in the Kentish Rag with Mr. W. H. Bensted (son of Mr. W. H. Bensted so often referred to in the Catalogue), who revived early memories of the finding of some of the important specimens. To Mr. L. A. Boodle, of Kew, and to Prof. F. W. Oliver, of University College, my special thanks are due for their kind examination of some of the fossils, for their valuable advice, and for the loan of slides of existing plants for comparison. To Dr. F. L. Kitchin and Mr. H. A. Allen I am indebted for much help in examining the Lower Greensand plant-remains in the Museum of Practical Geology. Dr. D. H. Scott and Prof. A. C. Seward have lent me the original slides of *Cupressinoxylon vectense*, and Dr. C. A. Barber kindly allowed me to use his exhaustive MS. notes on this fossil. Dr. E. A. Newell Arber favoured me with information about type-specimens, and

arranged for slides to be cut from two fossils in the Sedgwick Museum, Cambridge. Finally, I wish to express my appreciation of the continual help received from the staff of the British Museum (Nat. Hist.), among whom I must specially mention Dr. A. B. Rendle and Mr. W. N. Edwards. Mr. B. B. Woodward and Mr. C. Davies Sherborn have also afforded assistance in the Bibliography.

MARIE C. STOPES.

DESCRIPTIVE CATALOGUE

OF THE

LOWER GREENSAND (APTIAN) PLANTS OF BRITAIN.

Group THALLOPHYTA.

The Algæ and Fungi were dealt with comprehensively in the first part of this Catalogue. The only Lower Greensand form of any importance is "*Chondrites Targionii*," which is very plentiful in some quarries, and is often mentioned by the earlier writers (see Stopes, 1913, pp. 249 et seq., text-fig. 8). The mycelia of undescribed fungi are present in many of the wood and other sections of petrified Lower Greensand plants.

Group BRYOPHYTA.

The Bryophyta appear to be entirely unrepresented in the Lower Greensand Flora of Britain. This is probably due to the nature of the deposits, which is very unfavourable for the petrifaction of delicate plants (see p. xx).

The preceding Wealden Flora (see Seward, 1894, pp. 15 et seq.) has yielded a few Bryophytes, but, as is often remarked, fossils of this group are rare even in the beds in which they occur. As the Lower Greensand deposits are preponderatingly marine, it is not surprising that mosses and liverworts should not be represented in them, for such delicate land-plants do not travel so readily as drift-wood and stouter branches.

Group PTERIDOPHYTA.

Plants in which the alternation of generations finds expression in distinct, alternating individuals of very different types of organisation. The sporophytic generation is generally large, leafy, and provided with definitely differentiated vascular tissue: the gametophytic generation, on the other hand, is generally small, often minute, and very simply organised, and is without specialised vascular tissue. Reproduction in the sporophyte is by means of simple spores, produced generally on the foliage, which germinate rapidly in moisture to produce the gametophyte on which differentiated egg and sperm cells develop. In fossil remains we generally find only the sporophytic generation.

The organisation of the sporophyte varies enormously, from huge forest trees with massive woody trunks to the delicate plantlets of the filmy ferns. In the Palæozoic period the Pteridophyta produced cambiums which gave rise to masses of secondary wood: among living forms very few genera have any secondary thickening, and this is always very irregular and small in amount.

There are two principal lines of development in the Pteridophyta, the microphyllous and the megaphyllous. The microphyllous Lycopodineæ have but few representatives in the Mesozoic rocks, in which the two leading groups are the Equisetinæ and the Filicinæ. The former have small, narrow leaves arranged in definite, cyclic whorls on the straight, symmetrically branching stems, with spores in definite cones, provided with simple peltate sporophylls: the latter have large, often compound leaves, irregularly branched stems, and spores, generally in sori, on the foliage leaves.

Class FILICINÆ.

Vegetative habit of the sporophyte very various; stems aerial or underground, irregularly branched. True roots, principally adventitious, are diarch in the majority of families. Laminæ of the foliage leaves simple or exceedingly divided into bi-pinnate large fronds. Sporangia, with or without annulus, sometimes scattered, but generally in definite sori on the foliage leaves, and generally on the lower surface. In some cases fertile leaves are specialised to a greater or less extent, but they do not form cones.

Genus **WEICHSELIA,** Stiehler.

[Palæontographica, vol. 5, 1857, pp. 73–75.]

The genus is founded on the external impressions of fern-foliage.

Diagnosis.—Fronds bi-pinnate or tri-pinnate * along a broad and rigid rachis; pinnæ long, having strong axes which make the pinnules appear relatively small. Pinnules entire, alternate, attached separately by their whole bases; apices obtuse, varying somewhat in length but averaging 3–6 mm. long, and in general, half that width; margins of the pinnules nearly parallel. Venation finely reticulate, of the *Lonchopteris* type, with a very strong, well-marked middle nerve. In most specimens the mid-rib is all that remains of the veins, the fine secondary reticulations being very rarely preserved. Fructifications in the form of sori are reported, but fertile specimens are rare and not very distinctly preserved.

Impressions, and particularly sandstone-casts of the foliage, are common in Europe, numerous large fronds occurring in Germany, Russia, England, and elsewhere. It is also reported from Peru, and appears to be locally very common in South Dakota (see Ward, 1899). It is principally characteristic of the Neocomian as a whole, and is a typical "Wealden" plant, but is found as high as the Gault, though infrequently.

Judged simply by its external morphology, there seems no conclusive reason why *Weichselia* should not be included in the form-genus *Lonchopteris*, but it is customary to restrict the latter name to the forms from the older deposits, and retain Stiehler's generic name for the later forms, though he founded it in ignorance of the fact that the frond had reticulated veins like *Lonchopteris*.

The published figures of the venation are inadequate, even in the recent papers on the subject, and reference should be

* See Zeiller, 1910.

made to the account of the American specimens (see Ward, 1899, pl. clx, fig. 3) for the clearest sketch of the details of the leaf.

Seward (1894, p. 114) includes all the described specimens of the genus under the name *Weichselia Mantelli*, but with this neither Nathorst (see footnote in Seward, 1895, p. 225) nor Gothan (1910), who has recently revised the genus, is in complete agreement.

Weichselia reticulata (Stokes & Webb), Ward.

[Text-fig. 1.]

1824. *Pecopteris reticulata*, Stokes & Webb, Trans. Geol. Soc., ser. 2, vol. i, p. 424, pl. xlvi, fig. 5; pl. xlvii, fig. 3.
1825. *Pecopteris reticulata*, Sternberg, Flora Vorwelt, pt. 4, p. xx.
1827. *Pecopteris reticulata*, Mantell, Illustr. Geol. Sussex, p. 56, pl. iii, fig. 5; pl. iii*, fig. 3. [These plates are identical with those in the Geol. Trans. vol. i, given by Stokes & Webb.]
1828. *Lonchopteris Mantelli*, Brongniart, Prodrôme, p. 60.
1832. *Pecopteris reticulata*, Passy, Géol. Seine-Infér., p. 340, pl. xv, figs. 9 & 10.
1833. *Lonchopteris Mantelli*, Mantell, Geol. S.-E. England, p. 243, text-fig. p. 244, pl. i, fig. 3.
1836. *Lonchopteris Mantelli*, Brongniart, Hist. Végét. Foss., p. 369, pl. cxxxi, figs. 4 & 5.
1836. *Polypodites Mantelli*, Goeppert, Foss. Farnkräuter, p. 341.
1837. *Lonchopteris Mantelli*, Lindley & Hutton, Fossil Flora, p. 171, pl. clxxi.
1838. *Lonchopteris Huttoni*, Presl, in Sternberg, Flora Vorwelt, p. 166.
1838. *Lonchopteris Mantelli*, Presl, in Sternberg, Flora Vorwelt, p. 167.
1839. *Lonchopteris Mantellii*, Mantell, Wonders of Geology, p. 371, text-fig. 73.
1845. *Pterophyllum Murchisonianum*, Goeppert, in Géol. Russie d'Europe (Murchison & others), p. 501, pl. G, figs. 5 & 6 *a*.
1845. *Pterophyllum filicinum*, Goeppert, in Géol. Russie d'Europe (Murchison & others), p. 501, pl. G, fig. 4 *a* & *b*.
1845. *Polypodites reticulata*, Unger, Synopsis Plant. foss., p. 93.
1845. *Polypodites Mantelli*, Unger, Synopsis Plant. foss., p. 93.
1846. *Pecopteris Murchisoniana*, Auerbach & Frears, Bull. Soc. Impér. Nat. Moscou, p. 495, pl. ix, figs. 1–3.
1847. *Lonchopteris Mantelli*, Mantell, Geol. Excurs. I. of Wight, p. 287, fig. 21.

1847. *Lonchopteris Mantellii*, Fitton, Quart. Journ. Geol. Soc., vol. 3, p. 308.
1848. *Lonchopteris Mantelli*, Bronn, Index Palæont., p. 667.
1849. *Lonchopteris Mantelli*, Brongniart, Tabl. Végét. foss., p. 107.
1850. *Polypodites reticulatus*, Unger, Genera Spec. Plant. foss., p. 166.
1852. *Alethopteris recentior*, Ettingshausen, Abh. k.-k. Geol. Reichsanst., vol. 1, abt. 3, pt. 2, p. 16, pl. iii, figs. 17 & 18.
Polypodites Mantelli, Ettingshausen, *loc. cit.*, p. 17.
Polypodites reticulatus, Ettingshausen, *loc. cit.*, p. 17.
1854. *Lonchopteris Mantelli*, Morris, Cat. Brit. Foss., ed. 2, p. 12.
1857. *Weichselia Ludovicæ*, Stiehler, Palæontographica, vol. 5, p. 73, pls. xii, xiii.
1865. *Pteris reticulata*, Ettingshausen, Farnkräuter Jetztwelt, p. 117.
1868. *Weichselia Ludovicæ*, Eichwald, Leth. Ross., vol. 2, p. 21, pl. i, fig. 2.
1869. *Alethopteris Ettingshausii*, Schimper, Paléont. Vég., vol. 1, p. 569.
Weichselia Ludovicæ, Schimper, *loc. cit.*, p. 599.
Lonchopteris Mantelli, Schimper, *loc. cit.*, p. 623.
1871. *Lonchopteris recentior*, Schenk, Palæontographica, vol. 19, p. 4, pl. i, figs. 2–6.
1876. *Asplenites Klinensis*, Trautschold, Nouv. Mém. Soc. Imp. Nat. Moscou, vol. 13, p. 209, pl. xx, figs. 1, 5, 6, 8.
Polypodites Mantelli, Trautschold, *loc. cit.*, p. 220, pl. xix, fig. 8.
1880. *Lonchopteris recentior*, Hosius & von der Marck, Palæontographica, vol. 26, p. 201, pl. xlii, figs. 176–179; pl. xliv, figs. 190, 191.
Weichselia Ludowicæ, Hosius & v. der Marck, *loc. cit.*, p. 207, pl. xliii, figs. 187, 188; pl. xliv, fig. 189.
1883. *Lonchopteris Mantelli*, Renault, Cours Bot. Foss., vol. 3, p. 167.
1889. *Lonchopteris Mantelli*, Bristow, Geol. I. of Wight, p. 258.
1894. *Weichselia Mantelli*, Seward, Cat. Wealden Flora, vol. 1, p. 114, p. 120, text-figs. 12, 13; pl. x, fig. 3.
1899. *Weichselia reticulata*, Ward, 19th Ann. Rep. Geol. Surv. U.S.A., pt. 2, p. 651, pl. clx, figs. 2–4.
1907. *Weichselia Mantelli*, Neumann, Neues Jahrb. f. Min., etc., vol. 24, p. 74, pl. i, figs. 1, 1 *a*, 1 *b*.
1910. *Weichselia Mantelli*, Seward, Fossil Plants, vol. 2, p. 494, text-fig. 333.
1910. *Weichselia reticulata*, Gothan, in Potonié, Abbild. Beschreib., lief. 7, no. 126, p. 1, text-figs. 1–6.

1910. *Weichselia reticulata*, Zeiller, Comptes Rend. Acad. Sci. Paris, p. 1488.

1911. *Weichselia reticulata*, Berry, Maryland Geol. Surv. Low. Cret., various pp. in lists.

Diagnosis.—Most pinnules entire, with rounded apices, but towards the ends of the pinnæ tending to be more triangular with slightly pointed apices. Network of finer veins seldom visible, but when preserved the finer meshes about 3 to 4 per millimetre. In sandstone casts the pinnules often appear to be inclined at an angle toward the pinnæ, but this was probably not the case in life. Sori very rare, round, when present lying in double rows, one on either side of the mid-rib.

Horizon (of described specimen).—Lower Greensand.

Locality.—Ventnor, Isle of Wight.

General Distribution.—Very widely distributed throughout the *Neocomian*: recorded from Russia, Austria, Sweden, Germany, France, England, North and South America, etc. Rare as high up as the *Gault*.

Type.—Small fragments of pinnules, first recorded by Stokes & Webb, 1824, first diagnosed as *Weichselia* by Stiehler, 1857. The actual type-specimens appear to be lost.

Seward (1894) gave a detailed record of the history of this species under the name *Weichselia Mantelli*, which it is unnecessary to recapitulate, particularly as Gothan (1910) has brought the subject well up to date in a monographic treatment of the species in Potonié's series of 'Abbildungen.' Nathorst (1891, p. 19), Seward (1894, p. 116), and others have laid stress on the inclination of the pinnules toward the axis of the pinna as a characteristic of the fern; I, however, agree with Gothan (p. 6) that this was not a peculiarity of the living plant, but a probable result of its condition before being enclosed in the coarse matrix of the sandstone in which this appearance is now generally to be seen. In support of this view it is noteworthy that the specimens found in fine-textured shale do not show this feature. The general appearance of the fronds is "xerophytic," the pinnules apparently having been unusually thick and leathery. As Ward (1899, p. 652) points out, the nature of the imprint and the amount of carbonaceous matter sometimes left on the impression support this view; as also does the frequent occurrence of specimens in coarse sandy matrix, which is most unfavourable for the preservation of delicate green laminæ.

In Fitton's detailed account of the Atherfield section (see Fitton 1847, p. 308) he records the plant as follows:—"The vegetable remains in [beds] Nos. 36 and 37 have a glistening surface like that of plumbago. They were found by Mr. Morris to be distinctly portions of *Lonchopteris Mantellii*, a fern of the Wealden hitherto found in that deposit only, but which seems to be diffused in fragments nearly throughout the whole of the lower greensand. Its occurrence amidst shells exclusively marine makes it probable that, when these remains were deposited in the detritus which now forms the lower greensand, some portion of the Wealden land was still above the sea; but the fragments of *Lonchopteris* found here are very small, and so confusedly mixed together, that they may have been transported from great distances."

Regarding the habitat of the species, Gothan (1910, p. 11) makes a most interesting suggestion: according to his view *Weichselia* was a strand plant, possibly growing on sand-dunes. Its generally xerophytic habit and thick leaves accord well with this view, as does its occurrence in marine sandstones. In the present connection, it is interesting to note that it is the *only* fern-foliage (so far as I can discover) of which we have undoubted records in the British Lower Greensand, an essentially sea-shore and marine deposit.

The internal anatomy of the stem and petioles was recently described for continental specimens by Bommer (1911), to whose paper reference should be made. Such details cannot well be discussed here, as the few Lower Greensand fragments of the fern are only carbonised foliage-impressions.

Neumann (1907, pl. i) figures the sori of a Neocomian specimen from Peru, but unfortunately none of the English Lower Greensand fragments show any signs of fructification, so that comparison between the forms is impossible.

The nomenclature of this species has been considered exhaustively by Gothan (1910); he confirms and establishes Ward's (1899) use of the name *Weichselia reticulata*, Stokes & Webb, for the species called *W. Mantelli* by Brongniart. Seward, who follows Brongniart in this, does not dispute the priority of the former name, but prefers to use the latter because it is better known. The conclusion of some authors, that all the described species of *Weichselia* should be included in one, will probably need revision with the discovery of better preserved material.

Text-fig 1.—*Weichselia reticulata* (Stokes & Webb), Ward. Carbonised impression from the Lower Greensand showing the reticulate veins and mid-rib. × 4·5. No. 52547.

52547. Text-fig. 1. The specimen consists of a number of more or less macerated and carbonised fragments of the pinnules and rachises of *Weichselia reticulata* and other débris of plants in a coarse sandstone matrix in which there are broken fragments of *Pecten* and other organisms. Three of the pinnules, though carbonised, show unusually clearly the fine network of the secondary veins, which are rarely seen even in much better preserved specimens (see p. 3 *ante* and Gothan, 1910, p. 2, "die Maschenadern sind aber nur selten sichtbar, bei deutschen Exemplären fast nie"). These are figured in text-fig. 1 and serve to identify the plant reliably. Isle of Wight [probably Ventnor]. *Morris Coll.*

40938. Small fragment; pinnules on one side of secondary rachis. The specimen had been collected for a supposed "*Flabellaria*"-leaf, which is in reality a broken shell of *Pecten*. Ventnor, I. of Wight. *Purchased*, 1860.

V. 13077. Isolated, entirely blackened and carbonised fragments showing several separated pinnules in a coarse matrix.

In two or three of the pinnules the fine meshwork of the secondary veins stands out in relief from the carbonised surface. E. of Blackgang, I. of Wight.
Caleb Evans Coll., 1887.

V. 13078, 13079, 13080. Smaller fragments similar to the above, but more imperfect. E. of Blackgang, I. of Wight. *Caleb Evans Coll.*, 1887.

Genus **TEMPSKYA,** Corda (emend.).

[Flora der Vorwelt, 1845, p. 81.]

The genus is founded on petrified "false-stems," composed of groups of small stems ensheathed by a more or less imperfectly preserved common root-plexus.

Diagnosis.—"Stems of small diameter, erect, dichotomous and imbedded in a felted mass of their own adventitious roots. Dorsiventral, with the leaves in two rows on one side of the stem, and roots alone on the opposite side. Vascular system of stem a solenostele. Leaf-trace departs as a single strand. Roots diarch."

This diagnosis is taken from the recent paper by Kidston & Gwynne-Vaughan (1912), of which a *résumé* was published in the British Association Report for 1910. In 1911 Berry discussed the genus and described an American species, but the final paper of Kidston & Gwynne-Vaughan gives the first satisfactory exposition of these fossils, which have been known since 1824 as common Lower Cretaceous forms. As this valuable paper is unfortunately difficult of access and little known to botanists, some of the figures from it are reproduced in the following description.

Under the name *Endogenites* the plant was first recorded in 1824 by Stokes & Webb in their joint description of Mantell's specimens from the Tilgate Forest (1824, p. 423). They placed it among the Monocotyledons; a view followed by most of the older British writers. In 1845 Unger assigned the English species *erosa* to the genus *Protopteris*, and he was followed by Brongniart (1849). In 1850 Unger included the already well-known English species in Corda's more recently founded species, *Tempskya Schimperi*, which had been established in 1845 by Corda without any reference to the English forms. This fact appears to be the cause of the inclusion of all the English fossils in *T. Schimperi* by succeeding writers, though the condition of preservation both in Corda's type and in the numerous English representatives is so incomplete as to make it really impossible to be certain of their identity.

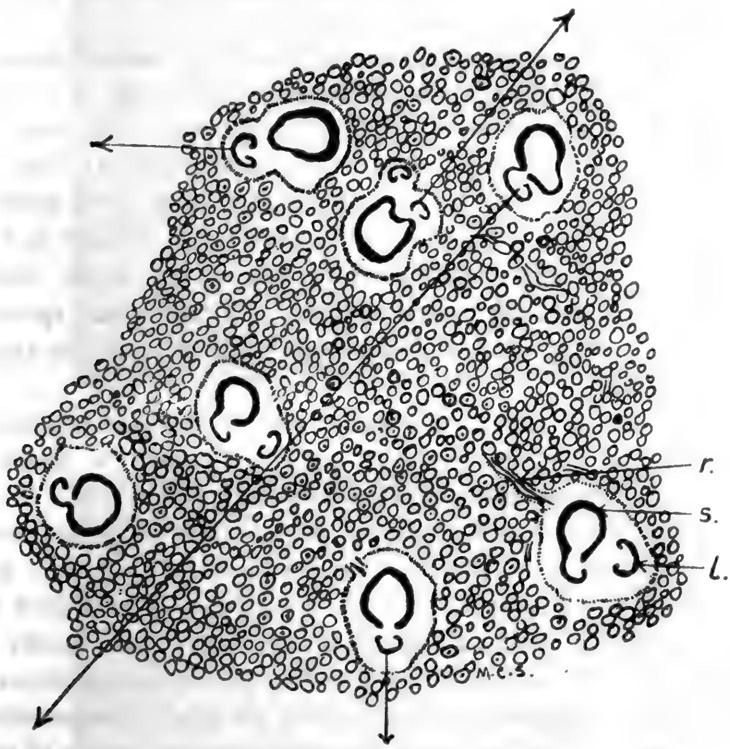
Indeed, until the recent description of the much better preserved *T. Rossica* (Kidston & Gwynne-Vaughan, 1912), the most fundamental facts about the genus were unknown. Solms-Laubach (1891 A, p. 159) referred to the "Tempskya condition" as though it were a special mode of preservation rather than a true genus, and even so recently as 1894 Seward (p. 149) wrote:—"It will be well for the present to retain Corda's term, if we regard it as implying a particular manner of preservation rather than any well-defined generic characters." This was due to the poor nature of the tissue-petrifactions of the specimens, though imperfect examples were widespread, abundant, and easy of identification.

Prof. Seward gives so full an account of the earlier literature of the genus (Seward, 1894, pp. 148–158) that there is no need to recapitulate it.

Of the older writers Schenk (1871 B, p. 260) most nearly approached the truth as it is now known, for he repudiated the view that the plant was merely the peripheral part of an ordinary tree-fern, and looked on it as a distinct genus in which there were several steles of various types imbedded in parenchyma. It is now clear that the separate steles were not parts of a polystelic axis, but each was the solenostelic axis of an independent stem. These separate small stems were aggregated to form a "false stem" of considerable size, and were surrounded by a common plexus of their adventitious roots. In its manner of growth the genus is unparalleled by any known fossil, and only approached among living plants by the curious *Hemitelia crenulata* recently described by Dr. Schoute from Java (see Schoute, 1906).

The small axes which Kidston & Gwynne-Vaughan showed to be distinct stems, *i. e.* primary axes, were those generally described (if mentioned at all) by previous writers as "petioles."

Each axis is traversed by a small solenostele (about 6 mm. in diameter) which gives off in rapid succession a series of horse-shoe-shaped meristeles, the true petiolar bundles. As many as 17 of these small axes are recorded as being contained in a single aggregate or "false stem." "In every transverse section of the fossil all the stems are also cut across transversely. It



Text-fig. 2.—Plan of *Tempskya*-stem in transverse section. Adapted from part of photo 1, pl. i, Kidston & Gwynne-Vaughan, 1912, and showing several stems imbedded in the weft of adventitious roots. *s.*, solenostele of stem; *l.*, leaf-trace; *r.*, adventitious root coming off from stem opposite exit of leaf-trace. The arrows indicate the directions of exits of leaf-traces in various stems, showing that they bear no relation to the orientation of the common axis.

follows, therefore, that they must have all grown very closely parallel with the longer axis of the fossil" (Kidston & Gwynne-Vaughan, 1912, p. 7)...."All the stems bore leaves, and in each individual stem the leaves are all inserted on the one side of the stem. The side opposite to this gives rise to roots alone."

The leaves are not only confined to one side of each stem, but occur in two regular alternating rows in rapid succession, so that sometimes two leaf-traces occur in the same transverse section. Nevertheless, though the position of the leaves on each small stem is so restricted, the orientations of the leaves on the various stems composing one "plant," bear no relation to each other and appear to arise at haphazard in any direction (text-fig. 2).

Detailed Anatomy.—The vascular system of each of the unit-stems is a single solenostele which is slightly oval in outline. The ring of the solenostele is frequently broken by the leaf-traces, but the leaf-gaps thus formed are small, as they are rapidly closed up. The xylem ring, except just at the point of preparation for the departure of the leaf-traces, consists of 8–10 tracheids in thickness, with which are mixed some smaller elements of soft-celled parenchyma. Protoxylem elements have not been identified, and the majority of the tracheæ appear to be scalariform.

The phloem is not properly preserved in recorded specimens, but Kidston & Gwynne-Vaughan see "no reason to doubt its existence on either side of the solenostele."

An unmistakable endodermis is present, the individual small cells of which it is composed being well preserved in good specimens; but frequently it is represented only by a dark line of carbonaceous matter. Such a dark line often marks the outline of the steles even in very poorly preserved specimens.

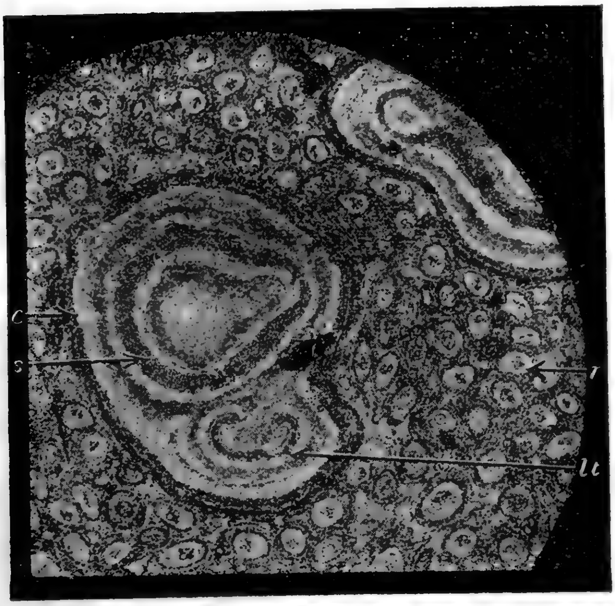
The cortex consists of two zones: an inner, comparatively parenchymatous, and an outer, sclerenchymatous, series of cells. The stems branch not infrequently, and when that takes place the solenostele is medianly constricted and dichotomises quite simply.

The stems, therefore, are individually very simply organised, and their peculiarity is shown in their leaf-arrangement and in their aggregation into a false stem.

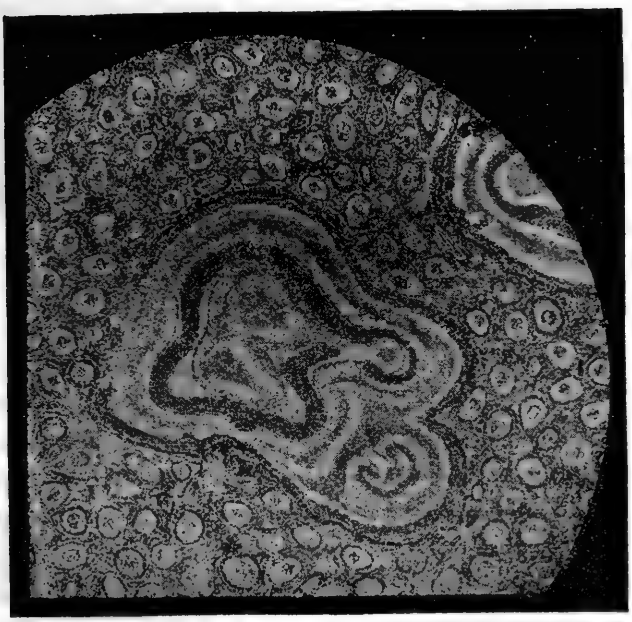
The *leaf-trace* is a simple horse-shoe, and is of large size in proportion to the main axis (see text-fig. 3). These leaf-traces only arise on one side of the stem, and there they occur in two rows alternately on either side of the median plane, and arising very close to each other.

The side opposite to the leaf-trace-exits in any stem, gives

A.



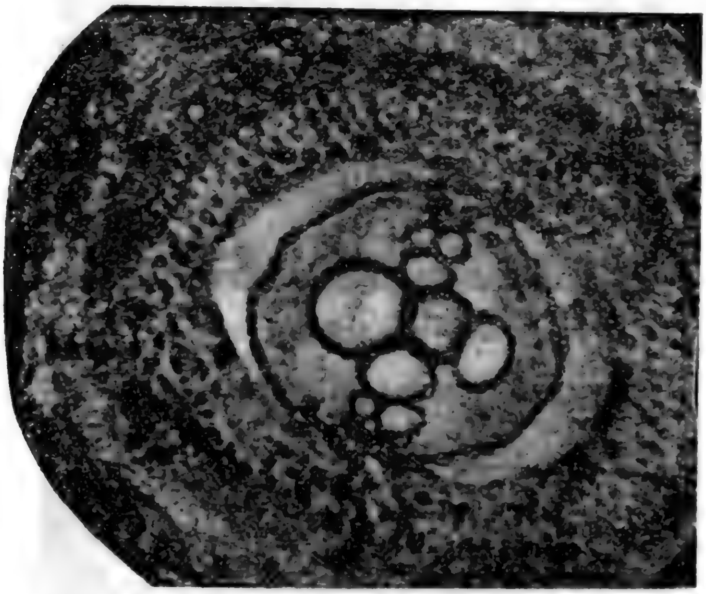
B.



Text-fig. 3.—*Tempskya Rossica*, Kidston & Gwynne-Vaughan. A. Transverse section of a stem giving off a leaf-trace, *lt.*; *c.*, cortical limit of stem; *s.*, solenostele of stem; *r.*, surrounding weft of rootlets. B. Transverse section of a stem nearing dichotomy and also giving off leaf-traces. × 5. After Kidston & Gwynne-Vaughan.

rise to the roots which, according to Seward, Kidston & Gwynne-Vaughan, and others, were all diarch (see text-fig. 4), though some writers maintain that they were pentarch. The diarch rootlets, as Seward (1894, p. 153) points out, militate against the view that the plant is of Marattiaceous affinities.

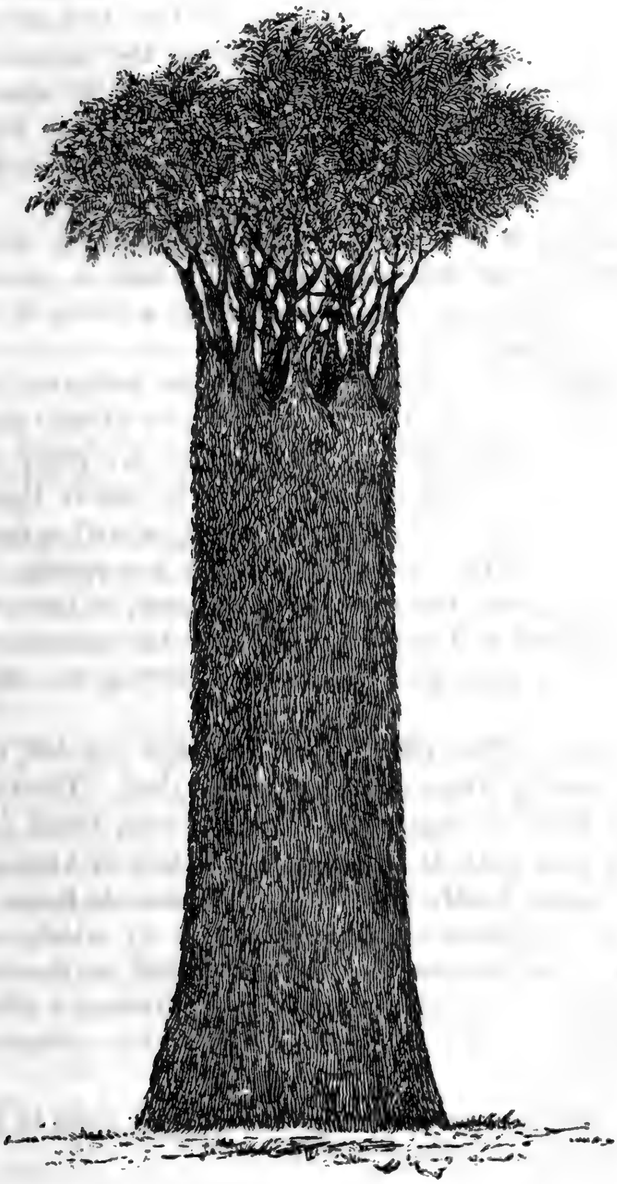
The *habit* of the plant may have resembled the unique living *Hemitelia*. The aggregate of stems and roots must have had much the external appearance of an ordinary rough-exteriored tree-fern. They must have grown to the size of a tree-fern



Text-fig. 4.—*Tempskya Rossica*, Kidston & Gwynne-Vaughan. Transverse section of root showing the diarch xylem. After Kidston & Gwynne-Vaughan.

also, for many of the fossil fragments reach a large size, and Fitton (1836) describes and figures one British example which was 9 feet long and 12 inches in diameter, though crushed.

Kidston & Gwynne-Vaughan consider that at the top of this upright "false-stem" the individual axes stood out separately. "The free stems at the top must have grown upright, and at first their root-coatings would not have been of even thickness all round. A buttress of roots of considerable thickness would already have been formed on the root-bearing side of the stem before the leaf-bearing side was covered at all, and for a long time the coating on the latter side must have been thinner than



Text-fig. 5.—*Tempskya Rossica*, a restoration of the "tree-fern"-like false stem resulting from the union of numerous small stems in a plexus of their own roots. The individual small stems stand up freely at the apex of the composite growth, and bear compound (?) foliage leaves. (Hitherto unpublished restoration, provided by Dr. Kidston and Prof. Gwynne-Vaughan.)

that on the former. The remains of the petioles are so rarely found in the root-felt that it is probable that they either fell off with a clean scar, or rotted away before the root-coating had extended over the leaf-bearing surface of the stem." The interesting restoration published in text-fig. 5 is kindly provided by Dr. Kidston & Prof. Gwynne-Vaughan, based on their Russian species and hitherto unpublished.

As Kidston & Gwynne-Vaughan point out, the strict dorsiventrality of the individual stems in such a complex is a matter for surprise; they explain it as a vestigial character recording a primitively creeping habit.

Fructifications in organic continuity are unknown, as also is the external form of the foliage. Boodle (1895) described a specimen from Hastings in which there is a group of spores amid the badly preserved rootlets. He figures these spores (1895, p. 138, figs. 1–4), and the figures, as well as the description, show that they are most probably fern-spores. There is nothing more than the association, however, to prove that the spores belonged to *Tempskya*, and this is too uncertain to allow of deductions from their structure regarding the affinities of the genus.

Affinities.—The affinities of *Tempskya* are left quite uncertain, even by Kidston & Gwynne-Vaughan. The older view, that the plant belonged to the Marattiaceæ, seems to be disposed of now that its anatomical structure is known; but it may lie in any family of the Leptosporangiate ferns. Solenosteles with horse-shoe meristeles occur in widely separated families. The likeness in external habit to the one other known plant with a similar peculiarity, *Hemitelia crenulata*, is not confirmed by the internal anatomy, which differs widely in the two plants.

It is therefore wiser to assign no definite place to *Tempskya* within the Leptosporangiate ferns.

Tempskya erosa, Stokes, Webb & Mantell, comb. nov.

1822. "Arborescent fern," Mantell, Illustr. Geol. Sussex, Foss. S. Downs, p. 42.

1824. *Endogenites erosa*, Stokes, Webb & Mantell *, Trans. Geol.

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* See p. 19 below.

Soc., ser. 2, vol. 1, p. 423, pl. xlvi, figs. 1, 2; pl. xlvii, figs. 5 *a* & *b*.

1827. *Endogenites erosa*, Mantell, Illustr. Geol. Sussex, Foss. Tilgate Forest, p. 54, pl. iii, figs. 1 & 2; pl. iii *, fig. 5. [These are redrawn from Trans. Geol. Soc. 1824.]

1828. *Endogenites erosa*, Martin, Geol. Mem. Western Sussex, p. 41.

1833. *Endogenites erosa*, Mantell, Geol. South-East England, p. 236, pl. i, figs. 4, 5, & 7.

1836. *Endogenites erosa*, Fitton, Trans. Geol. Soc., ser. 2, vol. 4, p. 172, pls. xix & xx, & text-fig. 1.

1845. *Protopteris erosa*, Unger, Synopsis Plant. foss., p. 107.

1846. *Endogenites erosa*, Dunker, Norddeutsch. Wealdenbildung., p. 17, pl. iii, figs. 1, 1 *a*, 1 *b*.

1846. *Sedwichia yuccoides*, Goeppert, in Dunker, ibid., p. 84.

1847. *Endogenites erosa*, Mantell, Geol. Excurs. I. of Wight, p. 288.

1848. *Endogenites erosa*, Bronn, Index Nomencl. Pal., p. 461.

1848. *Sedgwickia yuccoides*, Bronn, ibid., p. 1132.

1849. *Protopteris ? erosa*, Brongniart, Tableau, p. 107.

1849. *Protopteris erosa*, Gutbier, Verstein. Rothlieg. Sachsen, p. 17.

1850. *Tempskya Schimperi*, Unger, Genera et Spec. Plant. foss., p. 201.

1851. *Tempskya Schimperi*, Bronn & Roemer, Lethaea Geogn., vol. 2, p. 46, pl. xxviii, fig. 8 *a*, *b*, *c*.

1852. *Tempskya Schimperi*, Ettingshausen, Abhandl. k.-k. Geol. Reichsanst., vol. 1, part 3, no. 2, p. 19.

1854. *Endogenites erosa*, Morris, Cat. Brit. Fossils, ed. 2, p. 8.

1869. *Tempskya Schimperi*, Schimper, Traité Pal. vég., vol. i, p. 698.

1871. *Tempskya Schimperi*, Schenk, Palæontographica, vol. 19, p. 259, ? pl. xlii, fig. 4, pl. xliii.

1878. *Tempskya Schimperi*, Dixon, Geol. Sussex, ed. 2, p. 282.

1888. *Tempskya Schimperi*, Velenovsky, Abhandl. k. böhm. Ges. Wiss., vol. 2, folge 7, p. 23.

1894. *Tempskya Schimperi*, Seward, B. M. Cat. Wealden Flora, p. 150.

1895. Spores in *Tempskya* sp. ?, Boodle, Ann. Bot., vol. 9, p. 137, text-figs. 1–4, p. 138.

1911. *Tempskya Schimperi*, Berry, Maryland Geol. Surv. L. Cret., p. 108, etc.

1912. *Tempskya Schimperi*, Kidston & Gwynne-Vaughan, Verhandl. k. Russ. Mineral. Ges., vol. 48, ser. 2, pp. 2 et seq.

Diagnosis.—The "false stem" large, reaching at least a foot in diameter and nine feet in vertical height, and probably considerably more. Specimens, as found, are often elliptical in shape [which is possibly only partly due to crushing]. In most specimens the tissues are more or less petrified, and sections show that the roots are diarch, and the solenosteles of the stems have a ring of tracheids about 9 cells thick.

HORIZON.—Lower Greensand.

LOCALITY.—Potton.

GENERAL DISTRIBUTION.—Mainly found in the Wealden of England, not common in the Lower Greensand. If the continental species *T. Schimperi* is identical with *T. erosa*, as many have assumed, it is fairly widely distributed in the continental Lower Cretaceous. The genus is also represented in America by a species which may or may not have to be included in *T. erosa* when better specimens are known.

TYPE.—Semi-petrified "false-stem" recorded by Stokes, Webb & Mantell, 1824, under the name *Endogenites erosa* which appears now to be lost, though duplicates of Mantell's are in the Museum of Practical Geology, Jermyn Street.

The assumption that the British plant *Endogenites erosa* was the same as *Tempskya Schimperi*, founded by Corda in 1845, was based on the *generic* peculiarity and identity of the plants, coupled with the very imperfect state of the knowledge of the species, owing to the poor petrifaction of the tissues. But even if we assume, as is perfectly possible, that *T. Schimperi* is the same species as *Endogenites erosa*, the laws of priority of specific names necessitate the use of the name *T. erosa* for both. Prof. Seward (1894), who accepts the view of the identity of the two specimens (first promulgated by Unger in his Genera et Species Plantarum foss. 1850), uses Corda's name and describes the British forms as *T. Schimperi*. I consider that we have not well enough preserved specimens to be sure whether or not *T. Schimperi* and "*Endogenites erosa*" are identical: that if they are, then the species name *erosa* has priority, and both must be described as *Tempskya erosa*; in the present state of our ignorance, however, it is well not to eliminate *T. Schimperi*, but to keep the name as it was founded for the continental specimens described by Corda.

Regarding my addition of Mantell's name to the combination of Stokes & Webb as authors of the paper describing the

"Fossil Vegetables of the Tilgate Forest" in the Transactions of the Geol. Soc. 1824, the following note may be of interest. Gothan (1910), referring to the name *Weichselia reticulata*, attempted to clear up the confusion which dates back to 1836, when Brongniart attributed the names in this paper to Mantell. He confirmed Lester Ward's view that the authors were Stokes & Webb; but in the course of my work I felt that the mystery had not been entirely unravelled, because in 1827, in his volume on the Fossils of the Tilgate Forest, we find Mantell using the same plates as illustrate the Geol. Trans. paper, and using them as though they were his own. The Secretary of the Geological Society kindly allowed me to see the original hand-written Minutes of Council for the years concerned, and the following facts were discovered:—In 1823 Mantell submitted a paper "On the Strata of Tilgate Forest," which was referred, but the ballot ordered it *not* to be printed. A few pages further on is a note—"Resolved. That Mr. Webb and Mr. Stokes be appointed a Committee to communicate with Mr. Brown and the owners of the fossil plants upon this subject," and a note at the side adds "on fossil plants to be published." Still further on, in the accounts, is written—"Payment of a bill for the printing of two of Mr. Mantell's plates to be inserted in the 2nd part of Vol. 1, 2nd series of the Transactions now publishing." As Mantell has no other paper in this part of the Transactions, these two plates must be those under discussion. It is evident, therefore, that Mantell himself provided the specimens and the illustrations, and a paper describing them, and that the paper was revised or re-modelled by Stokes & Webb, who published the author's own plates. This then accounts for the contemporary view that Mantell was the author of the work; and it seems to me that it is only in a technical sense that Stokes & Webb can be considered the authors of the paper.

Regarding the distribution of *Tempskya* in the English Lower Greensand, so far as I can discover, the only specimens of the genus occur in the Potton Sands. The beds at Potton are peculiar in containing a number of fossils which are certainly derived, it may be from the preceding Wealden deposits. These fossils generally show a richly coloured, rolled, and often highly glazed surface, by which they can at once be distinguished by anyone well acquainted with the plants of the horizon. Of the specimens in the Museum, **V. 13081** lacks the most noticeable characters of the derived fossils, and might reasonably be regarded as a true Lower Greensand fossil. There is also one very fragmentary specimen from Ireland.

48047. A narrow slice of a petrified specimen, partly polished. The preservation of the tissues is imperfect, but indications of the solenosteles are visible, as well as the numerous small lacunæ of the rootlets. "Greensand;" Potton. *Purchased*, 1871.

48047 a. Microscopic sections of the above. Two narrow transverse sections are mounted together on the same slide. With a very low power the general characters of a *Tempskya* are visible, but the actual cellular tissue is almost entirely destroyed in the process of petrifaction, and none of the finer details are retained. Small concretionary zones, with black or yellow centres, mark the outline and position of the numerous rootlets. In a single case the xylem of a rootlet can be made out, and this bundle appears to contain six undoubted tracheids, one of which looks like an exarch protoxylem element; beside the uncrushed cells are others, which may also have been vascular elements. It is not possible to determine whether or no the rootlet was diarch, but, so far as its tissue is preserved, it harmonises with the view that the rootlets were all diarch in this genus.

On the other piece of the section, towards the middle, there is a small part of the solenostele of a stem which has its wood sufficiently well preserved for recognition. The stem lies at the edge of the section, so that rather less than half of the arc of the solenostele is included. The curve of the wood is unbroken, and the band of tracheal elements is massive (about 9 cells thick), so that presumably it was not from that region of the stem which was giving off leaves (*cf.* Kidston & Gwynne Vaughan's account of *T. Rossica*). Interspersed among the tracheids (which have fairly thick walls and empty lumina) are crushed fragmentary elements, which probably represent the xylem-parenchyma. The phloem, endodermis, and other soft tissues which must have surrounded the stele are not preserved, but are represented by an outlining configuration of the minute blackened granules in the matrix. "Greensand;" Potton.

V. 13081. A fragment, 26 cm. × 14 cm., and evidently half of one of the large lenticular specimens described by Mantell and others as common, which has been split longitudinally. The outer surface, which is convex, is somewhat weathered and rolled, and has fragments of a coarse granular matrix adhering to it; the inner surface shows the irregular reticulations formed by the weft of rootlets, which often have the appearance of small hollow tubes. The larger axes of the stems are not conspicuous. The specimen is largely silicified, and would show an imperfect petrifaction of the tissues in section. Phosphate bed, Potton.

No history.

V. 10262. Transverse section of a very poorly petrified fragment (2·5 × 2 cm.) showing only rootlets. In several of these the diarch stele can be clearly seen, but the other tissues are almost unrecognisable. Greensand; Ireland. *No history.*

Group SPERMOPHYTA.

Plants in which the alternation of generations is marked by the reduction of the gametophyte and its enclosure within the organs of the sporophyte. "The plant," as we know it, consists of the sporophyte, which is differentiated into root, stem, leaves, and sporangia. The "spores" are specialised and develop within protective envelopes, which compounded together form the "seed," and within the seed the much reduced gametophyte gives rise to an egg-cell which, when fertilised, produces a multicellular embryo which also develops within the the seed.

Vegetatively the plants vary from delicate filmy water-plants, in which a secondary reduction of the specialised tissues can often be traced, up to sturdy complex trees of large size and high differentiation of tissues. All living trees belong to this group, and also the great majority of the forms important in the recent floras. There are two main cohorts, one with naked seeds (the Gymnosperms), the other with seeds enclosed in an ovary (the Angiosperms).

Class GYMNOSPERMÆ.

Plant-body never much reduced, the majority of the forms being trees or sturdy shrubs with much secondary wood. Seeds tend to be large, all are naked, attached to open scales and not enclosed in an ovary. Seed-bearing scales may or may not be associated and modified to form cones. Fertilisation by means of passive nuclei brought by a pollen-tube or active free-swimming spermatozoa. Embryo multicellular, developed within the endosperm, with two or more cotyledons.

Sub-class CYCADOPHYTA.

This sub-class includes all those forms, both living and fossil, which have short trunks, with the characteristic *Cycad*-like external features. The sub-class is essentially one based on the external and vegetative morphology, for most of the fossil representatives have fructifications profoundly different from the simpler fructifications of the living genera. The plant-body of all the Cycadophyta, however, is extremely characteristic, and unlike that of any other cohort, so the foundation of the comprehensive group by Prof. Nathorst (1902) seems well justified.

The essential external characters of the plants are as follows :—trunk short, in some cases underground, in the majority of cases not more than a few feet high ; if branched the branching is irregular and adventitious, and the branch repeats the characters of the main trunk (see Stopes 1910, Wieland 1906, etc.). The whole outer surface of the trunk is covered by the persistent leaf-bases, which have extended rhomboidal outlines and are in very close spiral series. The leaves are all large and compound, typically with a strong central rachis and simple alternating pinnæ, each of which has a single midrib or a series of simple veins running parallel in the lamina and unbranched, or with simple, few dichotomising, branches.

Scale-leaves are also prevalent, and in some cases series of scars of scale-leaves and foliage leaf-bases alternate.

The sub-class contains two principal orders, the modern Cycadaceæ with relatively simple cones or sporophylls, male and female separate, which are borne externally and *apparently* terminally on the trunk: and the fossil order Bennettiteæ with complex, bi-sporangiate cones borne in large numbers laterally and embedded among the leaf-bases.

Order BENNETTITEÆ.

The Order is entirely extinct. The trunks, as described for the family, are commonly about 30–60 cm. in height, seldom more than 1 metre. Trunks, as a rule, conical or almost spherical, generally simple; but in some cases two or three similar short trunks are associated and evidently form a branching individual. The trunk may have a large terminal bud, but this is usually poorly preserved. Ramenta between the leaf-bases are very numerous multicellular scales or hairs. In weathered specimens these tend to form ridges of more resistent tissue round the weathered-out leaf-bases. The fructifications are very numerous, in some cases several hundred per individual *, and are all in the form of cones with a short central axis, bearing bi-sporangiate lateral appendages and enclosed in sterile scales. The whole cone in each case is deeply embedded among the protecting leaf-bases of the trunk. The seeds, borne singly on special appendages, contain when ripe an embryo which has two cotyledons almost filling up the seed-cavity.

Genus **BENNETTITES,** Carruthers.

[Trans. Linn. Soc., vol. 26, 1870, pp. 681, 694 et seq.]

The diagnosis given by Carruthers is as follows :—" *Trunk* ovoid, in transverse section elliptical, covered with the somewhat

* Thus Wieland, 1911, p. 135, describes as many as 500–600 ovulate cones in *half* a trunk in one of his new specimens.

long permanent bases of the petioles. *Medulla* entirely cellular, with numerous gum-canals. *Wood* consisting of a thin interrupted cylinder of striated tissue everywhere penetrated by medullary rays. *Fruits* borne on secondary axis, not protruding beyond the bases of the petioles."

As Scott (1909, p. 560) points out, the elliptical stem-section is not a true generic character, but otherwise, though incomplete, the diagnosis still stands.

The most careful recent diagnosis is that of Lignier (1894, p. 75); nevertheless, taking into account the importance of the later discoveries, and in particular the notable work of Wieland (1906), a revised diagnosis seems necessary.

Diagnosis.—Trunk shortly cylindrical or ovoid, externally covered by persistent leaf-bases arranged in a close spiral, each leaf-base roughly rhomboidal. Numerous ramenta between the leaf-bases, which often persist in weathered specimens. *Stele* monostelic and hollow cylindrical. *Pith* cellular, with numerous gum-canals; *wood* composed of irregular primary groups of elements, augmented by a secondary ring of radially arranged tracheids much separated by wide medullary rays; *phloem* much developed. A single leaf-trace departs from the stele and divides later. The leaf-bases contain a meristele irregularly broken up into collateral bundles with variable amounts of secondary thickening. Ramenta multicellular and fern-like. Fructifications very numerous, borne laterally between the leaf-bases which partly conceal them. Each fructification consists of an axis with sterile scales and fertile appendages in considerable numbers, ♀ and ♂, generally, and perhaps always, on the same cone. Ripe fruits consist of scales and special stalks bearing orthotropous seeds, ♂ organs having disappeared. Seeds contain each a large dicotyledonous embryo within a differentiated testa. The two cotyledons of the embryo practically fill the seed-cavity.

Since Carruthers first (in 1870) described this interesting and important genus much supplementary work has been done, the more important of the papers dealing with it being Solms-Laubach (1890, 1891), Capellini & Solms-Laubach (1892), Lignier (1894 and others), Ward (1894 A & B), Seward (1895), Scott (1909), Wieland (1906), and Berry (1911). Of these, Scott's detailed botanical work in the 'Studies' and Wieland's volume give the fullest accounts, to which reference is constantly made.

The American forms described by Wieland (1906, 1911, etc.) are all named *Cycadeoidea*, Buckland, 1828. As in some of the American species, the fruits are practically identical with the British form *B. Gibsonianus*, it is clear that *Cycadeoidea* as used by the American, and *Bennettites* as used by the British palæobotanists are largely synonymous. I favour the use of the generic name *Bennettites* for the forms in which the internal anatomy and fructifications coincide with Carruthers's type *.

For a history of the older views published from time to time reference should be made to the *résumés* in Seward (1895), Wieland (1906), and Berry (1911).

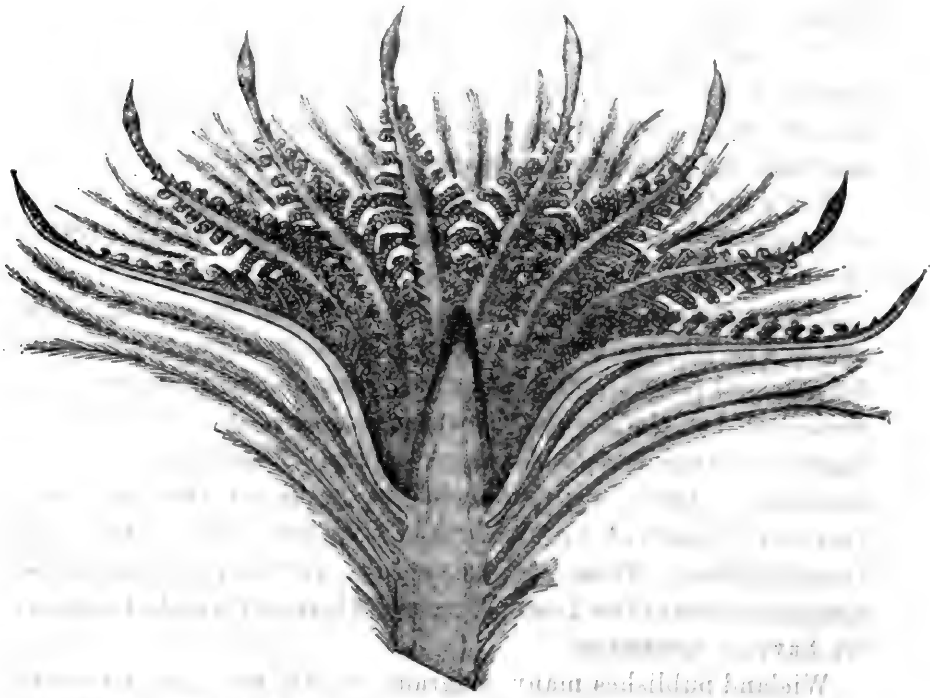
The general external form of the fossil can be seen in Pl. I, and is well illustrated in the fine series of photographs published by Wieland (1906). The details of stem and fruit anatomy are described for the Lower Greensand species in the following pages, and they can be taken as typical of the genus; but to supplement them mention must be made of the important features discovered by Wieland in the less mature American fructifications. These structures were probably present in the younger states of the Lower Greensand form, of which, however, we have no specimens.

Wieland publishes many diagrams which make the structure of the complete fructification clear, and two of these are reproduced in text-figs. 6 & 7. The term "flower" has been applied to the fructification because of its complex organisation and bisexual nature. Essentially it consists of a stout central axis which bears series of sterile bracts, in a variable number up to about 100, in close spiral series (see text-fig. 6).

Above the sterile bracts comes a whorl of microsporophylls. Of these there is a relatively small number, variable in the different species, but generally under twenty. At the base they are confluent, but each separate microsporophyll expands to form a large and pinnately compound structure, up to almost 10 cm. long. On each of the lateral pinnæ rows of sporangia are borne, varying in number according to the position on the leaf,

* See Appendix, p. 295.

the larger rows numbering about ten (see text-fig. 6). Above these, and terminating the floral axis, is the large rounded cone-like structure composed of closely packed ovule- or seed-bearing stalks and interseminal scales (text-fig. 6). As the fructification matures, it is this central axis which enlarges and forms

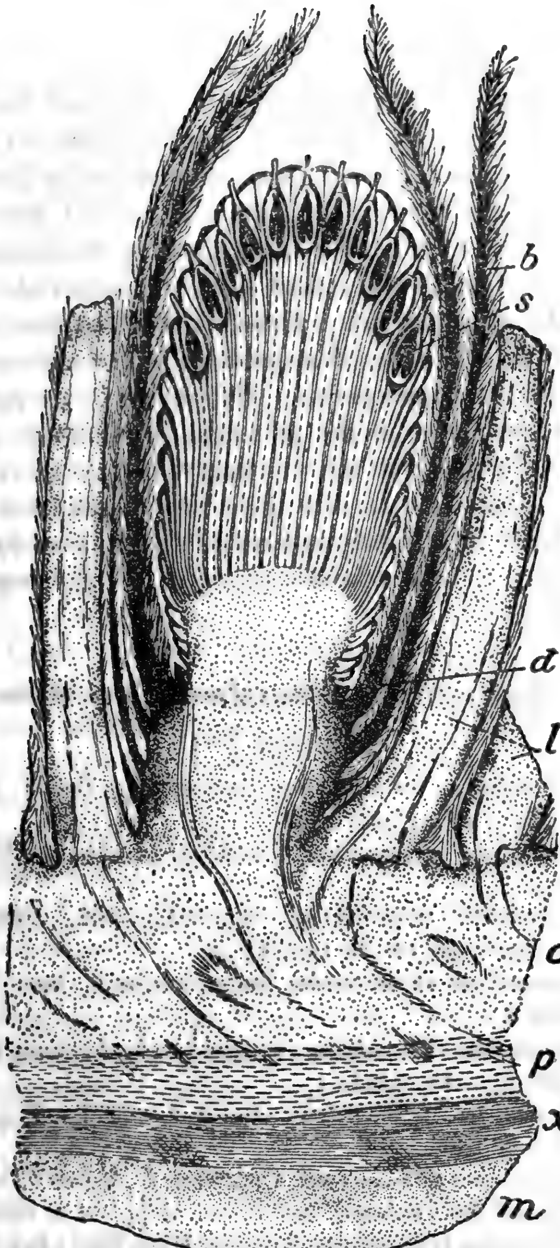


Text fig. 6.—*Bennettites ingens* (Ward). Restoration of an expanded bisporangiate strobilus in nearly longitudinal section. About $\frac{3}{4}$ nat. size. After Wieland.

the "fruits" such as occur in the British species. The male organs apparently disintegrate and make space for the enlarging female organs (see text-fig. 7).

For further details regarding the elaborate structures reference should be made to Lignier (1894), Scott (1909), and Wieland (1906, 1911, 1911 A, etc.).

The plants which fruited seem to have been prolific, and, as Wieland (1911, p. 134) has more recently shown, sometimes bore an immense number of cones simultaneously. Wieland has also suggested that the plants may have fruited but once at the end of their life, as is the case in several living palms etc.



Text-fig. 7.—Ovulate strobilus of *Bennettites*. Partly restored drawing from a longitudinal section. The arrow indicates the direction vertical to the trunk, the section passing through the exact median and vertical longitudinal plane of the axis of fructification. *m.*, medulla or pith; *x.*, xylem; *p.*, phloem; *c.*, cortex of trunk cut in radial longitudinal section; *l.*, leaf-bases; *d.*, insertion of dehiscent hypogynous disc of fructification; *b.*, sterile bracts; *s.*, seed on long-stalked pedicel. After Wieland.

to-day. In support of this it may be considered that the large number of cones must have been a great drain on the plant's resources; but, on the other hand, it must not be forgotten that the living *Cycas* indefinitely produces without suffering great numbers of larger seeds than those borne by *Bennettites*, in which the huge endosperms are packed with food-material.

From the complex and "flower"-like fructifications of this remarkable group many theories have been deduced concerning the origin of the Angiosperms. References to the papers on the subject will be found in the principal works above quoted. It may be noted that the extraordinary vegetative characters of Cycadophyta, as a whole, and their remoteness from the Angiospermic forms, is generally ignored or slurred over by those who consider mainly the relative positions of the organs in the fructification.

Bennettites Gibsonianus, Carruthers.

[Text-figs. 8–12]

1870. *Bennettites Gibsonianus,* Carruthers, Trans. Linn. Soc., vol. 26, p. 700, pls. lviii–lx.
1878. *Bennettites Gibsonianus,* Carruthers, in Dixon's Geol. Sussex, p. 281.
1887. *Bennettites Gibsonianus,* Solms-Laubach, Einleit. Paläophytologie, pp. 96–99, text-fig. 5.
1890. *Bennettites Gibsonianus,* Solms-Laubach, Bot. Zeit., p. 789, pls. ix, x.
1891. *Bennettites Gibsonianus,* Solms-Laubach, Ann. Bot., vol. 5, p. 419, pls. xxv, xxvi.
1891. *Bennettites Gibsonianus,* Solms-Laubach, Fossil Botany, pp. 94–96, text-fig. 5.
1892. *Bennettites Gibsonianus,* Capellini & Solms-Laubach, Mem. R. Accad. Sci. Bologna, ser. 5, vol. 2, pp. 34 & others.
1894. *Bennettites Gibsonianus,* Lignier, Mém. Soc. Linn. Normandie, vol. 18, p. 76.
1894. *Cycadeoidea Gibsoni,* Ward, Proc. Biol. Soc. Washington, vol. 9, p. 80.
[? 1895. *Bennettites Gibsonianus,* Seward, B. M. Cat. Wealden Flora, vol. 2, p. 142.]
1897. *Bennettites Gibsonianus,* Seward, Quart. Journ. Geol. Soc., vol. 53, pp. 22 et seq., pl. iii, fig. 7; pl. iv, fig. 10.
1906. *Bennettites Gibsonianus,* Wieland, Amer. Fossil Cycads, pp. 15, 16 & others, to 143.

1909. *Bennettites Gibsonianus*, Scott, Studies, vol. 2, pp. 560 et seq., text-figs. 200, 202, 203, 204, 205.

1911. *Bennettites Gibsonianus*, Wieland, Amer. Journ. Sci., ser. 4, vol. 32, pp. 133 et seq., text-fig. 2.

Diagnosis.—Trunk 20+? cm. high and 28×16·5 cm. in diameter (the elliptical compression petrifact?). Leaf-bases rhomboidal, 3–4 cm.×2–2·5 cm., tangentially extended; totalling 7–10 cm. in thickness in transverse section of the trunk. Meristele a curved and infolded horseshoe of mesarch, collateral bundles. Fructifications 5 cm. long, 2·5 cm. in diameter, enclosed in sheathing bracts, each with 3 vascular bundles. Pith 10×2·5 cm. Woody axis of main trunk broken by large curved leaf-traces, which run straight out to the leaf-bases. A single cambium gives rise to rather irregular radial series of tracheids. Tracheids all scalariform, up to 40×38 μ in diameter. Large quantities of phloem in which single thick- and thin-walled elements alternate. Pith, cortex, and leaf-traces, as well as scale-leaves, are all composed of a large-celled ground-tissue with numerous gum-canals.

Cones numerous, embedded between leaf-bases, about 2·5–3 cm. in transverse section. In the cone the expanded receptacle measures about 10×12 mm. Interseminal scales vary up to 3·5 cm. long. Seed-stalks roughly circular, 1–2 mm. in diameter. Seeds, when apparently ripe, measure 3×2 mm. up to 4×2·5 mm., not including the length to the tip of the micropyle from the shoulder of the seed. Testa three-layered, the central stone composed of one or two thick-walled cells. Seeds exalbuminous. Embryo massive, 5–6 vascular bundles in each of its two cotyledons.

The diagnosis originally given by Carruthers (1870, p. 700) is as follows:—"Trunk compressed elliptical, with small medulla and a thick subcontinuous woody cylinder; vascular bundles passing almost 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 subquadrangular."

Horizon.—Lower Greensand.

Locality.—Luccomb Chine, Isle of Wight.

Type.—A single, large, petrified trunk which was early broken up and distributed (see p. 40). The following numbers in the Geological Department of the Museum are all parts of it:—(slides) V. 13205, 6, V. 8398, V. 8399, V. 8400, V. 8401, V. 8406, V. 8410, V. 8422, V. 8425, V. 8426, V. 8427, V. 8428, V. 8429 *a–b*, 41388 *a*–41388 *c*; (blocks) V. 6140, V. 6137, V. 5706, 41388, V. 13203–4.

There are also three pieces, one finely polished, in the Botanical Department of the Museum. Other pieces are at Kew.

Dr. D. H. Scott has in his collection slides 350–55 and 357–364, cut from the type block at Kew, and Count Solms-Laubach has a similar set cut at the same time from the same piece *.

Dr. Wieland has some sections of the seeds of the type which he has cut himself, and there are possibly other portions of the type-specimen in private hands.

Finder.—Thomas Field Gibson, Esq., 1856 or 1857.

Description.—The trunk is described by Carruthers (1870) as having been 8 ins. long, but incomplete at both ends. It is somewhat compressed, the transverse section being oval, measuring 11 × 6·5 ins. The fructifications were approximately ripe at the time of petrifaction and may be described as *fruits* rather than "flowers."

The *pith* is 1 in. in diameter according to Carruthers (1870, p. 700). This is oval, and in the surface of the block now available measures 10 × 2·5 cm. Carruthers describes it as being "composed of large subspherical cellular tissue, free from separate woody bundles, but penetrated everywhere with gum canals." Except near the edge of the pith, where it is penetrated by the protoxylem groups, the cells are largely macerated and disorganised, so that a brownish mulch, penetrated by large and irregular gum-canals, is all that can be seen in some sections.

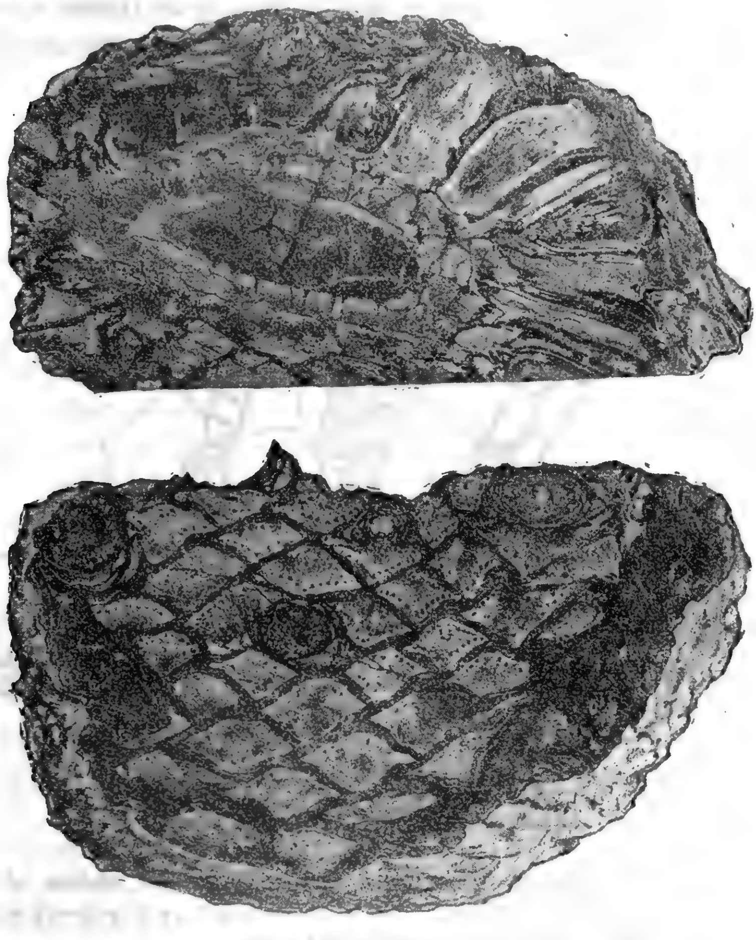
* Count Solms-Laubach has a second specimen (see p. 40) found by Dr. Leeson, and from this sections were cut from a part given to Dr. Scott in 1901 (Scott Coll. nos. 1590–1611). This is not a part of the type-specimen, nor is it a co-type, but it is of interest because of the rarity of the form.

Towards the edge of the pith the cells are large and comparatively thin-walled (see *p.*, text-fig. 9).

The *vascular tissue* is a hollow cylindrical monostele. The *primary xylem* is much broken up into small groups of elements, and these form isolated little clusters, separated by large ray and

A.

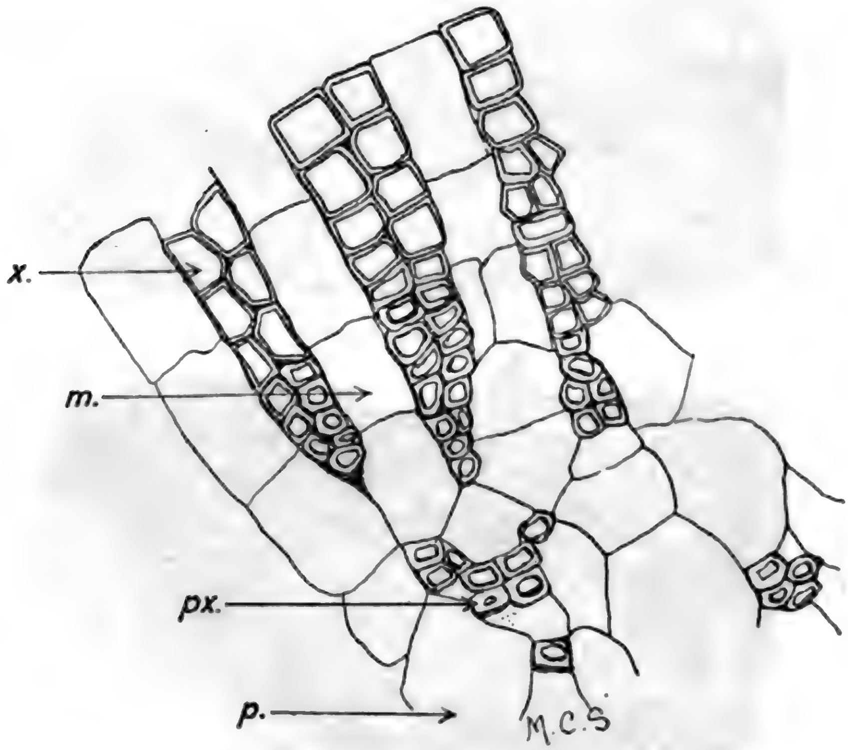
B.



Text-fig. 8.—*Bennettites Gibsonianus*, Carr. A. Trunk cut across. B. Cut tangentially to show cones and leaf-bases. After Carruthers.

medullary cells (see *px.*, text-fig. 9). These elements have very thick walls and are irregularly scattered. The *secondary wood*, forming a definite ring, is also of a very loose texture, the rays between the radial series of tracheids being both large and numerous (see text-fig. 9, *x.*). The wood is loosely grouped into large bays or bundles, which give a waving outline to the vascular cylinder, which is further broken by the exit of the leaf-traces.

In longitudinal section, Scott says that "the histological details of both wood and bark (which have more recently been minutely studied by Count Solms-Laubach in an Italian species, and by Dr. Wieland in the American material) agree precisely



Text-fig. 9.—*Bennettites Gibsonianus*, Carr. Transverse section of the inner zones of the wood. *p.*, pith-cells; *px.*, groups of primary wood; *x.*, secondary tracheids; *m.*, medullary rays.

with the corresponding structure in a recent Cycad." Wieland (1906, p. 75), however, states that "the xylem is composed mainly of scalariform tracheids. Spiral cells are present next to the medulla, but are not numerous. Idioblasts are occasional. No pitted tracheids have been noted, although preservation is such as would presumably enable ready recognition without staining, were such present in any of the several radial or tangential sections cut." My own observations on the xylem lead me to question the preciseness of the histological agreement between the wood of this species and that of living Cycads. I am inclined, indeed, to return to the original description of Carruthers (1870, p. 695), who says, "the minute structure [of the wood] would be described as scalariform, but it is certainly different from the typical form of this found in living ferns, or in the arborescent Lycopodiaceæ of the Coal-measures." The wood of this species is peculiar and interesting, and highly suggestive in many respects, and is worthy of the renewed examination in detail which Prof. Seward is undertaking (see p. 46, note). In transverse section the size of the secondary tracheids varies, but the largest elements measure about $40 \times 38\ \mu$.

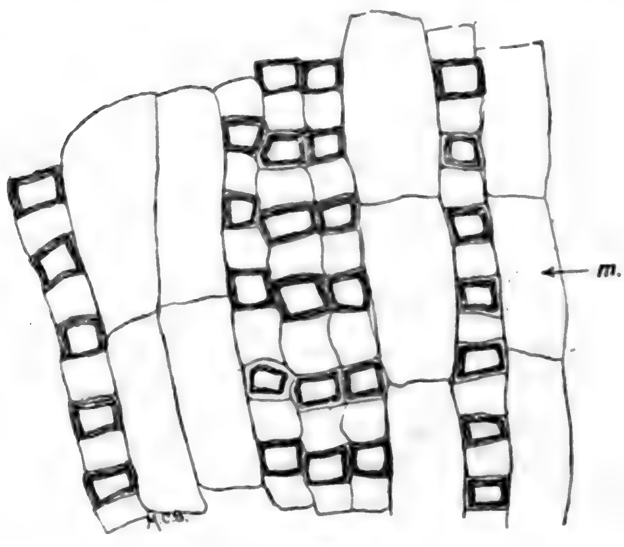
All indications of growth-rings are absent. No secondary or inverted cambiums have been observed in this species, though they occur in many plants of Cycadean affinity. Wood-parenchyma, resin-cells, and resin-canals are not developed in the secondary wood. They appear to be rendered needless by the very numerous and large medullary rays.

The *medullary rays* are biseriate or uniseriate. The individual cells of the ray are very large, often as much as twice the tangential diameter of the adjacent tracheids. The rays lie 1–2, a few 3–4, tracheids distant; as a large proportion of them are only 1 tracheid or 2 tracheids distant, the wood is very loose-textured. Unfortunately, I have no sections which show the rays in good radial section and am not able to determine whether or not their radial walls were pitted.

The *exit of the leaf-trace* is an important feature in this group. A single, large, curved bundle passes out from the wood-ring, in which its exit makes a wide gap.

The *phloem* is remarkably well preserved and is in considerable quantity. It is composed of irregular series of radially arranged secondary elements taking rise from the single cambium, the radial series of phloem elements consequently roughly corresponding to those of the xylem, but their sequence is more irregular. In radial series the phloem is composed of single alternating thick- and thin-walled elements (see text-fig. 10).

The *cortex* is composed of large cells, through which are scattered numerous large and irregular gum-passages. Through the cortex the big leaf-traces with their fan of secondary tissues pass out directly to the leaf-bases, and do not encircle the stem in their way out as is the case in living Cycads. Scott describes their course as follows (1909, p. 564):—"A single bundle leaves the ring, starting from the lower angle of one of the meshes, which (as shown in tangential section) are occupied by the primary medullary rays. As the leaf-trace passes out through the cortex it assumes a horseshoe form, with the concave side inwards. It then breaks up by successive subdivisions into a number of smaller bundles, which enter the base of the leaf.



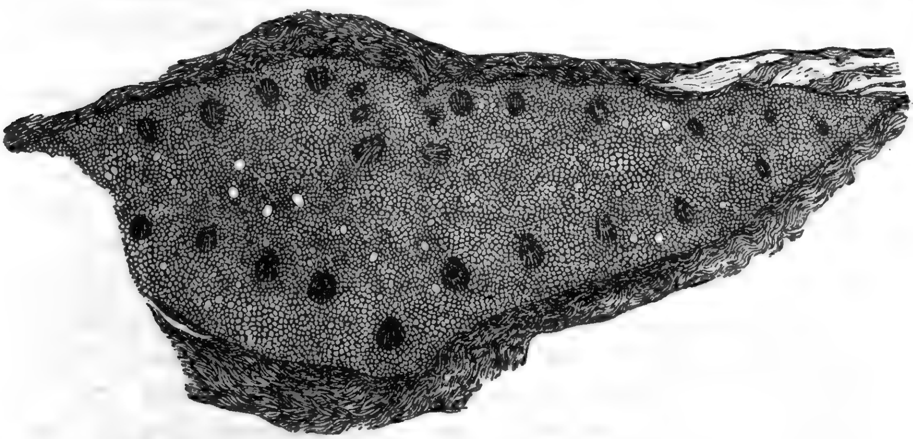
Text-fig. 10.—*Bennettites Gibsonianus*, Carr. Transverse section of part of the phloem, showing the regular alternation of thick- and thin-walled elements. *m.*, the broad medullary ray cells.

In the petiole the vascular bundles arrange themselves in an almost closed curve, slightly open and involuted towards the upper surface, as is well shown in tangential sections passing through the armour of leaf-bases" (see text-fig. 8).

The massive *leaf-bases* are well shown in this fossil. According to Carruthers (1870, p. 700), they account for 4 inches (10 cm.) of the thickness of the trunk. They measure tangentially from 3–4 cm. and vertically 2–2·5 cm. They are mainly composed of a large-celled ground-tissue, through which run innumerable gum-canals. At their edge there appears to be something in the nature of cork. The numerous bundles subdivide, and in the Museum sections they are cut in several directions and show very well the fine spirals and scalariform thickening of the wood-elements. These bundles, as described by Seward (1897), are mesarch in structure, and are directly comparable with those of existing Cycads.

Ramenta are very numerous between the leaf-bases (see text-fig. 11). In section these show their multicellular scaly nature. They appear much alike in all the species of this genus, and have been well illustrated by Wieland (1906).

The external form of the *foliage* of *B. Gibsonianus* is not known. There is little doubt, however, that it must have been



Text-fig. 11.—*Bennettites Gibsonianus*, Carr. Leaf-base cut across, showing the incurved horseshoe of bundles, the large-celled ground-tissue with gum-canals, and the ramenta lying around it. × 2·6. After Carruthers.

one of the large and pinnate leaf-forms, of which so many Mesozoic impression-species are known. Allied species from America show the most beautifully preserved young unfolded leaves in section, which are illustrated and described by Wieland (1906).

In this species the only *fructifications* known are in an approximately mature state. The male organs of the "flower" shortly described above for the genus, are therefore not known. Nevertheless, Solms-Laubach, working with Capellini (see Capellini & Laubach, 1892), made remarkably acute deductions from their study of the Etruscan species long before the "floral" structures were demonstrated by Wieland. This prophetic passage is translated by Wieland from the original German manuscript of the Italian paper as follows:—"We saw that every peduncle (Blüthenstiel) was apically branched into a tuft, these tufts forming a complete outer layer. Can they not have borne apically set anthers? As to whether the flowers of the spadix were male, hermaphrodite, or unisexual and interspersed, is immaterial, it only being necessary to assume a protandrous development of the whole. And if perchance the fruit of *Bennettites Gibsonianus* was likewise in its earlier stages beset by similar staminate organs, these must also have been attached to the external areoles. The interstitial organs of the whole tuft- or bundle-like fruit which unite to form its exterior layer would then represent filaments."

Carruthers's original description of these remarkable organs may be quoted (1870, p. 696):—"The axils of a large number of the petioles bore short branches. These axillary organs are important features in this group of fossil plants. In some fragmentary specimens, every axil is occupied by a bud, as described by Mr. Brown; but more frequently the majority of the leaves are without them. The proportion of the buds to the leaves appears to be greater in the lower portions of the stems and in stems belonging to old plants. These organs, however, are not properly buds; for, although they do not appear to have pushed themselves beyond the permanent bases of the leaves, they are fully developed organs, and differ from the secondary axes of *Mantellia*. . . . 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. They are composed of oblong cells, all of which are marked with transverse bars, like scalariform tissue. Large gum-canals abound in them; and two vascular bundles run through the leaf, one on either side of its median line. The back of the leaf is sparsely clothed with membranaceous scales, like the ramentum on the petioles."

"The branch terminates in a fleshy subpyriform enlargement, which bears the seeds. This is composed of, *first*, a cellular cushion; *second*, vascular cords supporting the seeds; and, *third*, a mass of irregular cellular tissue enveloping the whole. . . . . The seeds are confined to the convex upper portion of the fleshy pericarp, being buried in deep pits; and forming a somewhat compact layer immediately under its surface. They are small ovoid bodies, and are composed of two envelopes enclosing the albumen and embryo."

The single ripe "fruit" is a globoid oval mass, about 5 cm. long and about half that diameter. It is enclosed in the long, sheathing, sterile bracts.

The *axis*, or stalk, of the fructification terminates directly in the somewhat expanded receptacle. The ground-tissues of the axis are much like those of the leaf-bases, consisting of large irregularly rounded cells with a number of large irregular gum-canals. Running in the axis are vascular strands, which supply the fruits (see text-fig. 7, p. 27) and have a large amount of phloem.

The *bracts* are attached to the part of the axis below the terminal expansion. They have the structure of reduced foliage leaves, and are each traversed by three vascular bundles. There are also large gum-canals scattered through the ground-tissue, which is itself remarkably characterised by masses of scalariformly thickened cells which seem to be intermediate between tracheal and transfusion elements. Stomates are recorded by Scott (1909, p. 571) in the epidermis of the bracts in this species, and sections of scales in the Museum slides, cut transversely, show features in the epidermis very suggestive of stomates, though Solms-Laubach did not feel satisfied that they were present in *B. Gibsonianus*. Lignier (1894, p. 29) records them in the allied *B. Morierei*.

Numerous *interseminal scales* are placed on the receptacle which bears the ♀ organs. These steadily increase in size towards their terminal expansion, and are attached by simple stalks to the receptacle (see text-fig. 7, p. 27). Each stalk is of wavy irregular outline, and they fit together compactly. According to the position on the cone, the scales measure up to 3·5 cm. in length. At the base of the receptacle all the appendages are sterile scales of this type with short stalks, while further up they are arranged to surround the seeds and to form a false pericarp by their close adhesion. Small spaces between them give entrance to the micropyles of the seeds.

Each scale has a strong well-marked epidermal layer, and the ground-tissue is composed of large, irregular, rounded cells with intercellular spaces. There is a small central vascular strand in each.

The *seeds* are attached to *stalks* about 1–2 mm. in diameter, each of which is nearly uniform throughout its length and is roundish in outline. The epidermal layer is well marked, but it is common to the stalk and the adjacent sterile scales. The ground-tissue is composed of thick-walled rounded cells with large intercellular spaces. An endodermis-like layer surrounds the central vascular strand.

Each orthotropous *seed* is erect, placed centrally on the stalk bearing it, and has a long well-developed micropylar region, which is directed approximately at right angles to the surface of the cone. The seeds from base to tip of micropyle measure more, but the oval mass of the seed proper is about $3–4 \times 2–2{\cdot}5$ mm., the majority of the sections being 3×2 mm.

The *testa* is composed of three distinctly organised layers (see text-fig. 12): an outer flesh, a central stony layer one or two cells in thickness, and an inner flesh. These regions are clearly described and figured by Wieland (1911, fig. 2), who considers that, as in other members of the genus, the shoulder of the seed is thickened and ribbed, comparably to the seeds described by Oliver & Scott (1904) and Oliver (1909).

The *nucellus* is only preserved as a structureless membrane.

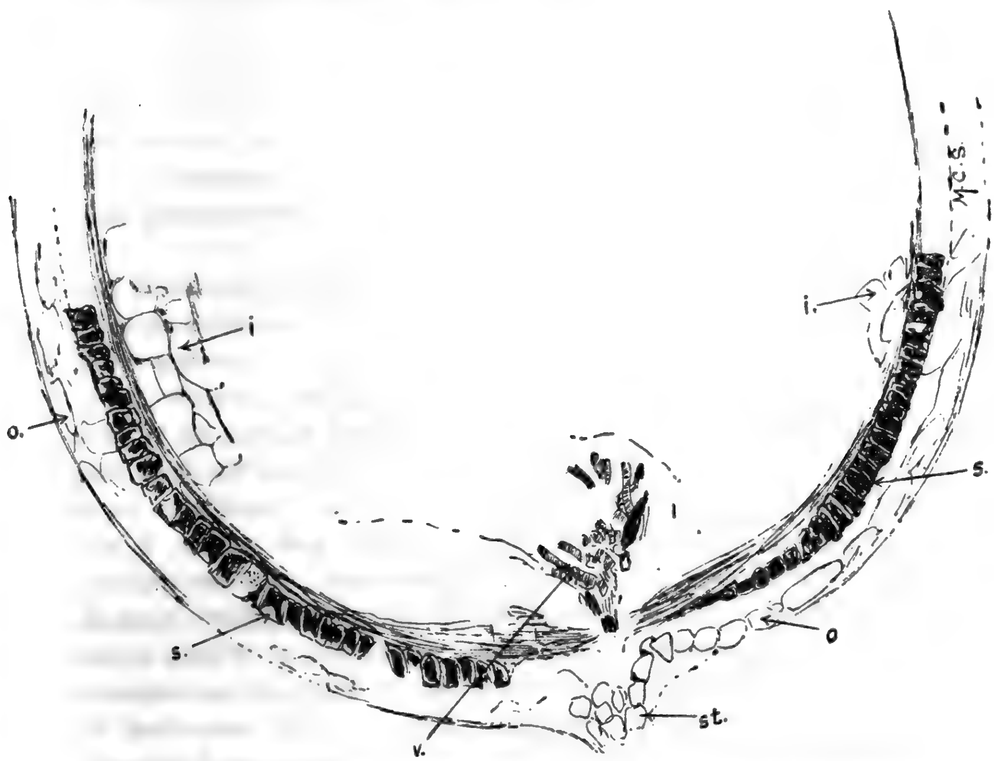
The *micropyle* is long and rather widely and irregularly opened, the inner layer being formed from the internal zone of the testa. Its characters and the details of the pollen-chamber, etc., are still desiderata.

The *endosperm*, if represented at all, is only a small fragment left to one side of the root-end of the large embryo; it is figured by Scott (1909, p. 569, text-fig. 203 D *e*).

The *embryo* practically fills the inner regions of the seed, and has a massive root-end pointing towards the micropyle. In transverse section its two cotyledons are very clearly seen, and their tissues are often well preserved. In each, running longitudinally, are five or six vascular bundles. Between the two cotyledons the plumule growing-point is sometimes preserved, and is figured by Scott (1909, fig. 205, p. 576).

The cells comprising the embryo in the allied *B. Morierei*

(Lignier, 1894, p. 50) are regularly arranged and closely packed. In the new sections of the type-specimen of *B. Gibsonianus* (see p. 46) some portions of the inner tissues of the embryo are beautifully preserved, and show also a small-celled epidermal layer surrounding them. In an American species exceedingly like *B. Gibsonianus*, Wieland has found a younger stage in the seed-development which shows the internal cavity filled with a pro-embryo (see Wieland, 1904 & 1906).



Text-fig. 12.—*Bennettites Gibsonianus*, Carr. The base of a tangentially cut seed, cut so that it slopes through the basal vascular bundle, *v.* *st.*, the cells of the outer flesh, *o.*, which run into the stalk; *s.*, the stone layer; *i.*, the inner flesh of the testa. No. V. 8422.

Discussion of the Literature.—Adequately to discuss the extensive and important literature which bears on *B. Gibsonianus* would necessitate a lengthy treatment of the subject, much of which is highly theoretical, and is therefore outside the scope of the present volume. A few points which bear especially on the Lower Greensand species may, however, be noted.

At the time when Carruthers (1870) suggested the modern interpretation of the form, he had the fructifications in only *Bennettites Gibsonianus* to deal with. Nevertheless, as Solms-Laubach wrote in 1891 (p. 422), so far as his material allowed he interpreted the form in "so masterly a manner from his numerous preparations, that at present I have chiefly only to confirm his results, though, as might be expected, a fresh examination may be found to throw further light on some questions of detail." In particular, Solms-Laubach's work increased the detailed knowledge of the embryo and its minute cell-structure, which he described and figured more accurately than had previously been done. He also gave a summary of the whole organisation of the fructification, and made clear the relation of the seeds to the false pericarp in which they appeared to be imbedded, which is formed by the cohesion of the expanded ends of the interseminal scales.

As the fructification of this Lower Greensand species is the type-specimen, not only of a species but of a whole extinct family, the history of its discovery and early treatment is of interest, and for this we are indebted to Solms-Laubach (1891, p. 427):—"With regard to the specimen known to be the original block of *Bennettites Gibsonianus*, we have the following memorandum, which was communicated to Carruthers by a member of the family of the discoverer, and which I was permitted to copy in the British Museum. It runs thus:—'This fossil plant was found by Thomas Field Gibson, Esq., in the Lower Greensand at Luccomb Chine, Isle of Wight, in the year 1856 or 1857. In the spring of 1858 it was taken to Mr. Yates' house at Highgate, where it was examined by Dr. Hooker and Mr. Morris, Professor of Geology at University College. They split it open, and found oval pods containing little seeds arranged regularly near the edge. Each pod was about an inch and a half long. The best pieces containing the most perfect pods were kept by Mr. Gibson and Dr. Hooker, but this piece is much larger than the other part which was broken up, being about two-thirds of the original lump. I believe a similar specimen was found by Dr. Leeson, of Bonchurch.'

"It appears, therefore, that the original block was broken in two with a hammer, and was thus split into two unequal halves, and beside these into a large number of smaller fragments.

This explains why the two main pieces do not fit into one another in their present state. Hooker took the smaller (upper) main piece, and it is now in the Museum at Kew *; the larger (under) main piece was made over by Gibson's family to the Botanical Department of the British Museum †. Hooker appears to have used some of the smaller fragments for the preparation of slices; others were kept by Morris, from whose hands they passed into the private possession of Carruthers. I gather this from the fact that Carruthers has a fragment which still bears Morris' label, written with his own hand."

Parts of the smaller fragments seem to have been scattered still further, for Wieland (1911) says that he has himself cut sections of *B. Gibsonianus*.

Though much had been previously written about the externals of the numerous American trunks of *Cycadeoidea*, the beginning of a real understanding of them, and the prelude to the important American contribution, lies in Wieland's first paper on their male flowers in 1899.

One of the most interesting results of the American work is that it shows how cosmopolitan was the *Bennettites*-type in Lower Cretaceous and Jurassic times. The fruits of some of the American species described by Wieland (1906 and others) are very closely similar to those of *B. Gibsonianus*.

As was realised by Carruthers (1870) when he originally established the group, the most surprising of the many unexpected features it exhibits is the fact that, instead of having fructifications as simple, or simpler than the living Cycads, they were more complex and specialised. All succeeding work has further established this fundamental fact, and has served to illustrate it more fully.

The best-known European species of *Bennettites* is the beautifully preserved *B. Morierei* (see Lignier, 1894, 1911, 1912) described by Prof. Lignier. In many respects it approaches *B. Gibsonianus*, but various details mark it out as a well-defined species. In connection with this plant Lignier (1911) suggests that possibly the forms which persisted into the Lower Cretaceous

* A fragment has now been transferred to the Geological Dept., British Museum (Nat. Hist.), and from it new sections have been cut (see p. 46).

† Some of this remains there, the rest has been transferred to the Geological Dept.

then became extinct through a parthenogenetic habit, which he detects in *B. Morierei.*

The following *slides* are in the general collection :—

V. 8398. Slightly oblique longitudinal section, $5{\cdot}5 \times 2{\cdot}5$ cm., through cone, with fragments of surrounding bracts. The seeds are poorly preserved and partly pulverised. The cone-receptacle is present and shows the attachment of the seed-stalks, interseminal scales, and bracts rather well. The bract-tissues are beautifully shown in longitudinal direction, the large gum-canals surrounded by irregular scalariform elements are present in great numbers.

V. 8399. Figured by Carruthers, Trans. Linn. Soc. vol. 26 (1870), pl. lix, fig. 3. Very slightly oblique longitudinal section, $6 \times 2{\cdot}5$ cm., through cone with parts of surrounding bracts. A piece of the section has broken out since it was figured by Carruthers, but this is only in the seed-stalk region; the seeds and the cone-receptacle are perfect. The tissues are rather blurred by the opaque mineral granules, but all the details described by Carruthers can be well made out.

V. 8400. Figured by Carruthers, Trans. Linn. Soc. vol. 26 (1870), pl. lix, figs. 2 & 6; Solms-Laubach, Bot. Zeit. 1890, pl. x, fig. 6, & Ann. Bot. 1891, pl. xxvi, fig. 6. Oblique section through seed-stalks, seeds, and scale- and bract-fragments. Two of the seeds in this are cut more nearly through the micropyle than is generally the case. Bract-tissues and ramenta in section can be well seen.

V. 8401. Figured by Carruthers, Trans. Linn. Soc. vol. 26 (1870), pl. lix, figs. 1 & 9; pl. lx, figs. 6, 8, 10. Parts refigured by Solms-Laubach, Bot. Zeit. 1890, pl. x, fig. 5 & Ann. Bot. 1891, pl. xxvi, fig. 5. Oblique section through seeds, seed-stalks, and sterile surrounding bracts. As Carruthers notes, the bracts are cut in good transverse section at the base of the slide.

These show their tissues remarkably well; the epidermis (with stomates?), the strengthened outer tissue, large gum-canals, small vascular strands, and masses of scalariform elements can all be made out.

V. 8406. Transverse section, 8×5 cm., of part of the main axis with leaf-bases and ramenta. The section is rather thick, but most of the tissues can be well made out. The pith is partly macerated, but shows its outer tissues and the large gum-canals all through it. The irregular groups of primary wood can be recognised, though in this part the section is rather thick. The zones of secondary wood, cambium, and broad phloem are all well preserved. The exit of several large fan-shaped leaf-traces shows well. The leaf-bases are cut obliquely and show bundles in various directions.

V. 8410. An oblique, poorly preserved section showing cone-bracts etc. (Cut from small block V. 5706.)

V. 8422. Text-fig. 12. A small section, $3{\cdot}5 \times 1$ cm., of obliquely cut stalks, bracts, ramenta, and three seeds. One of these (text-fig. 12) shows the tracheid group at the base of the seed, inside the integument, in a very beautiful state of preservation, the delicate scalariform markings of the irregularly shaped tracheids showing excellently with the high power. As the upper end of the seed has been cut very tangentially, the section slopes through the large-celled tissue of the inner soft zone of the integument, which shows unusually well. At the base of the seed the cells of the stone-layer and the outer flesh of the testa are also preserved exceptionally well for this species.

V. 8425. Figured by Carruthers, Trans. Linn. Soc. vol. 26 (1870), pl. lix, figs. 7 & 8. Obliquely cut section passing through cone-receptacle, seed-stalks, interseminal scales, and seeds ($3{\cdot}5 \times 1{\cdot}8$ cm. in area). Two seeds on the right, to which a small arrow points, are those figured by Carruthers. One is cut nearly medianly and shows the vascular strand at the seed-base, but not so well as in V. 8422. The section, however, is favourably cut, and at the apex shows the base of the micropylar extension. A neighbouring seed shows the inner tissues of the seed, as well as the stone and outer flesh, unusually well preserved.

V. 8426. Oblique section (6 × 4 cm.) through cone and the surrounding bracts. Most of the tissues are thick and opaque. Some of the seeds are cut very tangentially, so that the surface-view of the stone-layer appears in small tessellated patches, as Carruthers figures in his pl. lix, fig. 8.

V. 8427. Figured by Carruthers, Trans. Linn. Soc. vol. 26 (1870), pl. lix, fig. 5. Approximately transverse section through a cone, cutting also bracts, leaf-bases, and ramenta, all of which are well preserved. In the centre of the cone-section the seed-stalks are surrounded by well-preserved interseminal scales. The vascular bundles in the leaf-base are well preserved, and show their characteristic Cycad-like mesarch structure very well. Sections of the multicellular ramenta are also good.

V. 8428. Figured by Carruthers, Trans. Linn. Soc. vol. 26 (1870), pl. lix, fig. 4. Oblique section (3·5 × 2·3 cm.) of part of a cone with seeds, seed-stalks, and surrounding bracts. The tissues are all blackened and opaque and not very well preserved, but the embryos in the seeds show particularly well, as is indicated in Carruthers' drawings. The embryos are cut in different directions, some nearly longitudinal and some in transverse section. The seed at the top of the slide shows particularly well the two cotyledons cut across, and the indications of the single row of vascular bundles remaining in each.

V. 8429 a. Figured by Solms-Laubach, Bot. Zeit. 1890, pl. x, figs. 1–4, & Ann. Bot. 1891, pl. xxvi, figs. 1–4. A much broken section similar to the above, in which little but the seeds remain. In them the transversely cut cotyledons of the embryos show very well.

V. 8429 b. A much blackened and opaque section of a leaf-base and part of a cone (5 × 2·5 cm.).

41388 a. A much blackened and partly disintegrated section (5·5 × 3·5 cm.) of an oblique cut through part of two cones, bracts, etc.

41388 b. A section of part of a cone and bracts (5·5 × 2 cm.). The testa and bract tissues are well preserved; one of the seeds is cut in nearly median longitudinal section, and shows both the basal vascular strand and the micropylar regions remarkably well.

41388 c. A section of opaque fragments (2 × 3 cm.) with two poor seed-sections at one side.

41388 d. A small section with a few seeds in which the embryonic and seed-coat tissues are well preserved.

The last four slides cut from four small pieces numbered **41388.**

V. 13205, 13206. Two large sections, 11 × 7 cm. in area, showing the wood etc. of the main axis and several leaf-bases, ramenta, etc. The tissues are well preserved and the sections thin. Cut from block V. 13203.

All the above series of slides are from the type-specimen of *B. Gibsonianus*, and have been transferred from the Botanical Dept. from time to time without special histories.

The following blocks have had sections cut from them:—

V. 6140. A small slice (3·5 × 2 cm.) from the middle of a cone.

V. 6317. Two larger and three very small scraps of leaf-bases and seeds.

V. 5706. A small irregular piece of leaf-base and obliquely cut cone, from which slide V. 8410 was cut.

41388. Two larger and two very small irregular fragments, from which slides 41388 *a–d* were cut.

V. 13203. A good-sized block (12 × 10 × 7 cm.), smoothly cut on three sides and externally showing parts of broken and weathered leaf-bases and mineral matrix. The cut faces expose the stem, with its pith and vascular cylinder, and the large leaf-bases (up to 7 cm.) in various obliquely longitudinal sections.

V. 13204. A second piece (12 × 13 × 8 cm.) very similar to the above.

Slides V. 13205 and 13206 cut from the last two blocks.

All the above have been transferred from the Botanical Dept. and are part of the type-specimen.

The following *slides* have just been cut from a fragment of the type at Kew, recently transferred to the Geol. Dept. of the Museum. They will be described by Prof. Seward :—

V. 13237 a. Incomplete oblique section of cone, showing about a dozen seeds cut in various directions, a number of obliquely cut seed-stalks, ramenta, and parts of scales.

V. 13237 b. A much disintegrated section, but one which shows particularly well the shape and tissues of the cone-receptacle with the attachment of the seed-stalks and interseminal scales, cut longitudinally, slightly oblique.

V. 13237 c. Oblique section of a few seeds and scales, the seeds having their testal tissues and the embryonic tissues particularly well preserved.

V. 13237 d. Transverse section of a small part of the main axis showing wood and leaf-traces, very beautifully preserved.

V. 13237 e, f. Two smaller and much less perfect fragments of the above.

V. 13237 g. Oblique section of some seeds, scales, etc., the tissues of which are rather broken and macerated.

V. 13237 h. A section with several obliquely cut seeds, cut nearly horizontal to cone-axis. In the centre, a seed-stalk shows beautifully the placing of the inter-seminal scales round it. Tissues of the bract-scales are also very well preserved.

Bennettites Allchini, sp. nov.

[Plate I; text-fig. 13.]

As no sections of the specimen have been cut, and as the material appears to be too imperfectly petrified for anatomical study, a diagnosis of the external characters alone can be given.

Diagnosis.—Trunk 26+ ? cm. high, 21×14 cm. in diameter (the elliptical compression petrifact?). Leaf-bases rhomboidal, very small, $1{\cdot}5 \times 1$ up to $2 \times 1{\cdot}5$ cm., tangentially extended. Pith apparently $12 \times 4{\cdot}5$ cm. (woody axis too decayed for description). Leaf-bases much less extensive than in *B. Gibsonianus*, apparently only up to 3 cm. in thickness in transverse section of the trunk.

Several cones embedded between leaf-bases, about 1·5–2 cm. in transverse section.

Horizon.—Hythe or Folkestone beds, Lower Greensand.

Locality.—Near Ightham, Kent.

Type.—A large specimen in the Maidstone Museum (a plaster cast in the Brit. Mus. Nat. Hist., Geol. Dept. V. 13201).

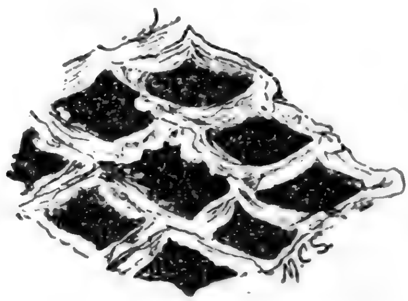
Description.—This handsome specimen from the Kentish Lower Greensand seems to be the only example of its kind. The petrifaction of the inner tissues would probably be incomplete, judging from the external texture of the fossil, and as it is a unique specimen no sections were attempted. It shows well, however, the leading characters of the genus *Bennettites*, both in the pith-cast at the top of the specimen, the closely packed persistent leaf-bases, and the numerous small cones embedded closely among the leaf-bases. The trunk was evidently longer in life than at present (26 cm.), for its broken upper end shows no sign of a natural termination.

The *pith* is preserved only as an irregular central cast (see the upper end of the specimen in Pl. I). The diameter of the pith is $12 \times 4{\cdot}5$ cm., and it is very much decayed and weathered.

It shows, however, the characteristic lenticular furrows forming the corrugated surface of the pith-cast so commonly preserved for plants of this affinity (cf. *Cycadeomyelon*, p. 54).

The *vascular cylinder* appears to have been a monostele, in the form of a single hollow cylinder, forming secondary wood. There is no sign of a secondary cambium.

The *leaf-bases* do not form a massive zone round the axis to the extent common in the genus, and appear to account for no more than about 3 cm. in the thickness of the stem. In tangential view they are roughly rhomboidal, and measure about 1·5–2 cm. by about 1–1·5 cm. vertically. They are mostly weathered out, and by analogy one may judge that the ridges between them represent cork and a mass of ramenta (see text-fig. 13).



Text-fig. 13.—*Bennettites Allchini*, sp. nov. Drawing of a few leaf-bases showing their shape, the ridges between them, and their deeply weathered-out centres. Nat. size.

Cones are buried among the leaf-bases in considerable numbers, and will be easily recognised in Pl. I. They are small, measuring only about 1·5–2 cm. in diameter. Most of them are much weathered out, and show no definite structures beyond the central cone-receptacle.

Comparison with other Species.—The only other British Lower Greensand *Bennettites* described in detail is *B. Gibsonianus* (see p. 28).

The specimen differs notably from *B. Gibsonianus* in the size of its leaf-bases, which are remarkably small, measuring only 1·5 × 1 up to 2 × 1·5 cm., whereas in *B. Gibsonianus* they measure 3 × 2 up to 4 × 2·5 cm.; and also in the smaller size of the cones, which measure apparently only 1·5 up to 2 cm. in diameter, while those of *B. Gibsonianus* measure 2·5 up to 3 cm. Another noticeable feature in which this plant differs from the only described British Lower Greensand form, is in the relative massiveness of the trunk and the leaf-bases. In the new species, where the trunk measures 21 cm. in diameter, the leaf-base thickness is only 3 cm.; but in *B. Gibsonianus*, with a trunk only 28 cm. in diameter, the leaf-bases account for about 7–10 cm. in the total diameter.

These differences are sufficient to indicate that we are dealing with a species different from *B. Gibsonianus*. Without the internal anatomy absolute certainty cannot be reached, but it seems to be a new species.

So far as I can judge, the specimen described by Capellini and Solms-Laubach (1892, p. 207) under the name *Cycadeoidea Capelliniana*, Solms, seems to approach it nearer than the other forms in the shape, size, and appearance of the leaf-bases. The only indications given in their figures of the cones in this species, however, make them out to be much larger than in the British specimen; while this may not be a true specific character, and may be due only to differences in age, it is a point that cannot be determined with the available material.

From the much older rocks of Portland, Buckland described a species named by him *Cycadeoidea microphylla*. The plant he figures (Buckland, 1828A, pl. xlix) is very much larger than our specimen (measuring, according to his illustration, 45 cm. in diameter), and the size of the individual leaf-bases also is greater. In the Museum there are now a number of Portland specimens labelled with this specific name, several of them much smaller than the type, but even in these the leaf-bases are distinctly larger than in our new form, and measure commonly over 2 cm. in tangential diameter; Buckland gives the size as 1 in. (2·5 cm.). (See also Appendix.)

As the difference in age between the plants is so great, I should in any case hesitate to place them in the same species without definite characters being determinable in each (see also Appendix, p. 295). I therefore name the new species after Mr. Allchin, the Curator of the Maidstone Museum, in which the type-specimen is preserved, to whom we are indebted for opportunities of studying and taking a cast of it.

V. 13201. Cast of the type-specimen. The cast gives an exact impression of the specimen (see Pl. I), and shows the pith, leaf-bases, cones, etc., as described above.

Made in the Museum, 1914.

Bennettites maximus, Carruthers.

[Text-fig. 14.]

1870. *Bennettites maximus*, Carruthers, Trans. Linn. Soc., vol. 26, p. 699.

1887. *Bennettites maximus*, Solms-Laubach, Einleit. Paläophytol., p. 100.

1891. *Bennettites maximus*, Solms-Laubach, Ann. Bot., vol. 5, p. 432.

1906. *Bennettites maximus*, Wieland, American Fossil Cycads, p. 19.

Diagnosis.—Trunk 22+ ? cm. high, 30 × 17 cm. in diameter (the elliptical compression shows no sign of being unnatural). Leaf-bases apparently rhomboidal, about 3–4 cm. (?) in tangential width. Pith 14·5 × 7 cm. Woody cylinder exceedingly slender, broken by leaf-trace exits. Xylem only 2 mm. in radial thickness, phloem 4 mm. A single cambium gives rise to the secondary vascular tissues. Leaf-bases extensive, about 7 cm. in total thickness in the transverse section of the stem.

The original diagnosis given by Carruthers is as follows (1870, p. 699):—"Trunk large, oval; medulla large; woody cylinder very thin and repeatedly broken; cortical layer large, everywhere penetrated by the ascending lunate vascular bundles, which are small and very numerous; sections of petiole triangular, with the lateral angles produced and very acute; ramentum very abundant and separating widely the bases of the leaves."

Horizon.—Lower Greensand.

Locality.—Shanklin, Isle of Wight.

Type.—The only specimen known, a large trunk cut in two in the Museum of Practical Geology, Jermyn Street (Registered No. 27,034).

Description.—Beyond the diagnosis quoted above, Carruthers merely notes that it is "very near to *B. Saxbyanus*; but can easily be distinguished by its greater size, and by the very slender woody cylinder." From an examination of the type and only specimen the following points can be added.

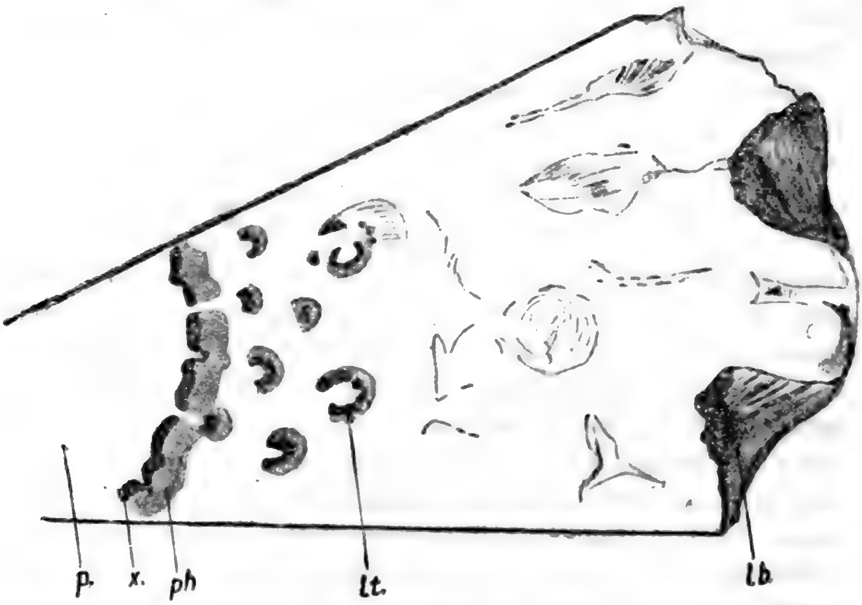
The large trunk has evidently been rolled about on the beach, because not only are the usually sharp ridges between the leaf-bases rounded and weatherworn, but it has a number of small beach-gravel pebbles wedged firmly into the deeper angles of the weathered surfaces. The block is cut in half horizontally, and the surface of one half is polished. The texture of the specimen is firm and dark, and much more like *B. Gibsonianus*, the other Lower Greensand species, than the Wealden *B. Saxbyanus*.

Before cutting, the whole specimen must have been of a flattened oval-lenticular shape, and measured $30 \times 17 \times 22$ cm., thus being considerably larger than *B. Gibsonianus*. The upper end is broken off and weathered, and has been ground down and pounded nearly flat by natural agencies. The general contours suggest that the trunk, when alive, was considerably taller than the 22 cm. now remaining. A number of very deep, almost cylindrical, funnelled-out hollows are present in the weathered exterior, and at first may be taken to represent decayed leaf-bases. These hollows are about 4 cm. deep and 1·5–2 cm. across, while between them are thick ridges about 1·2 cm. thick. Solms-Laubach remarks on the specimen (1890, transl. 1891, p. 432), and it is evident that he considers them as weathered-out cones. Their lining, which is ribbed by what might might very well have been the bracts, tends to support this view; on the other hand, they are so numerous that the true leaf-bases appear rather inadequately accounted for if they are all to be reckoned as cones. Owing to abrasion the natural contours are obliterated, and it is impossible to trace the exact size and shape of the leaf-bases. So far as can be judged from the cut surfaces, parts at least of the internal anatomy are well petrified and should yield good microscopic preparations.

The *pith* is $14{\cdot}5 \times 7$ cm. in diameter. It is impossible to determine its structure, but a few white flecks in the dark matrix suggest the presence of gum-canals.

The *vascular tissue* is a hollow cylindrical monostele. The secondary xylem and phloem form one ring, and originate from a single cambium. The woody cylinder is repeatedly broken by the outgoing leaf-traces. The vascular cylinder is astonishingly slender for a plant of the size, the xylem measuring only 2 mm. in radial thickness; the phloem is relatively thick, and appears to be 4 mm. in radial extent, so far as can be judged from the polished surface.

The *leaf-traces* arise as curved single bundles, completely breaking through the stele, in which they leave gaps. In the wide *cortex* the leaf-traces are very conspicuous and soon curve into a deeply arched horseshoe, which breaks up to form almost a ring of bundles (see text-fig. 14).



Text-fig. 14.—*Bennettites maximus*, Carr. Drawing of part of the cut surface of the trunk. *p.*, pith; *x*, xylem; *ph.*, phloem; *lt.*, leaf-trace; *lb.*, leaf-bases weathered out in the outer, waterworn surface. × about ⅔ nat. size.

The specimen is not cut to show the tangential arrangement of the leaf-base bundles, and one can only guess at the cones.

Comparison with other Species.—As Carruthers himself points out (1870, p. 699), this specimen recalls *B. Saxbyanus* in many ways. Without sections to show the internal anatomy, detailed comparisons are impossible, but it is immediately noticeable that though the trunk is much larger than in *B. Saxbyanus* (measuring 30 cm. as against 25 cm. of the latter species), yet the woody cylinder is strikingly slender, and measures only 2 mm. in the xylem zone. In *B. Gibsonianus*, on the other hand, also a smaller trunk, the woody zone is 16 mm. and more across in some of the new sections. Such a wood cylinder as that of our fossil forms a remarkable contrast to the American *Cycadeoidea* (*Bennettites?*) *Jenneyana*, for instance, where there is a close secondary zone of wood 80 mm. and more thick.

Without microscopical investigation it is, of course, impossible to attain final certainty, but, so far as can be judged, Carruthers was fully justified in placing this form in a species by itself. It is clearly different from the two other Lower Greensand forms.

Pseudo-genus **CYCADEORACHIS,** nov.

Diagnosis.—The stout, pinnately branched rachises of Cycadean foliage, which, while indicating the general character of the frond, does not show the shape of the pinnæ well enough to be associated with any of the many foliage-genera.

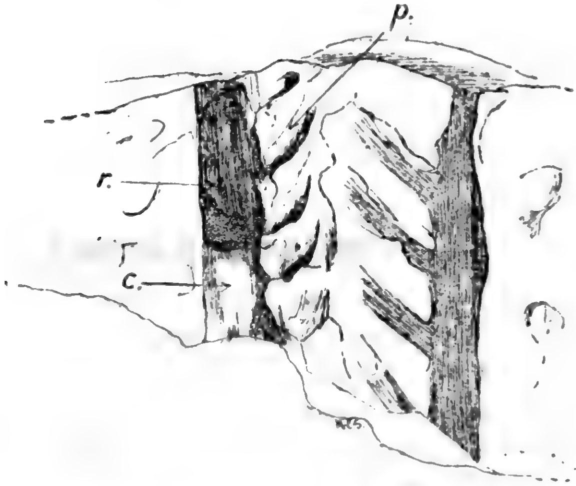
The sturdy and massive foliage of some of the Cycads, with their thick rachises and strong lateral pinnæ, is often preserved in coarse matrix, which does not retain any of those finer characteristics needed for the specific determination. For such specimens a comprehensive term such as the above may usefully be employed.

A good specimen of this kind is the following:—

V. 6690. In a mass of matrix ($17 \times 12 \times 6$ cm.) lie two sturdy rachises, about 1·5 cm. in diameter. One of these is nearly circular, half of the cylinder of the rachis being broken out of the matrix, the other is represented only by a flattened cast (see text-fig. 15); both show stout laterals which look like somewhat curled pinnæ. While these are more likely to be Cycadean than anything else, it is not impossible that they are part of a large palm-leaf. No decisively determinable remains of palms are recorded for this deposit (see p. 258), while other Cycadean remains are fairly common in the quarries in the Kentish Rag. The decomposing plant-fragments which I was able to detach yielded no helpful data. Kentish Rag; Maidstone. *No history.*

V. 6597. A rather similar specimen, in which a considerable number of pinnæ (?) lie partly embedded in the matrix. Iguanodon Quarry (Kentish Rag); nr. Maidstone.

Presented by W. H. Bensted, Esq., transferred from Botanical Dept., 1898.



Text-fig. 15.—"*Cycadeorachis*," presumably the rachis of a Bennettitalean leaf, showing the strong central rachis, *r.*, from which pinnæ (?), *p.*, are given off. *c.*, hollow cast in which the rachis lay. ⅓ nat. size. V. 6609.

Pseudo-genus **CYCADEOMYELON,** Saporta.

[Paléont. Franç., vol. 2, 1875, p. 331.]

Diagnosis.—"Medulla centralis primum substantiæ cellularis disperditione evanida, dein sedimento cylindrum lignosum intus vacuum cumulonte substituta et tunc post ligni circumfusi abolitionem cylindrum plenum plus minusve compressum fasciculorum meatuumque impressionibus superficialiter notatum efformans." (*Saporta.*)

While it is obvious that pith-casts alone do not represent a true genus, nevertheless such entirely de-lignified specimens are exceedingly common in the Jurassic and Lower Cretaceous deposits, and are much better described by such a pseudo-generic name which both indicates their true nature and affinity, than by such "generic" names as *Bucklandia, Fittonia*, etc., which are often applied to specimens showing leaf-bases as well, and cover a large number of different forms.

Exact determinations of the casts are impossible. As described by Saporta, the longitudinally running grooves and ridges form very narrow, vertically placed rhomboidal protuberances in which "Les parties saillantes correspondent évidemment ici à l'embouchure des prolongements médullaires, et les sillons à l'empreinte des faisceaux ligneux qui circonscrivent la moelle."

Species of various shapes and sizes have been described (see, for example, Lignier, 1895, p. 133).

The shape and nature of the lenticular ridges vary so much on the same specimen that it is evident that they alone cannot be used as reliable specific characters.

This pseudo-generic name is, however, useful if employed in a sense parallel with that of the term "*Sternbergia*," etc.

V. 761. A Cycadean pith-cast 22 cm. long, in shape a tapering cylinder 7×6 cm. in diameter, tapering to 5×3 cm. in diameter. At the narrower end there are internally some fragments which are suggestive of plant fragments, but the specimen, as a whole, is merely a cast in sandstone without vegetable tissue. Externally the surface is irregularly ridged by the long narrow lenticular or rhomboidal ridges characteristic of the "genus"; the ridges vary considerably, ranging from 3×12 mm. to $1{\cdot}5 \times 40$ mm. Between the ridges which stand out in high relief are finer vertical striations.

The specimen is much smaller than the pith in *B. Allchini*, and is probably from another, unknown, species.

Kentish Rag (Lower Greensand); near Maidstone.

Presented by F. H. Butler, Esq., 1885.

Another, and similar specimen, found in the Iguanodon Quarry, is now in the Maidstone Museum.

Sub-class CONIFERALES.

Stems much branched, tree-forms preponderating. Leaves simple, generally small, and with "xerophytic" morphology, principally evergreen. Sporophylls, bearing either seeds or pollen-grains, form separate and distinct cones. Male cells non-ciliated, and almost passive within the pollen-tube. Integumented seeds borne unenclosed upon open scales, which, however, may overlap so as to hide them. Embryos either dicotyledonous or polycotyledonous.

Casts or imperfectly petrified ♀ cones, casts or impressions of leaves, and decayed or well-petrified portions of the secondary wood of main trunks and branches, form the principal fossil remains of this group, of which a good general account is given by Seward (1895, pp. 185 et seq.).

In the Lower Greensand deposits at present being described, foliage twigs and cones are both exceedingly rare and can easily be dealt with under their respective families; fossil woods, on the other hand, are present in large numbers and offer a complex problem.

The researches touching the determination of fossil coniferous woods date from the beginning of last century, and are very extensive. A complete survey of the literature cannot be attempted here, but the following notes indicate some of the more important papers.

Hartig (1848) is given the first place in the historical sequence by Kraus (1864), who remarks on the accuracy of much of his detailed observation. Goeppert's famous monograph, which is the basis for several of the leading genera, was published in 1850. Outstanding, not only among the earlier writers, but among all work on the subject, is Mercklin's (1855) monograph for his magnificent illustrations of the exact appearance of the minutest details of a number of woods. In many of his drawings he illustrates well the pitting of the medullary ray-cells, a feature often overlooked by more recent workers.

Kraus made important investigations in 1864, 1865, and 1866, and in a section of Schimper's 'Paléontologie' (1870) established five of the main groups in which fossil coniferous woods are still placed, though his system has been considerably extended and further subdivided by Schröter (1880), Gothan (1905, etc.), and others.

Among papers of less significance about this time and even later, much stress was often laid on the width of the annual rings—a very deceptive character. As Conwentz (1876, p. 21) pointed out, the width and character of the annual ring varies "nach Klima, Boden, Alter, Organen, Arten und Geschlechtern." The height of the medullary rays also varies very much according to the age of the plant.

Schröter (1880) described some fossil woods from König-Karls-Land, and also considered and revised the classification of woods in general. Curtailed by cutting out the lists of genera included in each section, his revision of Kraus' system is as follows :—

I. Ohne zusammengesetzte Harzgänge (oder solche nur ausnahmsweise in Markflecken vorkommend).
  A. Harzzellen fehlend (oder sehr spärlich).
    α. Holzzellen ohne spiral fasern ;
      1. *Araucarioxylon* Kr., Tüpfel, wenn einreihig, gedrängt, wenn zweireihig, alternirend. Radiale Markstrahlzellwände mit 2 bis 10 Poren pro Holzzelle.
      2. *Cedroxylon* Kr., Tüpfel einreihig, selten zweireihig und dann opponirt. Radiale Markstrahlzellwände mit 1–4 Poren pro Holzzelle (nach Kraus).
    β. Holzzelle mit Spiralfasern (neben den Tüpfeln).
      3. *Taxoxylon*.
  B. Harzzellen reichlich :
      4. *Cupressoxylon*.

II. Mit Harzgängen (die lebenden hierher gehörigen Coniferen ausnahmslos auch mit zusammengesetzten harzgangführenden Markstrahlen).
      5. *Pityoxylon* Kr.
        1. Unterform : Markstrahlenzellen auf den radialen Längswänden nur mit kleinen Poren, ohne zackige Verdickungen in den äussersten Reihen.
        2. Unterform : Markstrahlzellen mit wenigen grossen (Ei-) Poren, aber ohne zackige Verdickungen der äussersten Reihen.
        3. Unterform : Mit Eiporen und zackigen Verdickungen.

Other writers, however, have not all been content with the comparatively small number of "generic" names used by Kraus, Schröter, and others, and have added to them. Felix (1882), for example, proposes the pseudo-generic names *Rhizocupressinoxylon*, *Cladocupressinoxylon*, etc., which are now discarded as valueless.

Kraus (1883), after describing some new species, gives a further consideration to the details of the identification of fossil woods in general, and revises the values attached to several features. He points out the importance of comparing parts of similar age, owing to the changes which take place as the size of the plant increases; and notes many other precautions which have been largely overlooked by the older writers. He carefully considers the values of the tangential pits in the tracheids, draws up general rules regarding their occurrence, and gives careful measurements and comparisons for many details of wood-structure. Regarding the medullary rays he says:—"Es ist offenbar, dass von den beiden Merkmalen, der Häufigkeit und der Höhe der Markstrahlen, das erstere bessere diagnostische Verwerthbarkeit verspricht als das letztere; die Häufigkeit der Markstrahlen dürfte daher zweckmässig als regelmässiger Terminus in jede Diagnose einzuführen sein." But later work has undermined the value of this feature also, though the importance of the medullary rays is now more fully recognised than ever before.

In many of the older diagnoses and descriptions, the vertical height of the medullary rays is held to be a character of specific value; the exhaustive and detailed work of Essner (1883), accompanied by many tables of measurements, disposes of this view, for he concludes that "Endlich zeigen auch verschiedene Individuen derselben Art nicht nur in den gleichen Jahrringen, sondern auch in Gesammtheit beträchtliche Differenzen."

Beust (1884) and Vater (1884) both consider at length the determination and estimation of the values of various details in fossil woods in papers which are still often referred to. An early and careful account of the pitting in the medullary ray-cells is given by Kleeberg (1885), who also examined the character of the walls in the ray-tracheids.

A useful historical summary of the numerous papers published up to date appears in Knowlton's (1889 A) work on the fossil woods of the Potomac, to which reference should be made. Every following year some papers describing fossil woods have appeared, but the next contribution of real importance is perhaps that of Conwentz (1892), who describes the remains of *Pinus* from amber very elaborately and with good illustrations.

In 1905 Gothan published his work on fossil woods, which has doubtless done much to stimulate research in wood-structures and to systematise our knowledge. He lays great stress on the pitting of the medullary ray-cells, a truly important character which most of his predecessors had overlooked.

His system of classification (abridged) is as follows:—

A. Hoftüpfel klein, alternierend, oben und unten abgeplattet, wenn mehrreihig, allseits (polygonal abgeplattet).	*Dadoxylon*, Endl., ex p. = [*Araucarioxylon*, Kraus, *Cordaïoxylon*, Felix, *Cordaïoxylon*, Grand' Eury, *Araucarites*, Goeppert, *Cordaïtes*, div. auct.].
B. Hoftüpfel rundlich, grösser, nicht gedrängt; wenn mehrreihig, meist gleichhochstend.	In this, with further detailed diagnostic characters, he includes the following genera:— *Taxoxylon*, Unger, ex p. *Piceoxylon*, Gothan, *Pinuxylon*, Gothan, *Cedroxylon*, Kraus, *Cupressinoxylon*, Goepp., *Glyptostroboxylon*, Conw., *Taxodoxylon*, Gothan, *Podocarpoxylon*, Gothan, *Phyllocladoxylon*, Gothan.

To these his later works (1908, 1910 A) have added more genera, some of them well founded (such as *Protopiceoxylon*), others which do not seem likely to stand the test of time, and appear to be based on characters which are less good specific criteria than he thought at the time the genera were founded.

Jeffrey and his pupils have proposed many generic names, frequently without either diagnosis or description, and nearly always based on an interpretation of facts or theories which it is difficult to follow. No adequate criticism of these genera can be made here, but reference will be made to them from time to time in connection with the fossils at present under description.

In 1907 Penhallow published his exhaustive book on the North American gymnosperms, in which he describes and illustrates many features of the wood which had often either been forgotten or overlooked. He has a specially good section on the medullary rays, and points out their great interest and significance. Regarding the rays he says (p. 101): "No other portion of the stem possesses so many elements of importance as the medullary ray, which, in consequence, attains the highest value in this respect [classification] and affords differential characters of wide range, great prominence, and easy recognition, and is of primary importance in the differentiation of groups, genera, and species; and, as a general summary, the utility of these characters for such purposes is approximately indicated in the following tabulation :—

"(1) Rays (tangential) of two kinds.
(2) Ray-tracheids.
(3) Pits on the lateral walls of the ray simple or bordered.
(4) Terminal walls of the ray-cells thin and entire or locally thickened. — Generic.
(5) Form and character of the ray-cell (tangential).
(6) Form and size of the pits on the lateral walls of the ray-cells.
(7) Ray-tracheids denticulate or reticulated.
(8) Direction and form of orifice of pits on the lateral walls of ray-cells. — Specific."
(9) Upper and lower walls of ray-cells.
(10) Ray-tracheids interspersed or marginal.
(11) Disposition of pits (radial).
(12) The number of pits per tracheid.

The second half of Penhallow's book gives systematic series of useful diagnoses of nearly all the living and fossil genera, and of the American species, but he has no short general key such as is supplied by Gothan.

The value of the study of reversions to archaic character under the stimulus of wounding has been much accentuated by Prof. Jeffrey and his pupils recently, particularly in connection with the formation of resin-canals and ray-tracheids (see Jeffrey, 1903, 1905, etc.). In addition to this, Jeffrey (1908) records the presence of ray-tracheids due to a wound, in a living plant of *Cunninghamia sinensis*, where they would not normally occur, and also has found ray-tracheids besides traumatic resin-canals in a Miocene fossil attributed by him to *Sequoia* (1904), as well as in the living species (1903).

The elaboration by many students of the recent work on woods, has accumulated data illustrating the immense variety and also the intermingling of detailed characters in the various families, so that very minute points of difference have now to be studied. For instance, Gerry (1910) and others of Prof. Jeffrey's students, following her, have used the "bars of Sanio" as of constant diagnostic worth. She says (p. 122):—"The distribution of the bars of Sanio as above described establishes a constant and useful diagnostic character in the determination of fossil woods. In woods with Abietineous affinities we always find bars of Sanio, even though at the same time we may find more or less Araucarian-like pitting. But in the Araucarineæ we never find bars, although in fossil forms such as the Araucariopityoideæ and the Brachyphylloideæ we find Abietineous as well as Araucarian pitting." As, however, Gothan (1910) points out, the lack of "bars of Sanio" in the Araucarineæ is very simply explained as being due to want of space between the crowded borders, while Groom (1913) has demonstrated that the American writers are in reality referring to the "rims" of Sanio. Furthermore, Holden (1914) has put an end to the systematic value attributed by Prof. Jeffrey and his pupils to the "bars of Sanio" by her discovery of an Upper Cretaceous *Araucarioxylon* in which they occur, though it had been held by the American school that their presence was the one sure test which marked off the Abietineæ from the Araucarineæ. Nevertheless, although such minute details are extremely liable to be destroyed in fossils, Holden makes their absence in some of the species of *Cupressinoxylon* from Cliffwood the basis of a new genus, which is not even diagnosed.

The following reasoning is also difficult to comprehend:—"The occurrence of three absolutely typical Pityoxyla, and not a single typical *Araucarioxylon*, among these lignites seems to indicate that in tracing back the families of living Conifers it is the Abietineæ which remain unchanged, and the Araucarineæ which become less and less like living representatives of that family." The large numbers of Araucarioxylons from other parts of the world, not only from deposits of this age, but also from rocks very much older, are here overlooked. The absence of *Araucarioxylon* from this one small deposit is surely a local accident or a record of past geographical distribution, and has no bearing on the relative *phylogeny* of the groups in the face of numerous earlier Araucarioxylons from other parts of the world.

General Remarks on the Present Identification of Coniferous Woods.

As will be gathered even from the short *résumé* of the many papers on coniferous woods given above, several of the older and the more recent writers have laid stress on *minutiæ* which have since proved to be merely individual variations and to have no specific value. Thus in many of the older papers diagnoses depended on the number of elements per annual ring, or on the size of the tracheids, or the height of the medullary rays. Careful study of living and fossil plants proves that these characters vary widely in the same individual, according to the age and time of development of the part of the wood examined; and that in two individuals of the same species great differences in these points are due to local differences of climate, soil, etc. As a consequence, many of the diagnoses, and sometimes the elaborate descriptions of wood-species, can no longer hold. "Genera" even have been founded on what were merely individual differences—for instance, fossils described separately as *Rhizocupressinoxylon* and *Cormocupressinoxylon* by Conwentz can be paralleled from parts of the same stem within a single year's growth, as has been pointed out by Kräusel (1913).

Even recent papers are often overloaded by elaborate measurements of tracheid-size, wall-thickness, or the diameter of the border of the bordered pits. For example, Barber (1898), in his account of a *Cupressinoxylon*, gives hundreds of measurements, and publishes tables illustrating minute variations which are entirely devoid of profound significance. Average measurements within certain rather wide limits are useful secondary characters, but it may now be confidently stated that the following details, which have so often in the past been made the chief basis for specific determination, are actually worthless as diagnostic characters:—width of annual rings and number of cells composing them; thickness of tracheid-walls; diameter of border or of pit in bordered pits; comparatively trivial differences in the height of medullary rays (though here it may be noted that *if in woods of the same age* wide differences occur, such as one wood having generally about 80 and another generally 2 cells in its rays, such a feature is of some value); differences in the *quantity* of resinous xylem parenchyma; and in the proportion of ray parenchyma to tracheids in a given bulk of wood.

Even the presence or absence of ray-tracheids is a less constant feature than was recently supposed, as they have been found in *Cunninghamia* (see Jeffrey, 1908), *Sequoia* (see Gordon, 1912), etc. This being the case, it may well be asked whether there is any possibility of determining fossil woods at all—and the answer is in the affirmative. Gothan especially has directed attention to a very important and relatively constant feature of woods, viz. the pitting of the radial and end walls of the medullary ray-cells. While the details may vary a little, the type of pitting here is remarkably constant in a species. Before accepting his conclusions, I worked over a very large number of both fossil and recent woods, and, as a result, can, in the main, confirm his position when he bases species and even genera on the ray-pitting. Though I must note that the "abietinean pitting" is not an absolute criterion of Abietinean affinity, since I have found that it is present in *Juniperus dentalis* and *J. pachyphlœa*, for instance; nevertheless, the radial pitting of the ray-cells is remarkably constant and is extremely valuable for separating species, for it may differ considerably and constantly in two species so alike in other respects of their anatomy as to be inseparable except from their external characters.

The leading features, which, when taken together, give enough data on which to base fairly reliable determinations are the following:—the presence or entire absence of growth-rings; the presence or absence of *normal* resin-canals in both vertical and horizontal directions, and if they are present the thin-walled, or thick and pitted nature of their epithelium; the presence and position of traumatic resin-canals; the presence or entire absence of resinous or other wood parenchyma; the presence or absence of tangential pits in the tracheids (the arrangement of the round bordered pits or absence of Sanio's bars is of secondary value); the presence of hexagonal-bordered pits in two or more rows in the radial walls of the tracheids; the uniseriate or multiseriate nature of the medullary rays; the thickening and pitting of the end walls and lateral walls of the ray-cells; the presence and character of ray-tracheids; and, in general, the degree of specialisation and differentiation of the cells of the medullary rays.

All the descriptions in the following catalogue of woods are necessarily brief, and might be much elaborated if circumstances permitted. For instance, the ray-tracheids in the Abietineæ have long interested botanists, but the descriptions of well-preserved fossil ray-tracheids on pp. 98, 110, etc., refer merely to the salient features which characterise the species. These fossils would repay detailed examination, such as Thompson (1910) has given to the ray-tracheids of living pines. All the phylogenetic conclusions reached by botanists from a study of living species must bear critical examination in the light of the actual features shown by these ancient fossil forms. Thus Thompson (p. 14) says: "That they [the ray-tracheids] are of cenogenetic origin is further indicated by the fact that in the older pines, the Pityoxyla of the Cretaceous, as described by Jeffrey and Chrysler, no ray-tracheids occur." [See also Holden (1913), p. 62), Bailey (1910, p. 293) and many others.] Now Jeffrey and Chrysler's *Pityoxyla* are of *Upper* Cretaceous age, and in the present work are described several forms of *Lower* Cretaceous age in which beautifully developed ray-tracheids are present.

It appears that for the present fossil woods are most usefully described in relatively few "genera" with wide diagnoses, and very minutely separated specifically, with very full and careful specific diagnoses and descriptions. I therefore propose to adopt the following scheme of classification:—

I. Resin-canals universally absent. Bordered pits in two or more rows, alternating and hexagonally compressed, or in one row, flattened or rounded. Medullary ray-cells all alike, with several small, bordered pits per tracheid-field in their radial walls. } *Araucarioxylon.*

II. Resin-canals present or absent. Bordered pits generally in a single row—if in two, the pits side by side and not alternating or compressed. Medullary ray-cells sometimes highly specialised and differentiated. Ray-tracheids often present.

A. Secondary tracheids with strongly marked accessory spirals. } *Taxoxylon.*

B. Secondary tracheids without spirals or with very fine and delicate markings. "Abietinean pitting" in ray-cell end-walls noticeable.

1. Resin-canals both vertical and horizontal present in wood and in multiseriate medullary rays.	*Pityoxylon.*
2. Resin-canals *only* vertical in the wood. Medullary rays all uniseriate normally.	*Protopiceoxylon.*
3. Resin-canals normally absent. Resin-containing xylem-parenchyma generally absent or present in exceedingly small quantities.	*Cedroxylon.*

C. Typical "abietinean pitting" generally absent. Resin-canals absent, but resin-parenchyma plentiful.

a. Medullary ray-pits small, roundish, 1–∞ per tracheid-field, commonly 1–6.	*Cupressinoxylon.*
b. Medullary ray-pits large, chiefly 1, sometimes 2 per tracheid-field, tending to be laterally extended.	*Podocarpoxylon.*

It must be understood that all the above are "pseudo-genera," and are founded only for convenience of description. Individual species, if well petrified, can often be identified and associated very closely with living genera or species. I think it is extremely important that no two specimens from different countries and different horizons should be identified as the same species, unless there is sufficient absolute proof that they are, *in all their parts,* truly identical. I am in the fullest agreement with Halle (1913), when he says (p. 369)—"The fact of two groups of forms being described under different names does not imply, therefore, that they are necessarily distinct species, but only that they cannot at present be proved to be identical." In this way only can ultimate order be attained, for, as Halle points out, the piecing together of the various organs of a plant then only results in the dropping of some of the names and is very easily accomplished; while if different forms have been included in the same "species," and stratigraphical and phylogenetic conclusions drawn therefrom, the confusion is endless.

Family ARAUCARINEÆ.

Only two living genera compose this family, *Agathis* and *Araucaria*, and both are from the Southern Hemisphere; but numerous fossils of wide-ranging variety must be included in it.

The salient feature of the living forms is the presence of only *one* seed on the seed-scale, which appears to be a single scale, and if it is compound in its origin, it is, at any rate, completely fused to form one structure now. Both male and female sporophylls form large cones, spirally arranged. The leaves are simple, generally broad-based, often large; though small, adpressed foliage is present in some species. The wood is without resin-canals, the pitting on the radial walls of the medullary ray-cells is bordered, and there are generally several pits per tracheid-field. The pits of the secondary tracheids are often adjacent and hexagonally compressed, in alternating rows, though in some parts of even an old tree this feature may be absent.

The family is well described by Seward & Ford (1906). It plays an extremely important part in the palæontologists' records. Its type of secondary wood is almost universal in the Palæozoic, and was widespread and common in the Mesozoic and Tertiary, in which deposits the remains are supplemented by cone-scales, foliage-branches, etc., showing undoubted Araucarian affinity.

Though now restricted to the Southern Hemisphere, the family was widely spread in Europe and North America as well as Asia so late as the mid-Tertiary. Good remains of *Araucaria* itself are found in the British Eocene (see Gardner, 1886, pl. xii, etc., and others). Members of the family are also recorded in the Wealden and Jurassic of this country, and there are many European records of Araucarians from various Mesozoic and Tertiary deposits (*e. g.* Fliche (1896), Velenovsky (1885), and innumerable others; Cretaceous records will be found listed in Stopes, 1913), as well as American representatives (see Berry, 1911, where the Lower Cretaceous, and Knowlton, 1898, where also the Tertiary records are listed). *It is therefore a matter of extreme surprise that there are no representatives of the Araucarineæ in the British Lower Greensand.* It must, of course, be remembered that the material already examined is far from being so extensive as one could wish, but in the course of this work (as the present volume will indicate) I have examined much more material than has hitherto been known from the Lower Greensand of England, and have had a large number of microscopic sections cut from the petrified woods. While it is not impossible that some even of the woods which have passed through my hands and have not been sectioned *may* be Araucarian, I am inclined to think that this is not the case, for I have examined the tracheid-dust of the badly preserved specimens (see Stopes, 1911, p. 56), and have had all the promising pieces cut. The blocks left uncut, though well preserved, were those which seemed externally identical with forms which had become familiar to me during the work. It remains, however, a fact that, among all my specimens, neither wood, foliage, scales nor seeds * show any Araucarian feature which could, even by stretching a point, cause one to look on them as evidence of the presence of Araucarineæ in the Lower Greensand of this country.

In this connection it is noteworthy that in his account of Arctic gymnospermic woods of Jurassic age, Gothan (1910 A) came to the same conclusion regarding them. He says (p. 46):—"Die Jahresringe sind ausnahmslos scharf und deutlich abgesetzt, so dass damals dort oben eine ziemlich fühlbare Periodizität des Klimas geherrscht haben muss. Die Prädominanz der Abietineen, die zu den Verhältnissen einer gleichaltrigen Flora unserer Breiten einen scharfen Gegensatz bildet, ist in dem Spitzbergener Material vielleicht noch deutlicher ausgesprochen als in dem (aus ungefähr gleichen Breiten stammenden) von König-Karls-Land. Ferner hat sich auch nicht ein einziger Rest eines Araucarieenholzes gefunden."

The absence of Araucarian remains in our English Aptian deposits is in all probability not merely an isolated and curious fact, but is probably to be correlated with the lack of the same family in the polar regions. It is possible that it may be, as Gothan supposes in his case, an indication that in the Aptian of S. England there was a cooling of the climate, which was

* *Kaidocarpum minus*, Carruthers (1868), is not forgotten, but, though it is put in *Araucarites* by Seward, its age is doubtful, and it is most likely a derived Wealden plant, as are so many of the fossils of the Potton Sands in which it was found.

certainly subject to well-marked *seasons* (see p. xxii). Unfortunately, there appears to be no evidence from vertebrate or invertebrate palæontology regarding the land-conditions of the time.

If Gothan's data are correct, they indicate, as he points out, that the origin of the Abietinean stock may be circum-polar; but the great obstacle to drawing any of the tempting deductions regarding the earlier distribution of these families is, that the work of Gothan on the polar "Jurassic" woods must be taken with considerable caution when applied to points of stratigraphical importance, for, as Burckhardt (1911) has demonstrated, their age is by no means beyond question. Indeed, it appears to be very unlikely that they are really Jurassic. From data provided in Nathorst's own work (1910), Burckhardt concludes that "die pflanzenführenden Schichten ('Växtforande Lager') ebenso wie der Basalt mitsamt den von Gothan beschriebenen fossilen Hölzern jünger sein müssen als das Neocom mit *Aucella Keyserlingi* da sie dieses transgressiv überdecken." . . . "Die von Gothan untersuchten fossilen Hölzer des König-Karl-Landes haben also gar keine Bedeutung für die Frage jurassicher Klimazonen, da sie nicht jurassisch sind . . ."

These plants, or part of them at least, were described by Heer as Cretaceous (probably equivalent to the Gault), and if that be their age they represent a flora more directly comparable with that of the Lower Greensand than one in an ancestral position toward it.

Regarding England, where the stratigraphical position of the fossils is securely known, the strongly marked growth-rings found in so many of them, coupled with the remarkable and total absence of the Araucarineæ, is highly suggestive of a relatively cool temperate climate for the district in Aptian times, though one must not forget that several species of *Bennettites* still lingered on (see p. 23, et seq.).

Family TAXODINEÆ.

Eight principal living genera compose this family, from various parts of the world, some with very local and restricted distribution. Several of the living genera are certainly represented among the fossils, and also a large number of rather incompletely known fossils are more or less certainly included in the family.

The salient feature of the living forms is the presence of a variable (sometimes very large) number of seeds on the ♀ cone-scales. The ♀ cone-scales are toothed, divided, etc., at the tip and indicate an apparently double origin, and are spirally arranged on the axis. Both male and female sporophylls form cones which are, on the whole, considerably smaller, and also contain fewer scales, than in the Araucarineæ and Abietineæ.

The leaves are generally small, often adpressed. The wood is difficult to distinguish from that of some of the Abietineæ, the pits on the tracheids are generally in single rows, the borders round and isolated.

Genus **SEQUOIA,** Endlicher.

[Synop. Conifer., 1847, p. 197.]

This genus has only two living representatives, the large "Redwood" trees of North America. In Tertiary times, however, numerous fossil representatives occurred in various parts of Europe and elsewhere.

Endlicher's *diagnosis* of the genus is as follows:—"Flores in diversis ramulis monoici. Staminig. Amenta axillaria globosa, subspicata, perulata. Stamina plurima, axi inserta; filamenta brevissime filiformia, in connectivi squamulam late ovatam, verticalem producta, antheræ loculis duobus, connectivi basi continuis, discretis, parallelis, postice longitudinaliter bivalvibus. Seminif. Amenta . . .

"Strobilus subglobosus, squamis coriaceo lignosis, suborbicularibus, ungue brevi excentrico peltatis, lamina rugosa margine involuta, medio breviter mucronata, persistentibus. Semina sub quavis squama, 5–7, infra ejusdem marginem superiorem libere pendula, tuberculis minutis hilo orbiculari inserta, elliptica, compressa, integumento subcrustaceo utrinque in alam membranaceam rigidam, latiusculam, basi ad hilum emarginatam, apice versus micropylen deorsum spectantem sensim angustatam producto. Albumen carnosum. Arbores Californicæ, giganteæ. Rami alterni, teretes, foliis abbreviatis anguste lanceolatis longe adnato decurrentibus vestiti; ramulorum foliis linearibus, alternis distiche lineari-subfalcatis, obtusiusculis v. acutis, rigide coriaceis, persistentibus, supra lucidis, sulco longitudinali exaratis, subtus nervo valido, et utrinque juxta nervum stomatum fasciis albidis notatis. Gemmæ terminales perulatæ, perulis ad innovationes persistentibus. Amenta staminigera in ramulis axillaribus brevissimis solitaria, sæpe spicam foliatam referentia. Strobili in ramulis brevibus, perulis imbricatis tectis ad innovationes solitarii, nucis Avellanae magnitudine, squamis in rhachi persistentibus."

The great majority of the numerous fossil Sequoias which have been described are based on impressions of the foliage. The external foliage characters of many living genera are so confusing that it is not surprising that a large proportion of the fossil determinations are worthless. There are, however, many well-authenticated species of this genus not only from Tertiary, but from Upper Mesozoic deposits in all parts of the world. In particular, various cones form the basis of trustworthy determinations (see, for example, *Sequoia ambigua*, Heer, recently revised by Berry, 1911, p. 449). Indeed, from the Portlandian of France (see Fliche & Zeiller, 1905) upwards, there is little doubt that *Sequoia* and forms very closely allied to it were widely distributed.

Sequoia giganteoides, sp. nov.

[Plate II; text-fig. 16.]

Diagnosis.—Foliage of the type of *Sequoia gigantea*, but smaller; (leaves ·5 mm. in diameter, axis ·3 mm. in diameter) *. Pith soft-celled, xylem bundles of primary wood in small groups, secondary tracheids very small, the largest up to 9 μ in diameter. Stone-cells in phloem. Leaf-trace single, giving rise to a single undivided bundle in the leaf. A large central resin-canal in the leaf, with a group of transfusion tissue on either side. Large palisade-cells radiate towards a double hypodermic sclerenchyma band on the lower surface of the leaf.

* These are probably not true specific characters. If, as is possibly the case, the fossil is an ultimate twig, other leaves of the same plant would certainly have had larger measurements.

Epidermis single-layered, with very thick cuticle. Stomates apparently confined to grooves between the leaf-bases (?).

HORIZON.—Lower Greensand.

LOCALITY.—Luccomb Chine, Isle of Wight.

FINDER.—M. C. Stopes, 1912 (*in situ*).

TYPE.—Three slides from the same twig, V. 13230 *a* and V. 13230 *b* (British Museum, Nat. Hist.) and S B *aa* (Stopes Coll.).

DESCRIPTION.—The type-specimen consists only of a minute twig cut in three sections.

This tiny plant-fragment had drifted into the locally decaying tissue of a larger plant (see p. 247) with other more minute and unrecognisable débris of vegetable cells, mineral granules, etc. With it is also a small seed (see p. 249). It consists of a central axis with secondary wood and six leaves surrounding it, and it is so minute that from the outer epidermis of one leaf to the outer epidermis of the leaf opposite, thus including the central axis and two complete leaves, it measures only 1·2 mm. The general contours and arrangement of the axis and surrounding leaves are seen in Pl. II, fig. 1. The central axis consists of a pith surrounded by xylem and phloem; and the cortex is merged entirely with the tissues of the adpressed leaf-bases. In proportion to the size of the central axis the leaves are large, though actually a single leaf measures only about ·5 mm. at its greatest width. Each leaf contains a single relatively large resin-canal and a mass of large-celled transfusion-tissue, which splits to form two groups, one on either side of the canal. Large palisade-cells lie beneath a hypodermic sclerenchyma-zone one or two cells wide. The epidermal cells are well preserved, and appear to have an enormously thick cuticle (see text-fig. 16, *c*.). From the shape and disposition of the tissues in the leaf, the morphologically under surface is evidently physiologically the upper and exposed one, indicating that the foliage was adpressed to the stem except for the free tips. Stomata appear to have been present only on the upper surface, in the grooves between adjacent leaves, but this is not quite certain. This small adpressed foliage is common in many Cupressineæ, Taxodineæ, etc., that specific determination of such a vegetative twig can only be attempted on a basis of the minutiæ of its internal anatomy.

The minute *axis* contains only pith, xylem, and phloem, as its outer tissues are merged in the leaf-bases.

The *pith* consists of about 12 very small, but relatively to the xylem large, cells (10–15 μ in diameter) of roundish shape and only slightly thickened walls (*p.*, Pl. II, fig. 3). No stone-cells are visible.

The *xylem* is primarily arranged in small bundles, 5 or 6 in number, consisting of four or five elements each; outside, this secondary growth forms a solid ring of wood 6 elements deep in radial direction (*x*, Pl. II, fig. 3). The largest of the secondary tracheids measures 8–9 μ in diameter.

Medullary rays run throughout the wood, and about three cells span the whole radius of the wood.

Phloem is relatively well developed, and forms a zone nearly as thick as the secondary wood. The soft cells are crushed, but a few stone-cells can be seen clearly, and seem to alternate with them.

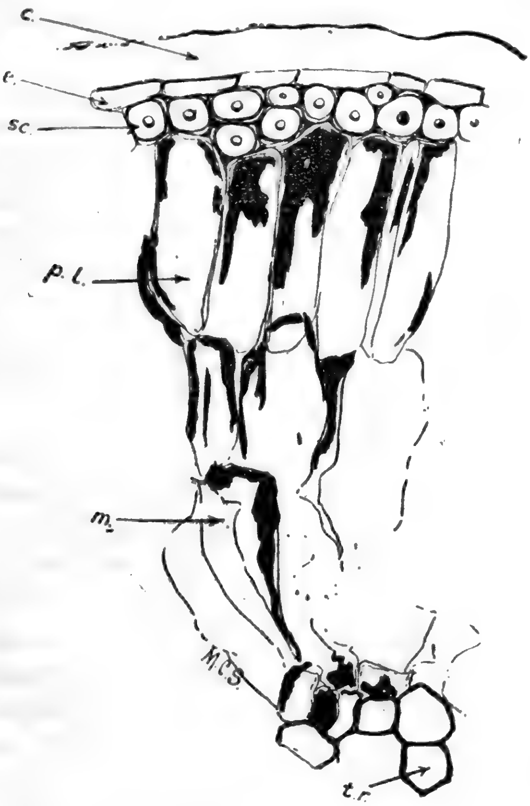
Longitudinal sections are not available, and the oblique one does not reveal the nature of the pitting on the vascular elements.

A small, obliquely cut *leaf-trace*, which appears to be a *single* bundle, can be seen on one side passing out to the largest leaf-base.

The *leaves* are cut at various levels, and therefore appear to have some variety in shape and character. So far as can be judged from the small number of sections, the central large resin-canal dies out at the base of the leaf, and here also the transfusion-tissue forms one large, tangentially extended mass (see Pl. II, fig. 3) before the leaf-trace is completely free from the axial wood. Higher up, what may be considered a typical leaf-section (see Pl. II, fig. 2) shows a large central resin-canal with a patch of transfusion-tissue on either side of it, a small single vascular strand opposite, and a stout curved under surface towards which the palisade-layer radiates (see text-fig. 16 & Pl. II, figs. 1–3).

The *vascular bundle* is very minute, and can hardly be made out in a satisfactory manner. I can only see four tracheids and a little mass of blackened tissue round them.

The *transfusion-tissue* is well developed, first as a single curved band of large thick-walled elements (see *tr.*, Pl. II, fig. 3), and at a higher level of the leaf as two patches, one on either side of the resin-canal (Pl. II, fig. 2, *tr.*). The cells are roundish or hexagonal, with thickened and apparently pitted walls, but as they all appear to be cut in good transverse section the character of their wall-perforations cannot clearly be made out. They are easily distinguished from the mesophyll of the leaf by their smaller size, compact arrangement, and thickened walls,



Text-fig. 16.—*Sequoia giganteoides*, sp. nov. Part of the leaf in transverse section. *c.*, cuticle; *e.*, epidermis; *sc.*, sclerised hypoderm; *p.l.*, palisade-layer; *m.*, mesophyll; *tr.*, transfusion-tissue. No. SB, *aa* (Stopes Coll.).

as can be seen in transverse section (Pl. II, figs. 2, 3, & text-fig. 16, *tr.*).

The *mesophyll* of the leaf is very large-celled, the inner cells being irregularly roundish and tending to break down, the outer series of cells forming a regular phalanx of palisade-cells radiating towards the underside of the leaf (see text-fig. 16, *p.l.*, & Pl. II, fig. 3), where the large size of these cells is apparent.

The *resin-canal* is large and round, and is lined by a double layer of smallish flattened cells. It appears to die out towards the base of the leaf (see Pl. II, fig. 3).

A *sclerised hypoderm*, partly one layer and partly two layers thick (see *sc.*, text-fig. 16), runs all round the outer (under) surface of the leaf. So far as I can judge from the few sections available, this is not interrupted by stomates, so it appears as though the stomates must have occurred only in the grooves between the leaves.

The *epidermis* consists of flattened cells, about equal to two hypodermic elements (see *e.*, text-fig. 16). They appear to have had an enormously thick cuticle (see *c.*, text-fig. 16). This cuticle is very sharply petrified in several leaves, and there is no doubt about its present extreme thickness, but it is very possible that it may have swollen considerably during or before petrifaction. It must, however, have been originally very thick to have swollen so much. Outside it are a number of well-petrified mycelia of fungi.

Affinities.—After the examination of many leaves of living conifers, one recognises that the likeness of this fossil to *Sequoia gigantea* is very noticeable. Without entering into any comparison with the other forms, it may be stated that I feel no doubt at all that the fossil is a species of the living genus *Sequoia* or an extinct genus extremely close to it. In their main features the leaves of the fossil and of *Sequoia gigantea* are similar: both have small adpressed foliage with free tips, both have a one- or two-layered hypodermic sclerenchyma, both have a single, large, central resin-canal with a flat double-layered lining, both have a single vascular bundle with two large masses of transfusion-tissue quite similar in structure in each. As pointed out by Masters (1891, p. 251), the position and number of the resin-canals in the leaf are very constant features, and are consequently of diagnostic value, and the single central resin-canal is found in the genus *Sequoia* at the present day.

Where the fossil differs from the living leaf, the differences are relatively trifling and are only of specific value. The chief differences are as follows:—In the living *Sequoia gigantea* stomates occur frequently on the under surface and interrupt the sclerenchyma-layer; they appear not to do so in the fossil. The palisade-layer in the fossil consists of larger and fewer elements than in the living form, where the cells are more numerous and smaller. The stone-cells scattered in the mesophyll of the living leaf appear to be absent in the fossil. The vascular bundle seems more highly organised in living leaves than in the fossil, but against this must be set the fact that even the ultimate twigs of the living plant have larger leaves than the minute leaves of the fossil.

The axis of the fossil also agrees with the living form in general structure, as well as in the presence of stone-cells in the phloem.

The other living species of *Sequoia*, *S. sempervirens*, has flattened and expanded leaves, unlike the fossil both in external morphology and internal anatomy; but I was interested to find that the small leaves which are crowded round the lateral axes just beneath the cones, have a structure almost identical with that of the fossil and the living *S. gigantea*. This might well be held as substantial evidence in favour of the view that the small-leaved foliage is the more primitive, and the expanded leaves the later modification in the genus *Sequoia*.

It seems not unlikely that the genus *Sequoia* may be represented in the Wealden deposits by some of the impressions of foliage-twigs of the kind so difficult to determine precisely, which Seward includes in the form-genus *Sphenolepidium* (Seward, 1895, pp. 199, 206, etc.). Several such "species," which Heer and others have included in the genus *Sequoia*, have been wisely placed by Seward in the non-committal genus *Sphenolepidium*, but it should not be forgotten that it is likely that several of them were really *Sequoia*.

Hollick and Jeffrey (1909) describe the internal anatomy of some small leafy twigs which much resemble the foliage generally identified as *Sequoia Reichenbachi* (Geinitz) Heer. They show, from the presence of a large pith with stone-cells etc., that the internal anatomy of these minute twigs is not that of the living Sequoias. Regarding Heer's species they say: "As commonly recognised its geographical distribution covered the United States, Canada, Greenland, and Europe, while stratigraphically it apparently extended from the Upper Jurassic to the end of the

Cretaceous period. We, therefore, desire to have it understood that the facts of internal structure, and the conclusions in regard to botanical relationships which are next described and discussed, are referable only to the species as it occurs in the Cretaceous deposits at Kreischerville or their equivalents elsewhere." Nevertheless, in spite of this statement, and in spite of the fact that such small-leaved conifer-twigs are practically unidentifiable from externals alone, they re-name Heer's species and proceed to state at the conclusion of their account: "In the case of the remains commonly called *Sequoia Reichenbachi* we have accordingly to do, not with a species belonging to the modern genus *Sequoia*, but with one of araucarineous affinities."

With our small twig, which in all its anatomical features *is* a true *Sequoia*, Hollick & Jeffrey's specimens have therefore no affinity; but the structure of our leafy twig, which shows indubitably that *Sequoia* was living already in the Lower Cretaceous, makes it more than likely that many of the specimens included by Heer and others in his *Sequoia Reichenbachi*, and removed to the Araucarians by Hollick & Jeffrey, were really true Sequoias as Heer supposed.

Woods of *Sequoia* and other Taxodineæ have not been recognised in the British deposit, but I think it is not impossible that some of the species temporarily described under the broad pseudo-generic names may belong to Sequoias or allied forms. Penhallow (1896) pointed out that in their wood-structure *Taxodium* and *Sequoia* approach each other closely, but are separable, for "in *Taxodium* the pits [on the lateral walls of the rays] are round and the orifice is narrowly oblong, the border therefore broad; while in *Sequoia* the pits are distinctly oval or elliptical and the orifice broadly oblong, the border thus becoming much narrower, and sometimes even obscure, and in petrifactions tending certainly to become very obscure and faint, so that the wood could not but be put in the wide 'genus' *Cupressinoxylon*."

The older writers did not attempt to separate the two genera *Taxodium* and *Sequoia*, but Gothan (1905) stated that the former is distinguished from the latter by the "auffallend starke Verdickung der Holzparenchymquerwände, die man im Tangentialschnitt betrachtet." However, this point was further investigated by Lingelsheim (1908), who found that it did not hold in all cases in the living American varieties he examined.

The likelihood that some of the species of wood now described belong to *Sequoia*, is illustrated by the reverse case, where Knowlton (1899 B) identifies one of the large fossil tree-trunks from the Yellowstone Park as *Sequoia magnifica* without any hesitation, though the pitting of the ray-cells, for instance, cannot be seen in the fossil. He says: "The dimensions of the various elements are much the same in the living and fossil specimens, thus leaving no doubt as to their close affinity." Such data, recent work has shown, afford no clue to true affinity; and I should hesitate to do more than term Knowlton's plant *Cupressinoxylon* sp. or some non-committal species. The fine photograph of the transverse section of the wood, while it is very similar to that of the living *Sequoia*, might equally be taken from any of half the known species of Conifers. Jeffrey (1908, p. 600) says that "the wood of early Cretaceous Pines had not yet acquired the marginal tracheids which are found in those of late Cretaceous and later epochs." The wide-reaching conclusions in this paper, which Prof. Jeffrey deduces from this misconception, may be summed up in his own words: "the Taxodineæ and Cupressineæ did not exist before the very end of the Cretaceous or, more probably, before the beginning of the Tertiary."

Cones of *Sequoia* have not been found in the Lower Greensand deposit, but from the French Portlandian undoubted cones are described, so that the want of cones in our deposits is probably a local accident (see Fliche & Zeiller, 1905).

The interest of the foliage of *Sequoia* just described lies in the fact that, as its internal anatomy is so well petrified, its identification is based on a sure foundation, and it suffices to prove the existence of *Sequoia* long before the Tertiary period; though Jeffrey (1908) endeavoured to demonstrate that all the early fossils referred by Zeiller and others to *Sequoia* were Araucarians, and that *Sequoia* did not appear till Tertiary times.

The new *Sequoia* is the only species, so far as I am aware, in which the internal anatomy of the leaf is petrified.

Both the following slides were cut from the type-specimen:—

V. 13230 a. Figured Pl. II, figs. 1 & 2. Transverse section of the minute axis and surrounding leaves as figured and described above. The little twig, with other débris, lies in the matrix in a large crack in a section of another plant (see p. 248). A second similar section is in the Stopes coll. S.B. *aa* (figured Pl. II, fig. 3 & text-fig. 16).

V. 13230 b. An oblique section of the same twig in another section of the larger plant (see p. 248).

Lower Greensand; Luccomb Chine, Isle of Wight.

Found and presented by Dr. M. C. Stopes, 1912.

Family ABIETINEÆ.

Nine or ten living genera, including the large genus *Pinus*, compose this family, and there are very many fossils, principally from the Tertiary and Upper Cretaceous, which must be included in it.

The salient feature of the living forms is the presence of two seeds on each ovuliferous scale and a double scale in the, generally large, female cones, in which the scales are spirally arranged. The leaves are nearly all narrow and pointed, and are either attached spirally directly to the main axis or borne in series together on "short shoots." The wood may or may not have resin-canals, the medullary ray-cells are specially thickened and pitted (the so-called abietinean pitting), and ray-tracheids are generally present. The tracheid-pits have round, generally isolated borders and are in one or two adjacent rows.

From Upper Cretaceous and Tertiary rocks Abietineæ are very numerous, and are preserved as casts and petrified cones; foliage-twigs, as impressions and petrified specimens; and more or less well-petrified woods. Fliche and Zeiller (1905) record undoubted cones of this affinity from the Portlandian of France, and remark on their relative scarcity in the higher beds in England. Probably more has been written on the fossil Abietineæ than on any two other Coniferous groups. Records in the Upper Cretaceous are very numerous, and may be found under a variety of modern and modified genera (such as *Pinites* in Part I of this Catalogue).

The question of date of the first appearance of the Abietineæ has aroused much interest and controversy. To establish his view that the *Pinus*-type is the most ancient conifer stock, Prof. Jeffrey and his school have sought for confirmation among fossils, and have in the past made much of the supposed existence of two forms of *Pityoxylon* in the Palæozoic. Various writers have doubted the validity of the statements based on the two fossils in question—*Pityoxylon Chasense* from the Permian and *P. Conwentzianum* from the Carboniferous (see, for example, Gothan, 1910 A). The matter has been finally cleared up by Thomson & Allin (1912), who demonstrate the fact that neither of these specimens is what it has been supposed to be, and that there is no evidence of the existence of *Pityoxylon* in the Palæozoic.

On the other hand, though Prof. Jeffrey has claimed this antiquity for *Pityoxylon*, he and his pupils have been content to conclude that the structures of the modern *Pinus* are of comparatively recent date, and they state (see Jeffrey & Chrysler, 1906, and others) that the ray-tracheids of the modern pines evolved in the Tertiary or Upper Cretaceous (see also p. 98, etc., where ray-tracheids of a much earlier date are described).

Notwithstanding the fact that the described Palæozoic Abietineæ have been discredited, and no reliable records of the existence of this family in the Palæozoic have been substituted, Prof. Jeffrey and his pupils do not discard their main argument, which was originally based on the now-discredited records.

At the same time, *Pinus*-like forms are undoubtedly very ancient, for, as Fliche and Zeiller (1905) have shown, they seem to have been already differentiated in the Jurassic, where it appears possible to recognise the two main sections of the modern genus *Pinus*, viz. § *Pinaster*, the "hard pines," and § *Strobus*, the "soft pines."

The difficulties in determining to which living genus the forms of the various Pityoxylons may be related, are naturally multiplied by the great distance in time which separates these fossil forms from those now living. Woods which show many features generally regarded as characteristic of *Pinus* may yet represent the ancestors of other living tribes. For example, interspersed ray-tracheids, which are a fairly characteristic feature of *Pinus*, have been detected in a wounded species of *Abies*, and the conclusion drawn from his investigations by

Thompson (1912) is that the ancestors of *Abies* normally showed that feature in their wood.

Until the various parts of the plants are more fully known and are definitely correlated, it is impossible to ascertain to what extent the ancient forms differed from those now living. That the fundamental differences may have been considerable is indicated by the existence of the interesting *Prepinus* (see Hollick & Jeffrey, 1909, and Stopes & Kershaw, 1910).

Genus **PROTOPICEOXYLON,** Gothan.

[Foss. Hölz. König-Karls-Land, 1907, p. 32.]

Diagnosis.—A woody Gymnosperm of normal abietinean structure, save that resin-canals are present *only* in a vertical direction. Normally the medullary rays are entirely uniseriate, and show typical abietinean pitting. The epithelium of the resin-canal is thick-walled and pitted; the canals may be either large or small, but are developed normally. There may be additional traumatic canals, which run in multiseriate rays, abnormally developed.

Gothan's original account of the genus is based on the single new species *P. extinctum*, and he gives no separate generic and specific diagnosis, but describes it as *genus et species novum* as follows:—"Abietineenholz, normalerweise nur mit vertikalen Harzgängen. Diese im allgemeinen nicht sehr zahlreich (bei Wundreiz aber sehr zahlreich, oft in zusammenhängenden Serien auftretend); bei Wundreiz auch hier und da horizontale, in Markstrahlen verlaufende Harzgänge von ungewöhnlicher Grösse, sich hier durch schon als Anomalien verratend; sonst durchaus ohne horizontale Harzgänge. Markstrahlen einreihig, Markstrahltüpfel klein, rundlich (sicher behöft gewesen); ca. 2–4 pro Kreuzungsfeld. Holzparenchym fehlend; die letzten Holzzellen des Jahresringes mit deutlichen kleinen Tangentialtüpfeln."

In a later account of the species Gothan (1910) somewhat re-arranges this diagnosis, and includes in his new species the already-described form *Pinites cavernosus*, Cramer, or *Cedroxylon cavernosum*, Schenk. He does not diagnose the genus separately.

The new Lower Greensand form, which, while it undoubtedly belongs to this genus, yet differs essentially from *P. extinctum*, makes it possible to diagnose the genus provisionally as given above.

Protopiceoxylon Edwardsi, sp. nov.

[Plate III; text-figs. 17–22.]

Diagnosis.—A woody branch, 4·5 cm. in diameter, with 17 wood-rings. The vertically running resin-canals are only in the autumn wood, and are present in every annual ring, and scattered all round each in larger or smaller numbers, either singly or in tangential series. Resin-canals are very small, many with only 4–5 epithelium cells, which have thick walls pierced by many pits, and are pointed or blunt at the ends in tangential section. The pith is large, without stone-cells. Primary xylem all apparently centrifugal. The secondary wood has stout, very well-marked annual rings with exceedingly thickened autumn wood. Spring tracheids up to $55 \times 50\ \mu$ in diameter, with round, isolated, bordered pits in a single row on the radial walls, the border of each pit being considerably less than the diameter of the tracheid-wall in which it lies. There are a few pits on the tangential walls of the autumn wood. Small quantities of resin-parenchyma are associated with the resin-canals, but apparently it is absent elsewhere. The medullary rays are all uniseriate, principally low, with very much thickened walls showing characteristic "abietinean pitting" and groups of 2–4 irregularly roundish pits per tracheid-field in the radial walls.

Horizon.—Lower Greensand.

Locality.—Berwick Green, Sussex.

Type.—Petrified branch, V. 4859, and slides cut from it, V. 4859 *a* to V. 4859 *m* in the British Museum (Nat. Hist.).

Description.—This species is founded on a single specimen, a short length (about 5 cm.) of a branch 4·5 cm. in diameter. The branch is decorticated and externally shows part of the woody texture, and is partly embedded in the coarse granular matrix. One end of the branch has been much weathered, and the well-marked annual rings stand out in high relief. The cut end of the specimen also shows very clearly the sharply marked annual rings, of which 17 are present, wholly or in part. This can be seen slightly enlarged in Pl. III, fig. 1. The details of the wood are beautifully preserved in a dark silicified medium, but the wood was evidently much bored by teredos before fossilisation, for a number of large borings are filled with the granular matrix. This also can be clearly recognised in the photographs, Pl. III.

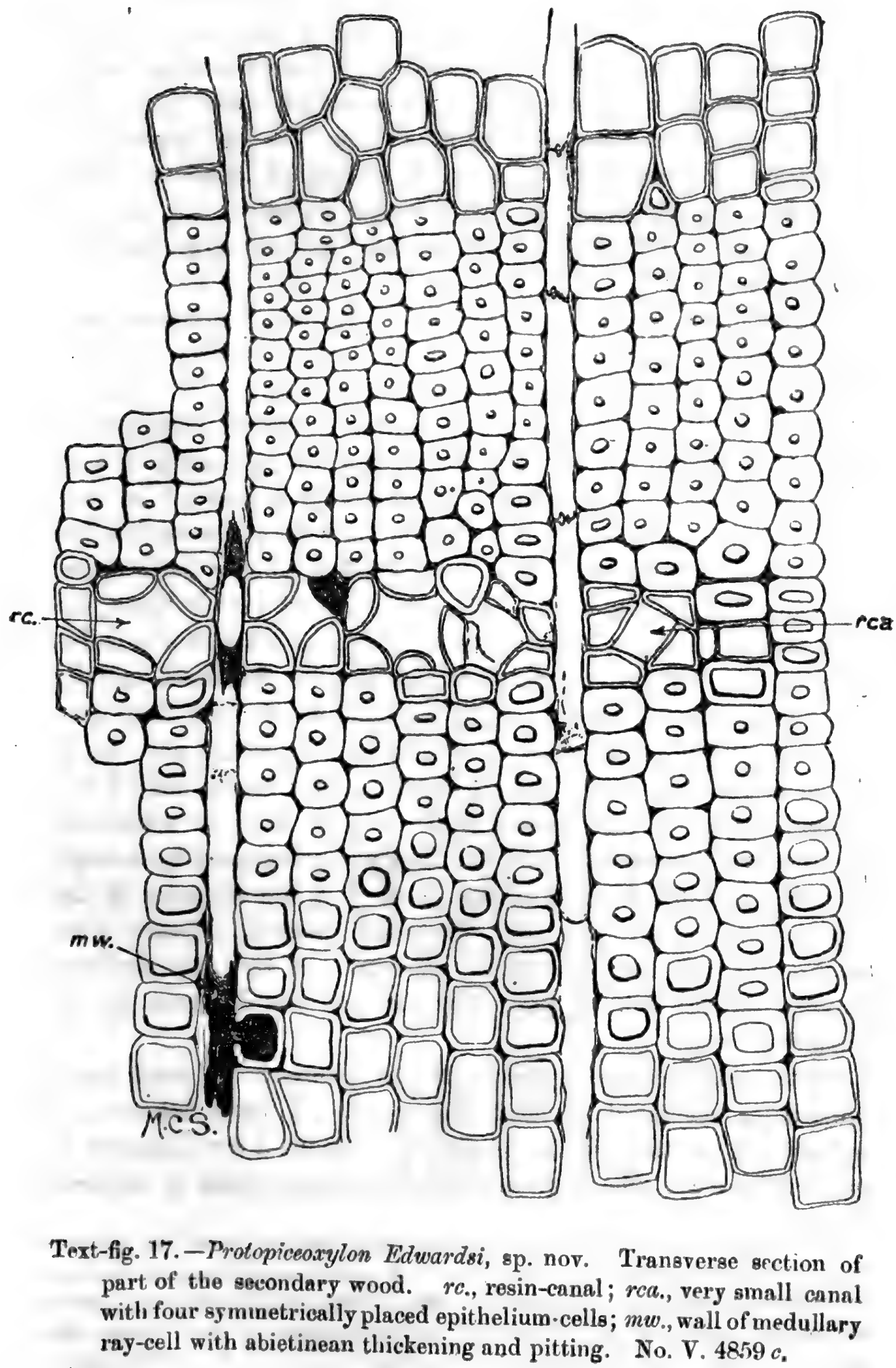
Topography of the Stem.—The *pith* is preserved and is large, measuring nearly 3 mm. in diameter. The cells composing it are all of one kind, and towards the centre are large, round, and with small intercellular spaces. The pith is roughly circular, but the deep bays of primary wood give it a stellate character with rather long points, formed by about 12 principal bundles.

The *primary wood* is well preserved and is arranged in well-marked bundles (see Pl. III, fig. 2). There is a medullary sheath of small cells round the protoxylems, but no centripetal wood has been detected. The *secondary wood* is in well-marked regular rings (see Pl. III, figs. 1 & 3). About 25 to 40 elements in radial series compose each ring, the largest of which measure about 2 mm. in extent. The extremely thickened autumn wood forms a broad zone in each ring, and is on the average about $\frac{1}{3}$ the total thickness of the ring. The tracheids are rounded off at the corners, and adjacent elements are generally on alternating tangents so as to fit into each other.

Resin-canals, either isolated or in rows, are found in the second and all subsequent annual rings, principally in the middle of the autumn wood and in a few cases just outside it (see text-fig. 17 & Pl. III, fig. 3). In some cases a row of canals almost encircles the whole stem, in others a ring may contain few isolated canals. These canals all run *vertically*, and, so far as I can discover, there are *no horizontal* canals.

Medullary rays are numerous and very conspicuous in transverse section. All are *uniseriate*, and are 1–15 tracheids distant, principally 4–6. The ray-cells appear to be all of one kind, though a number of them contain resin-like contents; all their walls are thickened and pitted. The rays vary from 1–20 cells high, the greater number being from 3–8 cells in height.

Details of Elements.—The cells of the *pith* are all roughly



Text-fig. 17.—*Protopiceoxylon Edwardsi*, sp. nov. Transverse section of part of the secondary wood. *rc.*, resin-canal; *rca.*, very small canal with four symmetrically placed epithelium-cells; *mw.*, wall of medullary ray-cell with abietinean thickening and pitting. No. V. 4859 *c*.

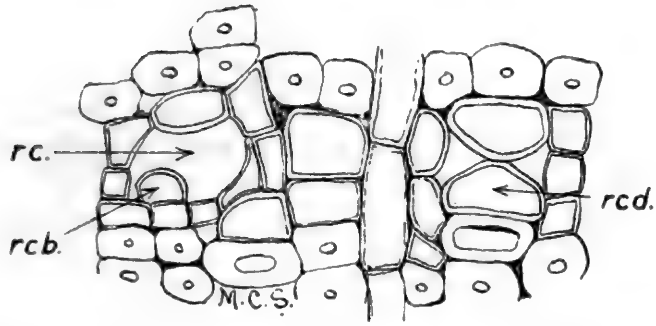
circular in transverse section, increasing towards the centre of the axis, where they measure as much as 90 μ in diameter. Their walls are all rather thickened, and their rounding leaves small, triangular, intercellular spaces between the cells. All these features can be seen in Pl. III, fig. 2. In longitudinal direction the cells are somewhat elongated, some of them having a length equal to twice their diameter, but most of them are shorter than that. The cross-walls are approximately rectangular.

Protoxylems appear to be *endarch*. The small elements composing them can be seen in longitudinal section to have extremely fine scalariform and spiral thickening.

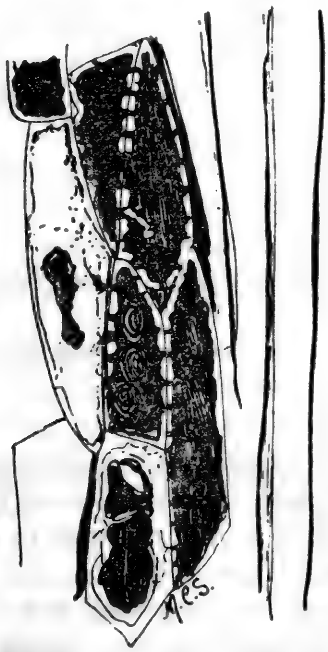
The *secondary tracheids* form regular rings of elements in which the distinction between spring and autumn wood is very sharply marked. The spring tracheids vary somewhat in size, the largest measuring about $40 \times 50–55 \times 50$ μ, the size of the tracheids in the outer rings of wood tending to be a little larger than in the first few rings. The walls are all rather thick, the first-formed spring elements having a wall at least 3–4 μ thick. The autumn * wood elements are not so much flattened radially as is generally the case in gymnospermic woods, but they have excessively thickened walls (see text-fig. 17), which may be as much as 10–20 μ thick, with a small circular lumen only 4–6 μ across. Pits on the radial walls can be seen in transverse section; in longitudinal section they are principally in a single row, the circular borders being about $\frac{1}{2}$–$\frac{2}{3}$ the diameter of the tracheid in which they lie. They are generally distant from each other, but may be almost adjacent. A very few elements have a double row of pits. A few pits can be seen in the tangential walls.

Wood-parenchyma appears to be present in very small quantities scattered through the wood. I have detected in radial and particularly in tangential sections a few elements in which there are true horizontal walls at right angles to the long

* It is not now usual to employ the term *autumn* wood, for, physiologically, it is late summer wood; but for purely morphological descriptions the old-fashioned term seems to offer a better contrast, and also leaves no possible confusion, for, in some of the old papers on fossil woods, the term "summer" seems to be used as "spring" is used at the present day.



Text-fig. 18.—*Protopiceoxylon Edwardsi*, sp. nov. Transverse view of two small resin-canals. *rcb.*, epithelial cell projecting irregularly into canal, *rc.* *rcd.*, symmetrical large cells, not yet fully separated to form canal (cf. *rca.* in text-fig. 17). No. V. 4859*c*.



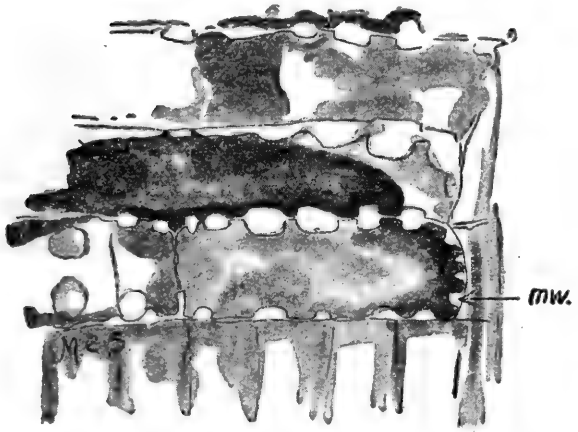
Text-fig. 19.—*Protopiceoxylon Edwardsi*, sp. nov. Longitudinal view of the thick-walled epithelial cells of the resin-canals, showing the pits in the walls. No. V. 4859*g*.

axis of the cells. But most of the elements which at the first glance appear to be parenchyma-cells are tracheids in which a very fine "spindle" of resin lies across the lumen (see text-fig. 22, *rs.*). There are also imperfect spindles in many of the tracheids adjacent to the rays. The wood parenchyma-cells nearly all contain resinous remains. A small number of parenchyma-cells are also associated with the resin-canals.

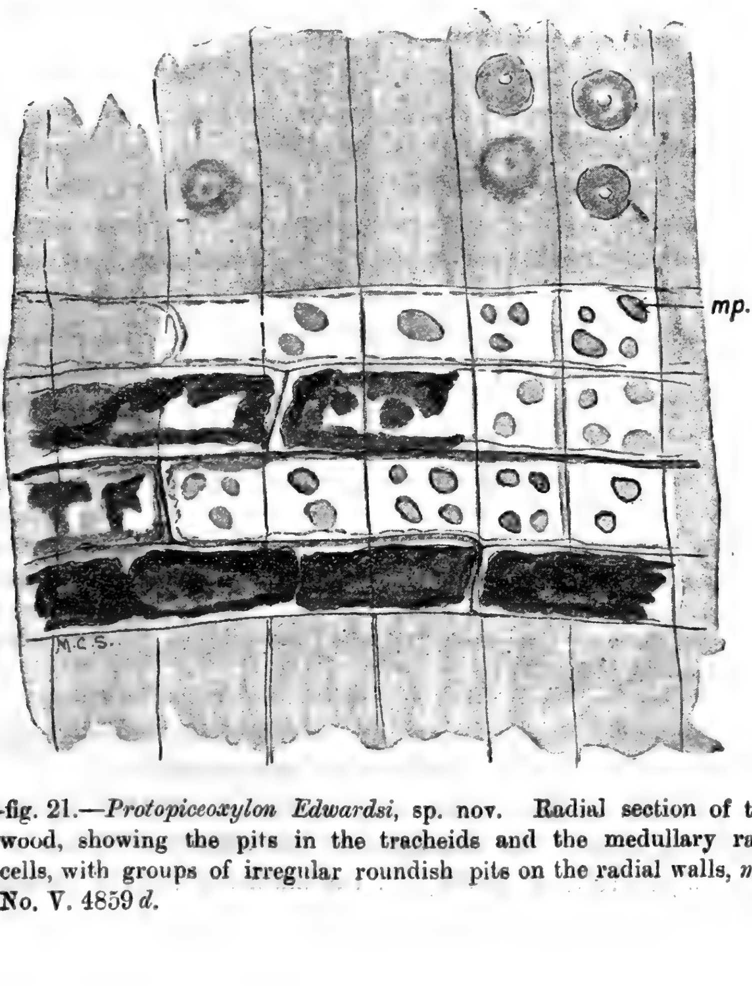
Resin-canals are normally present in the second and all subsequent rings. They are very beautifully preserved, and show their simple structure admirably. The majority of them are very small, as can be seen in text-fig. 17, but a number of them are rather larger and more irregular. The typical resin-canal, however, has only 4 or 6 epithelial cells, and sometimes these are arranged with extraordinary symmetry (see *rca.*, text-fig. 17). In other cases the epithelium-cell projects curiously into the cavity of the canal, as *rcb.*, text-fig. 18. Some of the canals, not yet completely formed, show very beautifully their mode of origin and development (see *rcd.*, text-fig. 18).

The walls of the epithelium are all thickened, and in some of the longitudinal sections their pitting can be well seen (text-fig. 19). The epithelium-cells appear to have sometimes straight and sometimes pointed ends; the xylem-parenchyma cells just outside them in some cases have generally rectangular end-walls. Most of the canals lie in tangential bands, as is seen in the figures, but a few are isolated. They generally lie just about the middle of the autumn wood. I have not observed any tyloses in the canals.

Medullary rays.—In transverse section the medullary ray-cells, particularly in the first five or six wood-rings, may have a tangential diameter as great or even greater than the adjacent tracheids; many rays, however, have cells a good deal narrower than the adjacent tracheids. The majority of the ray-cells equal 2 or 3, but may equal 5 or 6, tracheids in radial extent. The end-walls slope slightly, and even in the transverse section; with the high power the thickening and "abietinean" pitting of these walls can be made out (see text-fig. 17, *mw.*) in many places. In examining these sections deceptive appearances, due to mineral depositions round the walls, must be avoided. The well-marked "abietinean pitting" of the ray-cells may also be seen in some of the radial sections (text-fig. 20), where the

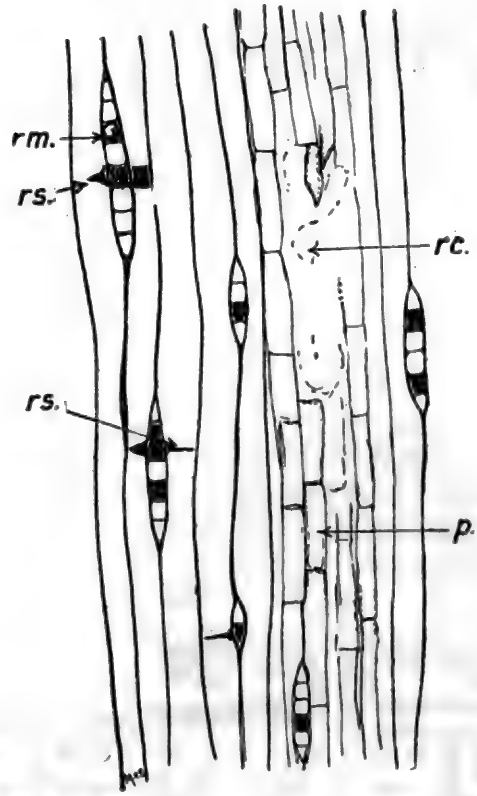


Text-fig. 20.—*Protopiceoxylon Edwardsi*, sp. nov. A few cells from the radial view of a medullary ray, showing the "abietinean pitting" of their end-walls, *mw*. No. V. 4859 *f*.



Text-fig. 21.—*Protopiceoxylon Edwardsi*, sp. nov. Radial section of the wood, showing the pits in the tracheids and the medullary ray-cells, with groups of irregular roundish pits on the radial walls, *mp*. No. V. 4859 *d*.

characteristic thickening of the wall appears to be locally well preserved. The pits in the lateral walls are rather irregular in size and shape, but are principally roundish or oval, and are disposed in groups of 2–4 per tracheid-field (text-fig. 21, *mp.*). So far as I can determine, all the ray-cells are of this nature, and, though some have much resinous contents and some appear devoid of it (text-fig. 22), there seems to be no differentiation of



Text-fig. 22.—*Protopiceoxylon Edwardsi*, sp. nov. Tangential view of the wood, showing resin-canal, *rc.*, in slightly oblique longitudinal section; *p.*, parenchyma surrounding it; *rm.*, resin-containing cells of the medullary ray; *rs.*, resin "spindle" in tracheid. (Slightly composite drawing of V. 4859 *l.*)

the elements. I can detect no ray-tracheids, but the end-cells of some of the rays are very narrow and pointed.

Affinities.—Regarding the inclusion of this species in Gothan's genus, and consequently its affinity with his *P. extinctum*, there is no doubt; for the main feature, the presence of *only* vertically running resin-canals, is confined to that genus, and is a character of great importance. There are, however, many points of difference between our fossil and Gothan's, as will be seen in the diagnoses and descriptions. Gothan's form has very large canals, in ours they are particularly small; Gothan's wood has traumatic horizontally running canals, while our specimen has none; his canals, normally, are few in number, ours occur, often in numbers together, in every growth-ring, always in the autumn wood; and, finally, our canals, so compact and small, and with such a definite small number of epithelium-cells, are very characteristic.

The position of the single canals and of the rows of resin-canals, which are constantly in the middle of the thick-walled zone of autumn wood, is of interest and possibly of specific value. As Jeffrey (1905, p. 16) noted, even the traumatic resin of *Cedrus* shows a constant difference in the position of the canals in allied species, those in *C. deodara* occurring in the autumn wood and those in *C. atlantica* in the spring wood.

Beyond Gothan's species, comparison is uncertain. Kräusel (1913) re-describes a Tertiary wood (first described by Goeppert) as belonging to this genus, but unfortunately he gives no figures, and from merely verbal description it is almost impossible to gain convincing impressions of some of the salient details.

The fossil described by Knowlton (1900) as a new genus, *Pinoxylon*, and associated by him definitely with *Pinus*, is considered by Gothan to belong to this genus, but Knowlton's illustrations are so unsatisfactory that no detailed comparison with our new species can be attempted.

The foliage and fructification borne by this genus are as yet unknown.

V. 4859. Type-specimen. A part of a petrified branch 4 cm. long, with some small pieces of the same, from which sections have been cut. The centre of the axis is petrified, and a number of well-marked annual rings make up a total diameter of about 4·5 cm., which, being decorticated, is probably much less than the true diameter of the branch. The exterior of the fossil shows decorticated wood-texture, partly covered by the coarse granular matrix. One end of the trunk is much weathered out and shows the annual rings very clearly, while the other end is cut and the regular zones of wood can be seen, as in Pl. III, fig. 1. The wood is considerably teredo-bored, and the borings are filled with coarse granular matrix. The petrified tissues are dark brown, the petrifying medium is partly silica and very close-textured, and the tissues are beautifully preserved.

V. 4859 a. Figured, Pl. III, figs. 1, 2, & 3. Transverse section from the above, showing all the features of the pith, primary wood and secondary rings of wood well preserved and as described above in detail. The broad zone of autumn wood is very noticeable, and in almost all of the wood-rings are to be seen the small vertically running resin-canals.

V. 4859 b. A thicker section like the above, but somewhat broken in the cutting.

V. 4859 c. Figured, text-figs. 17 & 18. A transverse section similar to the above. In it all the features described for the type can be seen. Resin-canals from different parts of the section show their detailed structure very clearly and are exceptionally well preserved.

V. 4859 d. Figured, text-fig. 21. Radial longitudinal section of the above, passing through the pith, the short oblong cells of which are well seen. The pitting of the radial walls of the medullary ray-cells can be made out in some places, though not in all the rays. The end-walls of the ray-cells can also be seen, and they slope at a low angle or are curved.

V. 4859 e. Another radial section similar to the above, but thicker. Parts of it are cut tangentially, and a small branch can be seen coming off.

V. 4859 f. Figured, text-fig. 20. Radial longitudinal section, thick and rather opaque in parts, but in one or two places it shows the "abietinean pitting" of the walls of the medullary ray-cells very beautifully, as is illustrated in the text-figure.

V. 4859 g. Figured, text-fig. 19. A further radial section of the above, part of which slopes obliquely into a tangential direction. In one place a resin-canal is cut obliquely and shows the thick and pitted walls of its lining very clearly, as is illustrated in the text-figure.

V. 4859 h, j, k. Further radial and obliquely tangential sections of the above, in which many of the described features can be seen.

V. 4859 l. Figured, text-fig. 22. Tangential longitudinal section showing the rays and also the longitudinally running resin-canals very beautifully.

V. 4859 m. A tangential section similar to the above, but rather thicker and somewhat oblique.

Lower Greensand; Berwick Green, Sussex.

Transferred from the Botanical Dept., 1898.

Genus **PITYOXYLON,** Kraus.

[In Schimper's Traité Pal. Végét., vol. 2, 1870, p. 377.]

The species of woods which Witham and, later, Kraus himself (see Kraus, 1864, 1866) described under the generic name *Pinites*, were placed in 1870 in a genus of equivalent value to those of other fossil woods, with the characteristic termination *-oxylon*. In Schimper's textbook, where the new generic name *Pityoxylon* is first used, Kraus defines it as follows:—"Lignum stratis concentricis angustis, latioribusve; cellulis prosenchymatosis porosis; poris magnis, rotundis, uni- vel pluriserialibus, oppositis; cellulis ductibusque resiniferis haud raris; radiis medullaribus compositis ductumque resiniferum includentibus vel simplicibus, cellulæ eorum haud raro biformes." To this Kraus adds:—"Le genre *Pityoxylon* est le seul dans lequel il soit possible d'établir des sous-divisions et des espèces sur les différences de structure qui se rencontrent dans le tissu. Les caractères distinctifs se trouvent en partie dans la disposition des canaux résineux, en partie et surtout dans l'organisation des cellules qui composent les séries inférieures et supérieures des rayons médullaires." Beyond these words he does not give any description, or even reference, to the cells of the medullary rays, which are now known to be so important a feature in the diagnosis of fossil woods.

In the genus *Pityoxylon*, particularly in the late Tertiary, are species clearly to be included in the living genus *Pinus*, and this was recognised by the earlier writers. For instance, Vater (1884) divided the genus *Pityoxylon* into four sub-forms, to which, however, no varietal names were given, but their characters were practically those of the modern Pines. In recent times Gothan (1905) has divided the genus into two genera, *Piceoxylon* and *Pinuxylon*, separating them as follows:—

(*a*) Harzgangepithel dickwandig, verholzt; Markstrahltüpfel nicht ei-porig; Spiralverdickung im Spätholz (selten auch im Frühholz: *Pseudotsuga*). Zahlreiche Tangentialtüpfel im Spätholz. Quertracheïden vorhanden, ohne Zacken. Abietineentüpfelung sehr deutlich.	*Piceoxylon*, Gothan (*Pityoxylon*, Kraus, ex p.; *Pinites*, Goepp. ex p.).
(*b*) Harzgangepithel dünnwandig, nur selten etwas dickwandig; Markstrahltüpfel (Frühholz!) stets ei-porig. Spiralverdickung im Spätholz stets fehlend, ebenso Harzparenchym. Quertracheïden mit oder ohne Zacken. Abietineentüpfelung bei den gross-eiporigen fehlend bezw. reduziert.	*Pinuxylon*, Gothan (*Pityoxylon*, Kraus, ex p.; *Pinites*, Goeppert, ex p.).

As Gothan points out, the name *Pinoxylon*, in place of *Pinuxylon*, would have been the natural one to take, but the generic name *Pinoxylon* had been used by Knowlton (1900) for a very poorly illustrated specimen of Jurassic age. His diagnosis of that genus is as follows:—"Internal structure of the wood same as in *Pinus*, except in the absence of fusiform rays." But, as Gothan (1908) points out, this absence really portends the absence of *horizontally running resin-canals*, and consequently the wood is *not* the same as recent *Pinus*, in which the presence of both vertically and horizontally running resin-canals is a universal feature and one of first-rate diagnostic significance. As has already been observed, the wood described by Knowlton appears to belong to the genus *Protopiceoxylon*.

I agree with Jeffrey & Chrysler (1906) that this division of *Pityoxylon* by Gothan does not serve a useful purpose, while the wider scope of the old generic name is more in accord with the range of variation possible in the earlier members of the group. I have therefore not adopted Gothan's sub-divisions, even though my new forms of *Pityoxylon* are certainly very *Pinus*-like (see also pp. 102, etc.).

It is curious that, though *Pinus*-like cones and foliage are common, petrifactions of wood-structure like that of modern *Pinus* are relatively rare, and, further, that, even in the deposits in which they do occur, they are much more infrequent than the other types of coniferous wood. For instance, Vater (1884, p. 821) mentions that in a collection (probably so recent as Senonian age) of about 250 specimens of petrified wood, only four were of *Pityoxylon*.

For comparison with our new fossils, therefore, there are not many already-described forms, and indeed there appear to be none which are of the same or very nearly allied species. In the most recent work on the Lower Cretaceous of America (Berry, 1911), unfortunately no species of *Pityoxylon* are described. The species of *Pityoxylon* which are described from Staten Island (Jeffrey & Chrysler, 1906, Bailey, 1911, and others), and referred to by some botanists as of "Lower Cretaceous" age, really belong to the Upper Cretaceous, and are therefore much younger than those in the present work. Comparison with their structure, however, is made in detail (see pp. 102, 120).

The only British specimen of Lower Cretaceous (Wealden) age, *Pinites Ruffordi*, Seward, 1896 c, is not near our fossil in its structure; of this he says it "may possibly be generically identical with the recent *Pinus*," but because of the absence of leaves or cones he gives it the non-committal name of *Pinites*. The pitting and the existence of both vertical and horizontal resin-canals in the wood place the specimen in the genus *Pityoxylon*, Kraus; but the fact that no horizontal ray-tracheids have been detected appears to me to render any close affinity with modern *Pinus* unlikely. The medullary ray-cells are uniform, with straight walls and simple oval or circular pits, generally two to each tracheid-field. This wood, without ray-tracheids, is not much like our new species, and does not appear to be so near to *Pinus* as was at first supposed by Seward.

The three species of *Pityoxylon* nearest in age and geographical distribution to our Lower Greensand species, are those described by Fliche (1896) from the French greensands of Albian age. They cannot be compared with the new species, however, as they do not appear to have the rays well enough preserved for adequate illustration or description. Regarding the best of them, *P. infracretaceum*, Fliche says :—"Ces rayons sont formés de cellules rectangulaires, présentant souvent d'une façon très nette le gros pore unique caractéristique, chez les pins actuels, de la section des *Pinaster,* mais on ne voit point les trachéides à parois en zigzag, qui dans le genre actuel les accompagnent constamment." *P. Argonnense* has also uniform rays, without ray-tracheids; while *P. Thomasi* is too poorly preserved to make it possible to determine whether or not ray-tracheids were present, the supposition being that they were not.

Pityoxylon Hollicki, Knowlton (Hollick, 1898 D, p. 134), is described very incompletely, for, as the author says, "the material is too obscure to permit either accurate description or satisfactory measurement." As the distinguishing characters are neither figured nor described, it cannot be compared with the new British species.

With the minutely-described *Pityoxylon* (*Pinus* of Conwentz) *Nathorsti* (Conwentz, 1892) satisfactory comparison of any of our species unfortunately cannot be made, for in Conwentz's specimen the medullary rays are so poorly preserved that it is not possible to be sure even whether or not ray-tracheids were specialised, while in the new English specimens the structure of the rays is well petrified.

In *Pityoxylon pinastroides* (Kraus, 1883), on the other hand, we have a specimen well enough preserved for comparison with our fossils, but it is of much more recent type, and has the toothed thickenings of the medullary rays characteristic of the so-called "Hard Pines" that are not represented in the Lower Greensand forms.

Bailey (1911) describes an Upper Cretaceous *Pityoxylon* in which ray-tracheids are developed. Therefrom he concludes that "the distribution of ray-tracheids in our lignite confirms these writers [Jeffrey & Chrysler] in their conclusion that the absence of ray-tracheids is a primitive condition, but shows that these structures were evolved during the latter part of the Cretaceous rather than in the beginning of the Tertiary. This is shown by the fact that the ray-tracheids are feebly developed even in the older wood of the stem, and do not occur during the first ten to fifteen annual rings." Bailey assumes that his specimen is really not only undeveloped but truly primitive, for he concludes that "the occurrence of ray-tracheids in this Cretaceous pine indicates that the development of these structures occurred in the Upper Cretaceous, and not, as has been supposed, in the Tertiary." Reference to the American species will be made in more detail when describing the individual new species. The presence of well-developed ray-tracheids in the new British Aptian fossils carries back this supposed modern feature further than was anticipated.

With the species of *Pityoxylon* here described and the Arctic forms described by Gothan (1910 A) a comparison would be of interest, but little can be done in this direction because the new Lower Greensand forms all show well-developed ray-tracheids, which are unrepresented in Gothan's species. His *Piceoxylon antiquius* differs from any of the species now described in having neither ray-tracheids nor tangential pits in the tracheid-walls. This species is supposed by Gothan (p. 21) to be the oldest undoubted wood of abietinean affinity, and is stated to be of Upper Jurassic age. One must, however, note the criticisms of the stratigraphy raised by Burckhardt (1911); see p. 68 of the present work. It seems to be not unlikely that the three *Pinus*-like members of the genus *Pityoxylon* described below are the oldest unquestionable wood-remains of truly *Pinus*-like character.

Pityoxylon Sewardi, sp. nov.

[Plates IV & V; text-figs. 23 & 24.]

Diagnosis.—Secondary wood with the characters of *Pityoxylon*, Kraus. The type is part of a trunk not less than 18 cm. (and probably more) in diameter. Growth-rings well marked, large. Tracheid-walls rounded at the corners, tracheids up to $25 \times 30\,\mu$ in diameter. Bordered pits on radial walls in single rows, border filling the wall, in most cases each pit isolated from the next one by about the diameter of the border. Parenchyma grouped round resin-canals; cells large, many containing resin. Resin-canals vertical and horizontal, isolated all through the wood, and in tangential groups of 2–4 in the outer part of the autumn wood. Single resin-canals up to $170\,\mu$ in diameter; epithelium apparently thin-walled. Some canals occluded by tyloses. Medullary rays numerous, distant 2–9, chiefly 3–5 tracheid-rows, uniseriate except those containing resin-canals. Medullary ray-cells frequently larger than the adjacent tracheids, averaging 30 μ in tangential diameter. Rays complex; parenchyma-cells with thickened or curved end-walls, single large pits in tracheid-field. Ray-tracheids above and below and in interspersed bands in the higher rays. Ray-tracheids simple, low; outline very little distorted, pitted by scattered round bordered pits. Multiseriate rays with resin-canals not numerous.

Horizon.—Lower Greensand.

Locality.—Ightham, Kent.

Type.—V. 1440, and slides cut from it; British Museum (Nat. Hist.).

Finder.—John Hale, jun., 1886; slides cut, 1912.

Description.—The single specimen from which this species is described is a good-sized portion of secondary wood which does not include any sign of either pith or bark. The mass of the secondary wood is in the form of a rough wedge, 27 cm. long by 13 × 6 cm. The disposition of the rings is such that the whole trunk could not have been less than 18 cm. in diameter. The cell-structure is well silicified and slightly iron-stained: free from matrix, the texture of the wood shows up well to the naked eye.

Topography of the Stem.—*Pith* and *bark* are both absent.

Growth-rings are very well marked and of large size. The thickness of each ring averages from about 4 to 6 mm., consisting of from 120–180 cells. It is difficult to make accurate counts of the exact number of cells, because about $\frac{1}{3}$ of each ring, the thinner-walled spring wood, is very much crushed and distorted. Though this crushing serves to make the annual rings very noticeable, the actual difference between the spring and autumn wood is not great.

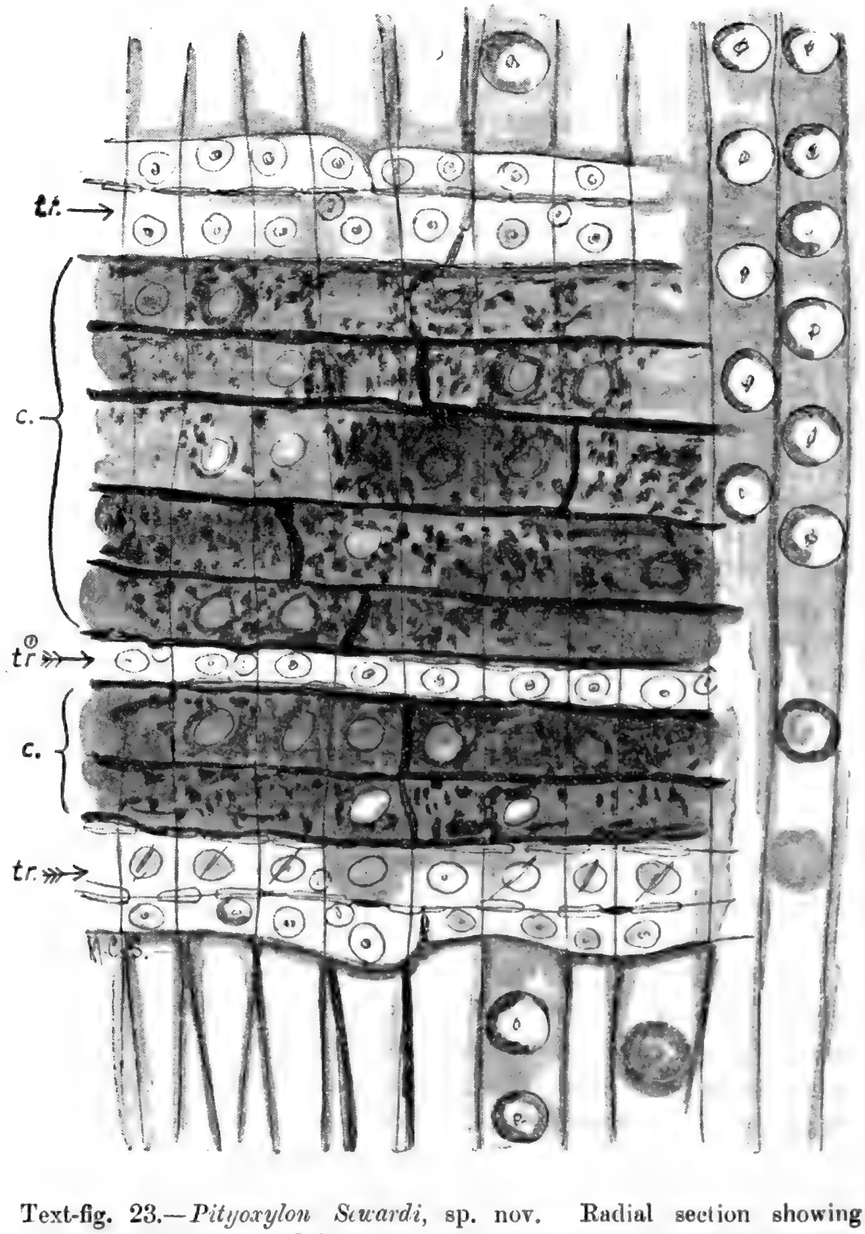
The general character of the *wood* is seen in Pl. IV. The uniform rows of tracheids consist of elements somewhat rounded off from each other. Parenchyma-cells are grouped round the resin-canals, which are scattered singly throughout the whole of the wood (Pl. IV, fig. 1, *r.c.*), and also tend to lie in rows of 3 or more towards the inner side of the autumn wood (Pl. IV, fig. 2, *r.c.a.*). Scattered through the wood are elements filled with blackened contents, which suggest resin. Some of these have rather thicker walls than the rest of the tissue, and may represent somewhat specialised "resin-tracheids."

The size and frequency of the *medullary rays* are both rather greater than the average in Coniferous woods (Pl. IV). In transverse section, the tangential diameter of the ray-cells is often greater than that of the adjacent tracheids, and as these cells are largely filled by blackened contents they are very conspicuous. The rays are all *uniseriate* (Pl. IV, fig. 1), except those which contain the transversely running resin-canal (Pl. V, fig. 1, *r.c.*).

No evidence of *branching*, or of the exit of short shoot traces, is found in the sections.

Details of Elements.—*Secondary wood* only is present. The *tracheids* average about $24 \times 20\,\mu$ to $30 \times 25\,\mu$ in diameter. The walls are somewhat rounded off, adjacent rows of tracheids not lying strictly on the same tangent, but slightly alternating, so as to fit the rounded walls into each other. The walls are not excessively thickened, and there is no tendency for the lumen to be obliterated, even in the outer zones of autumn wood. In transverse section the *pitting* is not a salient feature, though some of the autumn tracheids show tangential pits. In radial section the bordered pits are large (as wide as the tracheid), circular, and generally isolated by a distance equal to or greater than their own diameter (text-fig. 23). In a few cases, faint remains of "Sanio's rims" are visible.

Wood-parenchyma forms noticeable patches round the resin-canals. Some of the isolated elements containing blackened contents scattered in the main body of the wood *may* be parenchyma, but the petrifaction makes it a little uncertain. Most of these elements are certainly thick-walled. The parenchyma elements round the resin-canals are larger in diameter than the average tracheid (Pl. IV, fig. 2, *r.c.a.*); their walls, as well as their contents, are often blackened. I have not been able to detect any specialised pitting. The cells are irregular in outline, and are grouped round the resin-canals so as completely to connect those near each other. The cells are elongated in a vertical direction, and their transverse walls are at right angles to the vertical walls.



Text-fig. 23.—*Pityoxylon Sewardi*, sp. nov. Radial section showing tracheids in the medullary ray. The ray consisting of ray-tracheids, *tr.*, with thickened walls in which are small, round, bordered pits; and large contents-containing parenchyma-cells with simple large pits, *c.* Bands of tracheids are interspersed between these, as at *tr.*[1]. No. V. 1440 *b*.

Resin-cells.—Elements whose appearance and blackened contents are highly suggestive of *resin-tracheids* are scattered through the wood. They occur singly in the uniform tracheid-rows, and many of them appear to have walls which are nearly twice as much thickened as the adjacent elements. Apart from that associated with the resin-canals, which has already been mentioned, resin-parenchyma has not been recognised.

Normal *resin-canals* run vertically and horizontally throughout the wood, as described above (Pl. IV, fig. 2, *r.c.a.*, & Pl. V, fig. 1, *r.c.*). They are lined by an *epithelium* which appears to be thin-walled, no evidence having been found, even after careful examination, of thickened or pitted epithelium. The average diameter of the canals is about 150–170 μ. In some of the canals the lumen is blocked or partly blocked by outgrowths of tyloses.

The prominent uniseriate *medullary rays* are composed of elements averaging from 24 to 30 μ in tangential diameter. They are distant from 2 to 9 (3 and 5 being the commonest) tracheid-rows; the preservation being indistinct, the pitting is not apparent in transverse section, but in radial section it is clear that the rays are composed of two kinds of elements (text-figs. 24, 25). The larger darker cells with thick, somewhat blackened walls have simple large pits, one for each tracheid-zone (text-fig. 24, *c.*). Above and below these, and sometimes forming bands in between them (as at *tr.*[1], text-fig. 23) are the *ray-tracheids*, which have thickened walls with smaller *bordered pits*. These are not the most highly specialised form of ray-tracheid, and have fairly regular outlines, but some show a slight degree of bulging and irregularity of the outer wall (as at *tr.*, text-fig. 24). Among living Pines, tracheids of this type are found in *Pinus reflexa*, *P. monticola*, and others. The figure of the ray in *P. reflexa*, given by Penhallow (1907 A, p. 84, text-fig. 24), should be compared with the upper part of text-fig. 24 from the fossil.

In tangential section the distinction between the tracheids and the larger contents-containing parenchyma-cells is clear (text-fig. 24, *tr.* & *c.*; Pl. V, fig. 1). Rays from 3 to 20 cells high.

The horizontally running resin-canals are seen in the multiseriate rays, as at *r.c.*, Pl. V, fig. 1.

The most interesting feature of this fossil is the existence of well-defined *ray-tracheids*, not only forming the terminal cells of the rays, but also present in bands interspersed between the parenchyma-cells of the ray. It is interesting in this connection to notice the various conclusions which have been drawn by different writers on the discovery of fossils from the Upper Cretaceous, which show some degree of development of these ray-tracheids. Jeffrey & Chrysler (1906) described two species of *Pityoxylon* from the Upper Cretaceous of North America. In these two specimens no ray-tracheids were found; they therefore infer that "there can be little doubt that

Text-fig. 24.—*Pityoxylon Sewardi*, sp. nov. Tangential section of medullary ray, showing the ray-tracheids, *tr.*, alternating with larger contents-containing parenchyma, *c.* No. V. 1440 *c.*

in the peculiar structure of the rays we have to do with an ancestral feature.... The cells on the margins of the rays in our *Pityoxylon* are, moreover, related to the central cells of the rays and to each other by simple pits, and not by bordered pits as is the case with the marginal tracheids. It is obvious that the ray-structure of *Pinus* underwent a great change in the passage from the Mesozoic to the Tertiary period." The conclusion, based solely on the structure of *two* specimens from one locality of the Upper Cretaceous, is that "the appearance of marginal tracheids in the rays of *Pinus* is comparatively modern and does not in all probability antedate the Tertiary." Furthermore, the assumption is made that "the appearance of marginal ray-tracheids about the beginning of the Tertiary epoch, with the resulting improvement of water-supply, in all probability explains why so comparatively large-leaved a conifer should have been able not only to live on into the modern period, but to flourish as it never had before."

Later, however, another North-American Upper Cretaceous *Pityoxylon* was discovered and described by Bailey (1911). This specimen shows well-developed ray-tracheids. It is necessary to revise Jeffrey & Chrysler's conclusions, which Bailey does as follows (p. 323):—"The distribution of ray-tracheids in our lignite confirms these writers in their conclusion that the absence of ray-tracheids is a primitive condition, but shows that these structures were evolved during the latter part of the Cretaceous rather than at the beginning of the Tertiary."

Further specimens continued to be found in the Cliffwood locality, and Holden (1913 A) describes another species in which ray-tracheids are present (p. 614). Ray-tracheids, "though rare in the first annual ring of *P. protoscleropitys*, and their abundance later, seem to indicate that they are a more ancient feature than has been assumed by any of the above-cited investigators. It is probable that they were developed in the Lower Cretaceous if not in the Jurassic."

The above quotations illustrate the uncertainty of conclusions based on single fossils or a small number of finds from isolated localities. The new British species is of Lower Cretaceous (Aptian) age, and shows ray-tracheids of a truly modern type. Consequently, I do not attempt any surmise as to *when* they were first evolved, but content myself with describing these early specimens, the earliest yet known, in which they exist. The only older known British specimen in which ray-tracheids might be anticipated is "*Pinus*" *Ruffordi*, Seward (1896 c), from the Wealden, but they do not occur in this fossil.

In all the papers describing fossil forms of *Pityoxylon*, as well as in many descriptions of recent Conifers, theories regarding the origin of the ray-tracheids are elaborated; but the palæontological material is still insufficient for the discussion of the subject.

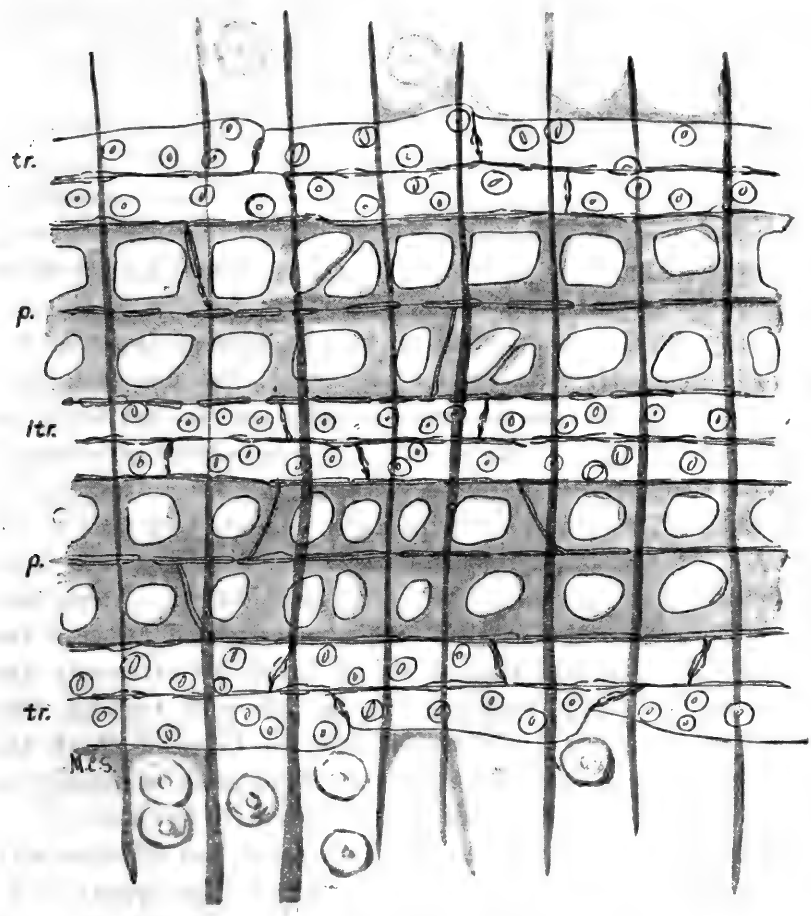
Affinities.—The species of *Pityoxylon* described from the Cretaceous are few, and with none of them does this new species show any close affinity. In geological age and geographical distribution the three French species described by Fliche (1896) from the Albian are the nearest, but in the essential point—the character of the ray-cells—these specimens differ widely.

The Upper Cretaceous specimens from Staten Island and Cliffwood, N.J., however, are well preserved and described in detail. Of these, *P. statenense* and *P. scituatense*, Jeffrey & Chrysler (1906), being without ray-tracheids, cannot be near our fossil. *Pinus scituatensiformis*, Bailey (1911), has ray-tracheids, as can be seen well in the tangential photographs of this wood given by Bailey. Unfortunately, he does not illustrate adequately the radial view of these tracheids, so that it is impossible to see how closely they agree in detail with those in the older British specimen. In possessing thick-walled ray-parenchyma, and also in the grouping of parenchyma-cells round the resin-canals, the American and the British fossils resemble each other. The existence of thick-walled and resinous parenchyma-cells is a feature which Bailey considers "without parallel among living pines," while it is found in other Cretaceous specimens. Bailey is fortunate in having pith and the short-shoot bases in his specimen, which ours lacks, and which confirm his determination of the species as referable to *Pinus*. In this American species the ray-tracheids are more feebly developed than in the much older British form, and while these two resemble each other more closely than any other described fossils, they are not identical.

Of the three species from Cliffwood, described by Miss Holden (1913 A), two have no ray-tracheids and therefore do not come near our fossil, while the third, which has ray-tracheids, has also the well-marked "teeth" projecting from the horizontal walls which are characteristic of the "hard" pines of to-day, though not developed in our fossil.

Pityoxylon Aldersoni, Knowlton (see Knowlton, 1899 B, p. 763), is apparently too imperfectly preserved for any accurate comparison to be attempted. Knowlton does not describe the pitting of the medullary ray-cells, but in his photograph of the tangential section some of the rays look as if they had ray-tracheids of relatively small size like those in our wood. Comparison with *P. amethystinum*, Knowlton, is also impossible for want of the essential data in this species.

Among the described fossils of *Pityoxylon*-type, one may compare this specimen to some extent with that described by



Text-fig. 25.—*Pinus monticola*, living species, for comparison with *Pityoxylon Sewardi*. Radial section of a medullary ray showing tracheids, *tr.*, parenchyma, *p.*, and interspersed bands of tracheids, *itr.*

Goeppert and Menge (1883) as *Pinites stroboides* (see particularly pl. x, fig. 71), though the agreement between our fossil and that from the amber is not so exact as that between it and the living *P. monticola*.

The narrow marginal tracheids found in our fossil, as in his, are "in marked contrast to the other Cretaceous *Pityoxyla*, especially *Pityoxylon statenense* and *P. scituatense* of Jeffrey & Chrysler, in which the marginal cells are not noticeably narrower than the central cells of the ray" (Bailey, 1911, p. 317); but in this feature they resemble *Pityoxylon* (called by Bailey *Pinus*) *scituatensiformis*, though in other respects our much older fossil is more highly advanced and more like the living genus than is the Upper Cretaceous fossil.

Turning to Tertiary fossils, though several species of *Pityoxylon* have been described, none come very close to the new species.

The genus *Pityoxylon*, Kraus, in a wide sense, comprises several forms representing widely distinct modern genera within the Abietineæ. In many cases, the fossils do not show sufficiently salient features to make possible any close comparison with living genera, but in the present instance the fossil is not only well enough preserved, but has such characteristic features in its resin-canals, and in particular in its ray-tracheids, that affinity with *Pinus* is securely established. Among those species of living *Pinus* which I have personally examined, *P. monticola* comes in many respects very near to the fossil. It has large resinous parenchyma-cells in the rays, each with large single pits in each tracheid-field. Above and below the ray, and in narrow bands interspersed between the parenchyma-cells, are narrow simple tracheids extremely like those in the fossil (compare text-fig. 23 with text-fig. 25). Nevertheless, great as is the likeness to *Pinus*, I think the fossil species is best described as *Pityoxylon,* especially as the leaves or cones of this ancient form remain unknown.

It thus appears likely that the new species had affinities with the "soft pines": as no dentate thickenings appear to be developed on its otherwise well-preserved cell-walls, it seems fair to conclude that they were normally absent.

V. 1440. Type-specimen. A large wedge of secondary wood (about $27 \times 13 \times 6$ cm.), and some smaller pieces of it from which the sections have been cut. The petrifaction is clean of matrix, and shows the woody texture in the longitudinal direction very clearly. Both in the cut and the weathered transverse surfaces the very broad annual rings are apparent to the naked eye, as is the slight crushing and distortion of the spring wood in places. The specimen is iron-stained, and is very close and hard in texture, and the tissues are beautifully petrified.

V. 1440 a. Figured, Pl. IV, figs. 1 & 2. Transverse section of a part of the above, $3{\cdot}5 \times 4{\cdot}5$ cm. The well-developed, very broad rings are clear, and also the numerous rather broad uniseriate rays. Resin-canals are present, both singly throughout the wood and in tangential groups towards the outer region of the growth-ring.

V. 1440 b. Figured, text-fig. 23. Radial longitudinal section of the above. In parts of this the character of the medullary rays, with their interspersed bands of ray-tracheids, shows up very clearly. The pitting both of the ray-tracheids and of the parenchymatous cells can be made out.

V. 1440 c. Figured, text-fig. 24 and Pl. V, fig. 1. Tangential longitudinal section of the above, part of which slopes into a radial direction. In the tangential sections of the rays the alternation of the ray-tracheids and the parenchyma-cells shows very well, as is illustrated in the text-figure. In many cases multiseriate rays show the cut ends of horizontally running resin-canals.

Lower Greensand; Ightham, Kent.

Presented by John Hale, Esq., 1886.

Pityoxylon Benstedi, sp. nov.

[Plates V, VI, VII; text-figs. 26, 27.]

Diagnosis.—Wood with the characters of *Pityoxylon*, Kraus. The type is a small branch, about 6 cm. in diameter, and with a large circular pith 3·5 mm. in diameter with numerous primary bundles round it. Pith without stone-cells. Growth-rings well marked. Tracheids small, largest spring wood 30–35 μ in diameter, rounded at the corners. In radial walls, large round isolated bordered pits, a few smaller pits in tangential walls of late-formed wood. Small amount of wood-parenchyma round resin-canals, and also isolated in the wood.

Small resin-canal in each primary bundle and scattered singly throughout secondary wood, vertical and horizontal. Epithelial lining very thick-walled and pitted. Medullary rays uniseriate; and multiseriate with resin-canals. All the ray-cells thick-walled and pitted, "abietinean pitting" very noticeable, pits of a few elements large and simple, chiefly in groups of several roundish small pits per tracheid-field. Ray-tracheids conspicuous, very irregular in shape and size, walls irregularly thickened but not toothed, small round bordered pits irregularly placed.

Horizon.—Kentish Rag, Lower Greensand.

Locality.—Near Maidstone, Kent.

Type.—38353 and sections cut from it, British Museum (Nat. Hist.).

Finder.—W. H. Bensted, 1858; slides cut, 1912.

Description.—This new species is represented by a small petrified stem. About 3 cm. in diameter is petrified, but, as the outer rings of wood are worn off much more on one side than on the other, the stem could not have been less than 6 cm. in diameter when alive. The pith is preserved, and in two of the sections a small branch, like the main one, is being given off. No bark or other organs are present. The plant is represented by two short segments, which are evidently part of the same stem. Some of the coarse, light-coloured, granular matrix remains attached to the specimens, which externally do not show much of the wood-fibre. The specimens are fairly well silicified *, and black in texture where cut across.

Topography of the Stem.—The *pith* is large, 3·5 mm. in diameter, circular in main outline, star-shaped with numerous small points coming between the primary wood-bundles.

* I describe the woods as "silicified" when they appear to be at least partly petrified in silica, though the variability in the proportions and chemical nature is probably considerable. It has not been possible so far to have analyses of the various specimens made, though the subject would be interesting for special research. Fliche (1896, pp. 239, 240) indicates the complexity of the mineralising medium in some French specimens of Albian age.

Growth-rings to the number of 19 are present, well marked, variable in thickness up to a maximum of 3 mm. in the outer zones, containing about 135 cells. The spring wood forms only about one-fourth of the whole thickness of the ring, and its cells are slightly crushed and filled with black carbon grains, which give the rings their well-marked appearance. The autumn wood-elements are not very much thickened.

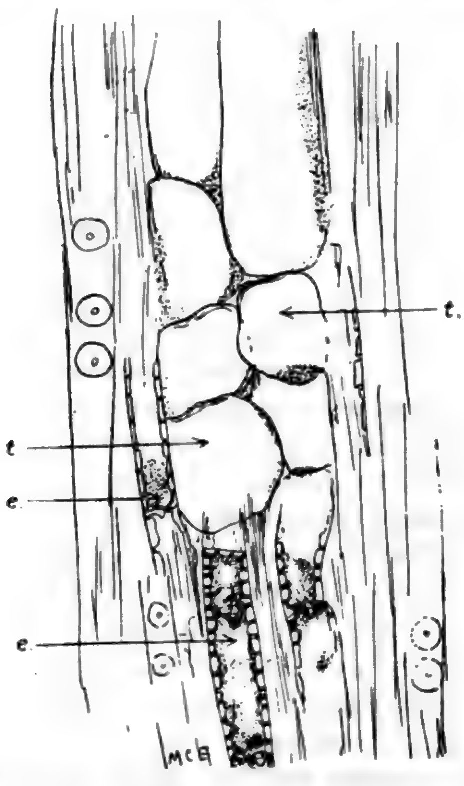
The *primary wood* is well preserved, projecting in large numbers of bundles into the pith (Pl. VI). Resin-canals are present in the primary bundles (Pls. VI & VII, fig. 1).

The *secondary wood* is close in texture, the elements small, slightly rounded at the corners, adjacent cells on slightly alternating tangents, so that the rounded walls fit compactly. In the first three annual rings the medullary rays are numerous and conspicuous, but in the later-formed wood they are narrow and remarkably inconspicuous. Horizontal and vertical *resin-canals* are present throughout all the wood, but are more numerous in the first five, than in the outer rings.

Uniseriate medullary rays are numerous and conspicuous in the earlier rings of wood, while in the outer rings the cells are small and very inconspicuous in transverse section; one to fifteen cells high, principally 1–6. In radial section the complexity of the ray, the abietinean pitting of the walls, and the ray-tracheids are well seen. *Multiseriate rays* contain resin-canals.

Details of Elements.—The *pith*-cells are large (Pl. VI, *p.*, & Pl. VII, *p.*), about 90 μ in diameter, rounded in outline, and with walls considerably thickened and pitted. This is shown in Pl. VII, *p.*, where the pits between adjacent cells are very clearly seen in the photograph. A number of the cells contain blackened and granular contents, but none seem specialised as resin-cells, nor are there any special thick-walled idioblasts. In longitudinal section the cells are elongated to a length about equal to $1\frac{1}{2}$ to 2 transverse diameters. The cross-walls are mainly rectangular.

The *primary bundles* in the *wood* vary somewhat in size; an average bundle is shown in Pl. VII, fig. 1. Round the pith there are not less than 30 bundles, with smaller ones between them. The *protoxylems* appear to be endarch (Pl. VII, fig. 1, *px.*), but it is not possible absolutely to confirm this from the sections available, as none of the longitudinal sections show protoxylems with undoubted tracheids lying towards the pith within them. The protoxylem elements which are recognisable in longitudinal sections, have fine, close, spiral, approximating to scalariform, thickening. In the transverse section, groups of small elements, about four or five deep, lie on the internal side of the protoxylems; they may consist only of "bundle sheath," or may possibly contain a few centripetal xylem-elements. So far as we can judge from the transverse



Text-fig. 26.—*Pityoxylon Benstedi*, sp. nov. Longitudinal section showing resin-canal filled with tyloses, *t.*, and with thick-walled pitted epithelium cells, *e.* No. 38353 B *e.*

sections, there certainly seem to be a few centripetal xylem-cells.

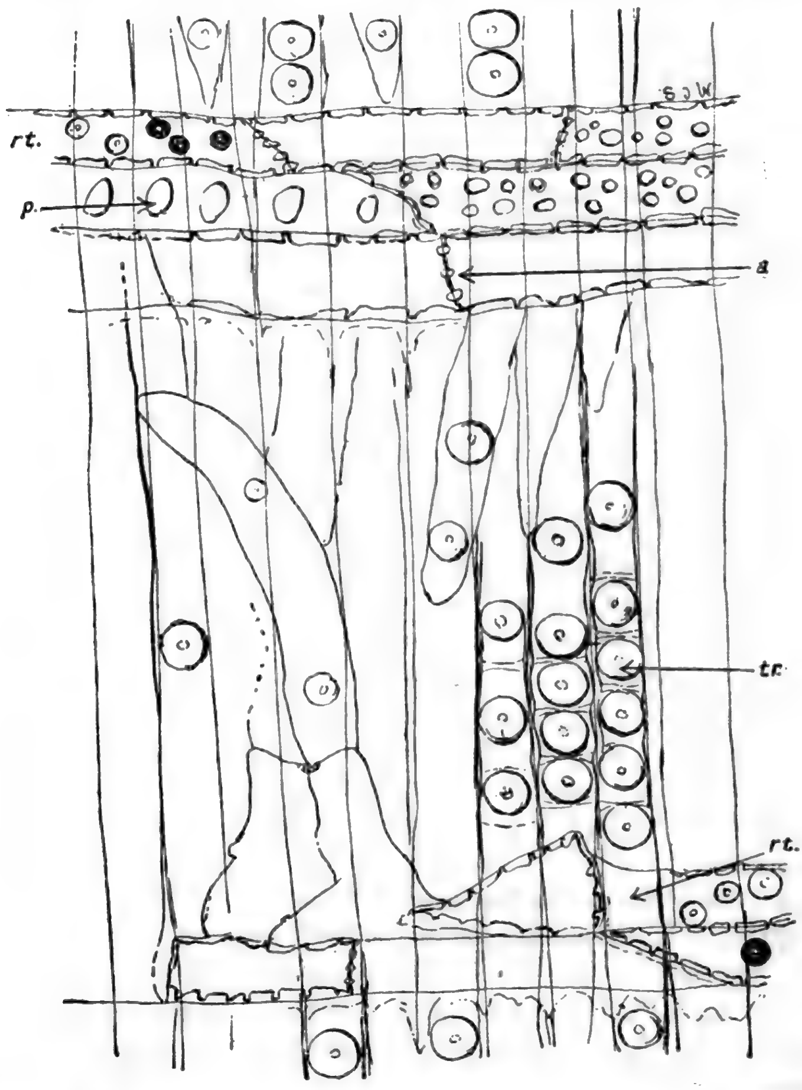
In the *secondary wood* the annual rings are sharply marked, the tracheids of the spring wood being about $25 \times 30\ \mu$ to $30 \times 35\ \mu$ in diameter, and those of the autumn wood about $15 \times 20\ \mu$ to $19 \times 25\ \mu$. The thickness of the wall in the last zones of autumn wood is about $5\ \mu$, thus nearly as great as the diameter of the cell-lumen. Comparison of these measurements with those of the majority of gymnospermic woods will show that the wood-elements are throughout small in size. In outline the elements are rounded, and fit closely together. In transverse section, owing possibly to the preservation, pitting is not apparent. In longitudinal section a few of the tracheids show small tangential pits. In the radial walls the bordered pits are circular, as large as to fill the diameter of the tracheid-wall, the pores are circular and large. The pits lie in a single row on the tracheid-wall, in many cases close together, others separated by as much as the width of their own diameter. There is no flattening of the border, the outline always being completely circular. Between the pits traces of "Sanio's rims" are often very conspicuous (text-fig. 27). There are no additional thickening spirals on the tracheid-walls.

Large areas of *wood-parenchyma* like those described for *Pityoxylon Sewardi* are not present, nor have I been able to detect any wood-parenchyma cells other than those containing resin (see below).

Specialised *resin-containing tracheids* do not seem to be present. *Resin-containing parenchyma-cells* can be recognised in transverse section scattered among the tracheids, but are best seen in radial section. These cells are about the same diameter as the adjacent tracheids, their walls are somewhat thickened, and their transverse walls at right angles to the longitudinal walls. The cells are vertically elongated from twice or three times their transverse diameter to very much more than that, and are filled with blackened or brownish remains of their resinous contents.

Normal resin-canals are scattered throughout the secondary wood, and one canal lies in each of the main primary bundles. The structure is the same in all cases, the *epithelium* lining the canals being *thick-walled.* The pitting on these thick-walled cells is well seen in longitudinal section, where the wall is perforated by a large number of small pits (Pl. VII, fig. 2, *e.*, & text-fig. 26, *e.*). In many cases these cells have brownish or fine black granular contents.

The majority of the canals contain *tyloses.* These are seen in the primary canals in Pl. VII, fig. 1, and also in the canals in the secondary wood in Pl. VII, fig. 2, *t.* A longitudinal view of these tyloses is seen in text-fig. 26, *t*. As may be judged from the photographs and drawings, the walls of the tyloses are of a rather unusually firm appearance, which may possibly be correlated with the fact that the epithelium from which they arise is



Text-fig. 27.—*Pityoxylon Benstedi*, sp. nov. Longitudinal section, showing tracheid-pittings, *tr.* Two medullary rays illustrate the various types of cell comprising the ray. *rt.*, ray-tracheids; *p.*, ray-cells with large pits; *a.*, typical "abietinean pitting" of end-walls of medullary ray-cells. No. 38353 B.*f.*

thick-walled. As is well known, tyloses in canals with thick-walled epithelium are much rarer than in the species with a thin-walled lining to the resin-canal.

In transverse section in the first two or three annual rings the *medullary ray-cells* are numerous and conspicuous, the individual ray-cells often exceeding the tangential diameter of the adjacent tracheids, the radial extension of the cells averaging in the outer zones about 4–7 tracheids. The elements are all thick-walled and pitted, the majority being *ray-tracheids* (Pl. V, fig. 2, and text-fig. 27). The ray-tracheids have round bordered pits and a comparatively regular outline. In a few cases cells which appear to be parenchyma-cells have single large pits in each tracheid-field (text-fig. 27, *p.*). Whether these are normal pits the preservation of the fossil does not allow one to determine with absolute certainty. The end-walls of the ray-cells show the typical "abietineau pitting" (text-fig. 27, *a.*).

Comparisons.—Among previously described Cretaceous species of *Pityoxylon* none appear to approach this new form. Conwentz (1890) figures a portion of pith and primary wood much resembling our fossil (pl. x, fig. 5) from the Tertiary amber, which he includes in his *Pinus succinifera.* He uses *Pinus* in the broadest sense, and points out the great difficulty of separating it from *Picea* on the evidence of portions of wood and bark alone. Judging by Gothan's descriptions, the parenchyma-cells of the resin-canals in the new species are similar to that in *Piceoxylon antiquius*, Gothan (1910 A, p. 20), though, unfortunately, no illustrations of this point are given by Gothan. The two fossils, however, differ essentially in the presence of specialised ray-tracheids in the Lower Greensand form and their absence in the Spitzbergen fossil.

Affinities.—If among the described Cretaceous fossils there are none with which to compare this new fossil, it has many features which make comparison with living genera profitable. The extremely thick walls of the epithelium of the resin-canals and their pits (*cf.* text-fig. 26) are very suggestive of *Larix*, as is the thickened and pitted nature of the medullary ray-cells. The tyloses which are so prominent in the fossil may at first sight seem to militate against the view that the plant is allied to *Larix*, but tyloses in the living genus have been found not to be entirely absent as was once thought likely, but to be very rare. Furthermore, the pith, which is so noticeable in the new fossil, is *Larix*-like in having no stone-cells.

I incline to the view that the new fossil comes near to *Larix* in its affinity, but recognise that on the material available this cannot be certain. Bailey (1909) points out the difficulty and uncertainty in separating such closely allied genera as *Picea*, *Larix*, etc., by their woods alone, and instances the Californian fossil wood identified by Gothan (1906) as *Piceoxylon Pseudotsugæ* which he places very near to, if not identical with, the living Douglas fir. Bailey summarises Gothan's argument as follows:—"The fact that the resin-canals are typically non-pine like, with thick-walled epithelium, shuts out *Pinoxylon*. The presence of wood-parenchyma and spirals in the spring wood shows its relation to *Pseudotsuga*. *Pseudotsuga macrocarpa* has ray-tracheids with spirals, and in *P. Douglasii* they are absent." Bailey's work on the distribution of these features in recent plants forms the basis of his criticism of Gothan's conclusion. He says:—"In the first place, as we have seen, *Pseudotsuga Douglasii* possesses spiral thickenings in the ray-tracheids. This, according to the author's own line of reasoning, would exclude *P. Douglasii*. Further, let us consider the statements in regard to the presence of wood-parenchyma and spiral thickenings in the spring wood. As has been shown above, both these conditions occur in *Picea sitchensis*, a spruce from the Pacific coast. Can we be sure whether this fossil is more closely allied to *Pseudotsuga*, *Picea*, or even *Larix*?"

The very *Larix*-like appearance of the cones of *Pinites Solmsi* from the Wealden seems to support the view that a *Larix*-like wood may very well have been developed so early as the period of the Lower Greensand.

38353. Type-specimen. A small piece of petrified branch, now 3 cm. × 2 cm. and about 4 cm. long, and some small pieces of the same from which sections have been cut; a second small piece, obviously of the same specimen, was also cut into sections. Those labelled A are from the piece remaining, those B are from the piece which was entirely cut up. The petrified wood does not show much on the outside, but within the black close-grained medium has petrified the tissues very well. The rather irregular growth-rings can be clearly seen on the cut surfaces.

38353 B a. Figured, Pl. VI, fig. 1. Transverse section showing the large pith very beautifully. Round this the numerous primary bundles can be well seen, and outside the irregular and interrupted rings of secondary wood through one side of which a branch is coming off. In the primary bundles and in the earlier growth-rings the resin-canals are very numerous and conspicuous.

38353 B b. Figured, Pl. VII, fig. 1. A transverse section very similar to the above. The resin-canals in the younger zones of the wood show well, and are filled with large thin-walled tyloses, as figured.

38353 B c. Figured, Pl. VII, fig. 2. A part of a transverse section similar to above, the pith and inner rings are perfect, and the outer zones broken away. The tyloses filling the resin-canals in some of the rings of secondary wood are well seen and are illustrated.

38353 B d. Longitudinal section of the above, in oblique tangential direction. The height of the rays, etc., can be seen.

38353 B e. Figured, text-fig. 26. Median radial section, passing through the pith, primary wood, and an outgoing branch. Parts of the section cut the resin-canals slightly obliquely, and there the thick-walled and pitted epithelium-cells can be beautifully seen, as well as the large tyloses filling the canals.

38353 B f. Figured, text-fig. 27. Radial longitudinal section showing the details of the medullary ray-cells very well in places, as is illustrated. The thickened walls with their "abietinean pitting," the large pores of the ray-parenchyma, and the irregular outline of the ray-tracheids as well as their bordered pits can all be clearly seen. Between the rays, and connecting with the irregular ray-tracheids, lie elongated and somewhat irregular short tracheids with small round bordered pits.

38353 B g. Radial section; as in all preparations of this specimen the pitting of the various tissue-walls is well preserved.

38353 B h. Median longitudinal section through the pith and a small part of the wood. The pith-cells are well preserved, and the exit of the primary rays, which have their walls immensely thickened and covered with "abietinean pitting," is particularly distinct.

38353 B k & j. Two further median sections showing the pittings of the tissues. Longitudinally running resin-canals filled with tyloses can also be seen.

38353 B l. A thick transverse section showing pith and the irregular growth-rings.

38353 A m. Transverse section showing half the pith and some rings of secondary wood. A very slight obliquity blurrs the primary bundles, but the secondary wood and the resin-canals show well.

38353 A n. A section similar to the above, but showing better some of the primary bundles. The small resin-canals, one in each primary bundle, can be well seen.

38353 A o. Median radial section passing through the pith. The pitting of the rays, etc., can be well seen.

38353 A p. Rather oblique radial section, running into tangential at one side where a branch is given off.

38353 A q. Tangential longitudinal section, partly oblique and blurred, but locally showing the tangential view of the medullary rays.

All from the Kentish Rag, Lower Greensand; near Maidstone.

Presented by W. H. Bensted, Esq., 1858.

Pityoxylon sp.

V. 8134. Transverse section (rather thick and uncovered) of a branch, at present 3 cm. in diameter. The pith, however, is at one side, and so the living branch must have been at least 5 cm. in diameter. The annual rings are very well marked. The pith and primary bundles are jarred and broken, and the section permeated by large cracks. At one side there is a wound, which has caused large numbers of traumatic resin-canals to develop. As no longitudinal sections are available the specimen cannot be named, but the tissue is well preserved in places, and if the original block could be found and sections cut from it, the specimen could certainly be identified. It is possible that the resin-canals are all due to the influence of the wound, in which case the plant is not a *Pityoxylon* in the narrowest sense, but for the present may best be placed here. Lower Greensand; Maidstone.
Transferred from the Botanical Dept. [*Carruthers Coll.*].

V. 8284. Longitudinal tangential section of a gymnospermic wood, very poorly preserved. The uniseriate rays show in tangential view fairly well, and there are some larger spaces which may represent resin-ducts in multiseriate rays. Lower Greensand (?); Maidstone.
No history [*Carruthers Coll.*].

V. 8285. Radial longitudinal section of a gymnospermic wood, showing round bordered pits in one series. The walls of the medullary ray-cells are much thickened and show in places good examples of the typical "abietinean pitting." Lower Greensand (?); Maidstone.
No history [*Carruthers Coll.*].

The above two slides appear to belong to the same wood, their cover-glasses are similarly cut at the corners, and their colour and texture are the same, and both have "Maidstone" in the same writing cut on the glass. In this point, and also in the colour and character of the petrifaction of the wood they agree with V. 8134 described above, and I think it almost certain that the three slides represent the same specimen. As it is unproved, however, they cannot be diagnosed.

Pityoxylon Woodwardi, sp. nov.

[Plates VIII, IX; text-figs. 28, 29.]

Diagnosis.—Secondary wood with the characters of *Pityoxylon*, Kr. The type is part of a trunk which, judging by the curvature of the rings, must have been of some considerable size. Growth-rings very well marked, the walls very much thickened. Tracheids of spring wood large, $50 \times 65\ \mu$, up to $90\ \mu$ in diameter, with large, round, bordered pits, or "twin-pits," or pits in pairs on the radial walls. Tangential pits in autumn wood. Wood-parenchyma in quantity between the resin-canals. Resin-canals exceedingly numerous and conspicuous, in all the growth-rings, in tangential bands alternating in adjacent rings; all in autumn wood. Resin-canals large, ·2–·3 mm. in diameter, epithelium apparently thin-walled. Medullary rays conspicuous, cells differentiated. "Abietinean pitting" seldom visible. Radial walls with a single, large, very narrowly bordered pit per tracheid-field, ray-tracheids irregular in outline, smooth-walled, with small, round, bordered pits.

Horizon.—Lower Greensand.

Locality.—Woburn, Bedfordshire.

Type.—V. 5429 and sections cut from it; British Museum (Nat. Hist.).

Finder.—H. Veasey, Esq., before 1898.

Description.—This species is represented by a flat wedge-shaped specimen of secondary wood, 1·5 × 3·5 cm., and about 20 cm. long, evidently part of a large trunk. The external surface is much weathered, and the end is rounded off by water-wear, apparently before it was petrified. The petrifaction is irregular, the inner portions being dark brown in colour.

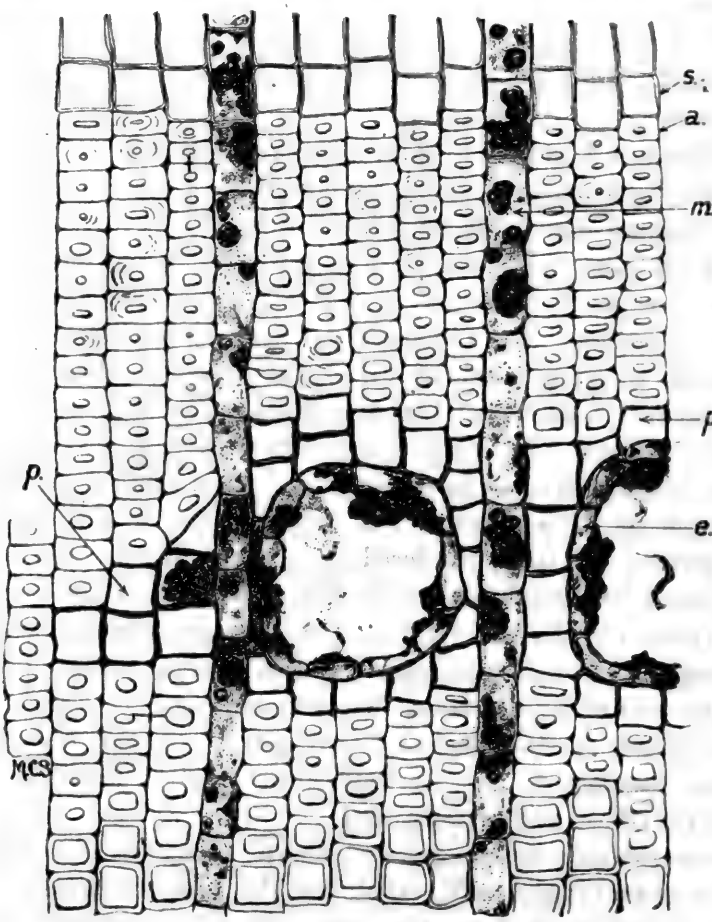
Topography of the Stem.—*Secondary wood* only is preserved, and in this the growth-rings are very well marked. The elements composing a ring number in radial series from about 35 to 70, the maximum thickness being about 2·5 mm. The autumn wood is about half the total thickness of the ring, and consists of extremely thickened and stony cells; even the first elements of spring wood have thickened walls. Rows of large *vertical resin-canals*, forming tangential bands in the autumn wood, are a very conspicuous feature of this plant. Large *horizontal* canals can also be seen in transverse section running in the medullary rays across more than one growth-ring.

Medullary rays are uniseriate and multiseriate, the latter containing resin-canals. The uniseriate rays are broad and conspicuous, from 1 to 6 tracheids distant. In radial extension many of the elements are short, only $1\frac{1}{2}$ or 2 tracheid widths in extent. In radial section the existence of *ray-tracheids* is very clear.

Details of Elements.—The *spring tracheids* (Pl. VIII, fig. 2) are generally crushed, though a few patches remain uncrushed. The elements are large, squarish, and, where uncrushed, fitting into each other with but little rounding of the corners. They measure as much as $50 \times 65\,\mu$, $40 \times 50\,\mu$, and some even up to $90\,\mu$ in diameter. Even in the first-formed spring wood the walls are thick, being as much as $4\,\mu$ in the largest spring elements adjacent to the last-formed autumn wood. The autumn tracheids have extremely thickened walls, often leaving only a small round pore or slit-like lumen (text-fig. 28); these walls may be as much as $12\,\mu$ thick. The radial walls of the tracheids are pierced by large bordered pits, lying in one row, when the round border approximately fills the width of the tracheid-wall (as in Pl. IX, figs. 1 & 2, *a*). Sometimes in such a tracheid the single pits are intermingled with pairs of pits closely crushed together and within the same "Sanio's rim" (as in Pl. IX, fig. 1, *b*), which might be described as "twin pits." On the other hand, a large number of the tracheids have pits in adjacent pairs (as in Pl. IX, *c*, and text-fig. 29).

In the autumn wood some of the walls are seen in transverse section to be tangentially pitted, but the great thickness of the walls somewhat distorts the pits. In all the bordered pits observed on tracheid-walls, the pores are round (Pl. IX, fig. 1). Some close, very faint striations are noticeable in the longitudinal views of the tracheids; these may possibly be based upon some sort of tertiary thickening in the walls, but it is not clear that it is not due solely to the arrangement of the mineral matrix.

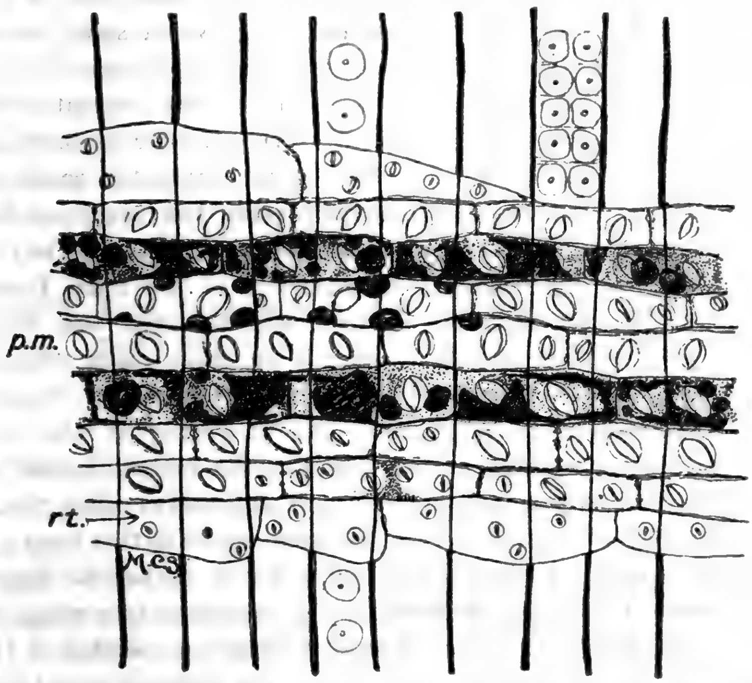
Wood-parenchyma appears to be absent from the general texture of the wood, but groups of large wood-parenchyma cells lie round the resin-tracheids, and form in some cases interrupted tangential bands between them (text-fig. 28). The vertical extension of these cells is about 2–4 times their transverse diameter, which equals that of the adjacent tracheids. Many of the wood-elements contain blackened contents, a few of these which lie isolated among the empty tracheids may possibly



Text-fig. 28.—*Pityoxylon Woodwardi*, sp. nov. Transverse section of part of autumn wood with resin-canals. *e.*, epithelium of canal; *p.*, parenchyma; *a.*, limit of autumn wood; *s.*, spring wood; *m.*, medullary ray. No. V. 5429 *a.*

have been resin-containing tracheids. There is nothing, however, to distinguish them from the others, and the great majority of the elements with blackened contents are clearly due to mineralisation.

Resin-canals are very numerous and conspicuous, and lie in rows forming tangential bands in the autumn wood (Pl. VIII, figs. 1, 2, & text-fig. 28). I have not observed any single isolated canals, or any in the spring wood except those which cross it transversely, running horizontally in the medullary rays. The canals appear to be normal; there is no evidence of wounding, and they lie in these alternating tangential bands throughout the wood. Individually the resin-canals are large,



Text-fig. 29.—*Pityoxylon Woodwardi*, sp. nov. Radial section showing the medullary ray-cells and their pitting. *p.m.*, pitted cells, with a single, large, oval pit per tracheid. *rt.*, ray-tracheids with small, round, bordered pits. No. V. 5429 *b*.

·2–·3 mm. in diameter. The epithelium lining them appears to be thin-walled, but is rather obscured by the blackened contents which line the cavity. The parenchyma immediately adjacent to them consists of short squarish cells, with rectangular end-walls. I have not observed tyloses. Adjacent canals are often separated only by a medullary ray. Connecting these vertically running canals are remarkably conspicuous transverse canals which run in the wide medullary rays.

Medullary rays are conspicuous, even the *uniseriate* rays being noticeable in transverse section (Pl. VIII, fig. 2, *m.*); they measure 30–40 μ in tangential diameter, and radially correspond to 2–4 tracheids. In radial section some of the elements are rectangular, and some narrow down at each end to a spindle-shaped form (see text-fig. 29). Many of the elements, both bordering and interspersed through the ray, are true *ray-tracheids* with small, round, bordered pits (text-fig. 29, *rt.*). The distinction between these and the other ray-elements is not very sharp, and there are all gradations between small round pits and the large open slits with a very narrow border (Pl. IX, fig. 3, *p.m.*, and text-fig. 29, *p.m.*). Some of the elements with the larger pits have masses of dark brown granular contents, as is seen in text-fig. 29 and in the dark horizontal bands in Pl. IX, fig. 3. The ray-tracheids bordering the ray show but slight irregularity of outline, and do not appear to have any of the denticulate thickenings characteristic of the hard Pines. Owing to the fine granular deposit which masks the walls of most of the elements, it is difficult to make quite reliable observations on the point, but there do seem to be true, though small, "abietinean pittings" on the end-walls of the ray-elements. In tangential section some of the end-walls can be clearly seen to be perforated with small oval and circular pits.

Affinities.—Whether or not the resin-canals in this form are traumatic instead of normal is a point which cannot be determined from the given material. The specimen is a wedge of wood measuring only 1·5 × 3·5 cms. in diameter, so that if the wound had been serious it is not beyond the realm of possibility that the whole of this area should have been under its influence and thus forced into the production of traumatic resin-canals. On the other hand, this would be rather an unusually large area to be so uniformly affected by a wound of which there is no sign in the section. It must be noted that the rows of resin-canals are fairly uniformly distributed all through the wood in rather regularly diffused, alternating, tangential bands (Pl. VIII, fig. 2). Furthermore, the canals, on the whole, do not have the characteristic of running together tangentially, which is noted by Jeffrey (1905) as one of the features to be seen in traumatic resin-canals. As Jeffrey observes, an actual wound is not the only stimulus which will produce traumatic canals, but they may follow an attack of *Chermes* (the witches' broom). In such a case it is probable that the area uniformly affected might be larger than that resulting from a wound, and so our fossil may have only traumatic resin. On the other hand, there is a strong argument in favour of the resin-canals being normal, in the exceedingly Pine-like character of the rays and their ray-tracheids (Pl. IX, fig. 3, and text-fig. 29).

This new species and *P. Sewardi* agree with the Upper Cretaceous *Pityoxylon scituatense* and *P. scituatensiforme* in having considerable quantities of large-sized and resinous parenchyma associated with the resin-canals, a feature said by Bailey (1911) to be "without parallel among living Pines."

The radial section (text-fig. 29) is so much like that of several living species of *Pinus* that the fossil has doubtless considerable affinity with that genus, probably among the species of the section of "soft Pines."

V. 5429. Type-specimen. It consists now of a flat wedge of much-weathered secondary wood, 3·5 × 1·5 cm. and 18·5 cm. long, as well as some small pieces of the same from which sections have been cut.

V. 5429 a. Figured, Pl. VIII, figs. 1 & 2, and text-fig. 28. Transverse section of rings of secondary wood, with no pith or outer tissues. The alternation of the seasonal growth is very strongly marked, and the autumn wood is wide and thick-walled. There are series of resin-canals throughout the tissue, as is illustrated.

V. 5429 b. Figured, Pl. IX, figs. 1–3, and text-fig. 29. Radial section of the above, which shows the ray-tracheids and parenchyma-cells with their pittings as described and illustrated.

V. 5429 c. Tangential section, showing the rays, some of which are multiseriate and contain large, transversely running resin-canals. Part of the section slopes into the radial direction, in which the rays can be well seen.

V. 5429 d. Thick, uncovered, transverse section, cut as sample.

Lower Greensand; Woburn, Bedfordshire.

[*Veasey Coll.* ?], *transferred from the Botanical Dept.*, 1898.

Genus **PINOSTROBUS**, Feistmantel.

[Sitzb. k. böhm. Ges. Wiss., 1874, p. 272.]

Diagnosis.—Fossil ♀ cones with overlapping scales, having a greater or less degree of likeness to *Pinus* in the narrowest sense, but all clearly of abietinean affinity.

This generic name was never diagnosed, nor its use commented on or explained by Feistmantel, who employed it for two Cretaceous species, *Pinostrobus prolongatus* and *P. vallidus* from Bohemia. It was not adopted by Fritsch & Bayer (1901) in their monograph on the plants of the same deposit, and it does not appear to have been quoted by any other author. It is, however, appropriate for the more or less doubtfully *Pinus*-like, but certainly abietinean, cones, which occur isolated in the Upper Mesozoic and Tertiary deposits.

Several writers (*e.g.*, Seward, 1895) use *Pinites* for such cones, but as *Pinites* is equally applied to foliage, twigs, cones, and wood, and as it was originally proposed for wood which was not even abietinean, its use is ruled out both by the laws of nomenclature and the inconvenient vagueness of its application.

It is well that the names of fossil cones should terminate in *-strobus*, for then the nature of the specimen is obvious, even in lists where the name only is given. In the present case *Pinostrobus* is appropriate, as the genus *Pinus* used at one time to cover the more recently segregated genera *Larix*, *Picea*, *Abies*, etc.

The following cones are described under this generic name:—

A. Cones closely allied to, if not identical with, the living genus *Pinus*:

1. *Pinostrobus sussexiensis* (Mantell), nov. comb.

B. Cones less clearly allied to any given living genus:

2. *Pinostrobus Benstedi* (Mantell), nov. comb.
3. *Pinostrobus oblongus* (L. & H.), nov. comb.
4. *Pinostrobus patens* (Carr.), nov. comb.
5. *Pinostrobus cylindroides* (Gard.), nov. comb.
6. *Pinostrobus pottoniensis* (Gard.), nov. comb.
7. *Pinostrobus* sp., *cf.* ? *Pinus longissima*, Vel.

Pinostrobus sussexiensis (Mantell), comb. nov.

[Plate X, figs. 2, 3, & 4; Plate XI, fig. 3; text-figs. 30, 31.]

1843. *Zamia Sussexiensis*, Mantell, Proc. Geol. Soc., vol. 4, p. 34.
1843. *Zamites Sussexiensis*, Morris, Cat. Brit. Fossils, p. 25.
1844. *Zamiostrobus sussexiensis*, Goeppert, Uebers. v. Schles. Gesellsch., p. 129.
1845. *Zamiostrobus sussexiensis*, Goeppert, in Unger, Synop. Plantarum Foss., p. 162.
1846. *Zamia Sussexiensis*, Mantell, Quart. Journ. Geol. Soc., vol. 2, p. 51, pl. ii, fig. 1.
1866. *Pinites Sussexiensis*, Carruthers, Geol. Mag., vol. 3, p. 541, pl. xx, figs. 5, 6.
1867. *Pinites Sussexiensis*, Carruthers, Journ. Bot., vol. 5, p. 13, pl. lviii, figs. 5, 6 [same plate as Geol. Mag., 1866].
1870. *Pinites Sussexiensis*, Schimper, Traité Paléont., vol. 2, p. 296.
1886. *Pinites Sussexiensis*, Gardner, Rep. Brit. Assoc., 1885, p. 245.

Diagnosis.—That given by Carruthers, who was the first to recognise the true nature of the species, is as follows:—"Cone oblong, truncate at both ends; axis slender; scales leaving axis at a very acute angle, bearing two ovate seeds in a hollow very near the base; scale in transverse section triangular."

To this should now be added:—Cone 14 cm. long, by nearly 5 cm. in diameter, exposed area of overlapping scales, about 2 cm. in tangential and 1·3 cm. in vertical extent, border of scale curved and thickened. Seeds 4 mm. in diameter and 1 cm. long; stone-layer corrugated; wings broad and stout. Irregular double series of bundles in cone-scales oriented in various directions.

Horizon.—Lower Greensand, very near junction with Gault.

Locality.—Selmeston, Sussex.

Type.—V. 3349, and slides V. 3349 *a–c* cut in 1912; British Museum (Nat. Hist.).

Finder.—Dr. G. A. Mantell, about 1841.

Description.—The type and only known specimen of this species is a cone 14 cm. long by about 5 cm. in its greatest diameter. When found by Mantell it was evidently complete, for there are in the Museum now two casts of it which resemble Mantell's original figure (Mantell, 1846, pl. ii, fig. 1). Mantell himself never cut a section of it, for he says (p. 51): "The specimen has fallen into the possession of another, or I should have made a transverse section of it, as suggested by M. Adolphe Brongniart."

The specimen was for some time in the collection of Robert Brown, who made a section from its apex, as Carruthers (1866 B, p. 541) mentions and figures (pl. xx, fig. 6). At about this time also the specimen was broken open, Carruthers saying: "I found that it had been cracked, and, inserting my knife into the crack, I separated the pieces, when it exhibited, as has been accurately drawn by Mr. Fielding (pl. xx, fig. 5), the internal structure of an Abietineous cone."

The specimen is now in three pieces: one showing much of the outer scales (Pl. X, fig. 2), as well as the broken transverse view of the central axis and seeds (Pl. X, fig. 3); the second split longitudinally from this; and the third a small transverse segment, from which I have had three sections cut (Pl. X, fig. 4; Pl. XI, fig. 3). The cone is exceedingly like that of a modern *Pinus* of the *Strobus* group, and appears to have been quite or nearly mature at the time of petrifaction, for the testas of the large seeds are hardened and ripe, and the scales and other tissues are much sclerised. Unfortunately the seeds are empty, and none of the endosperm or embryonic tissues seem to be preserved.

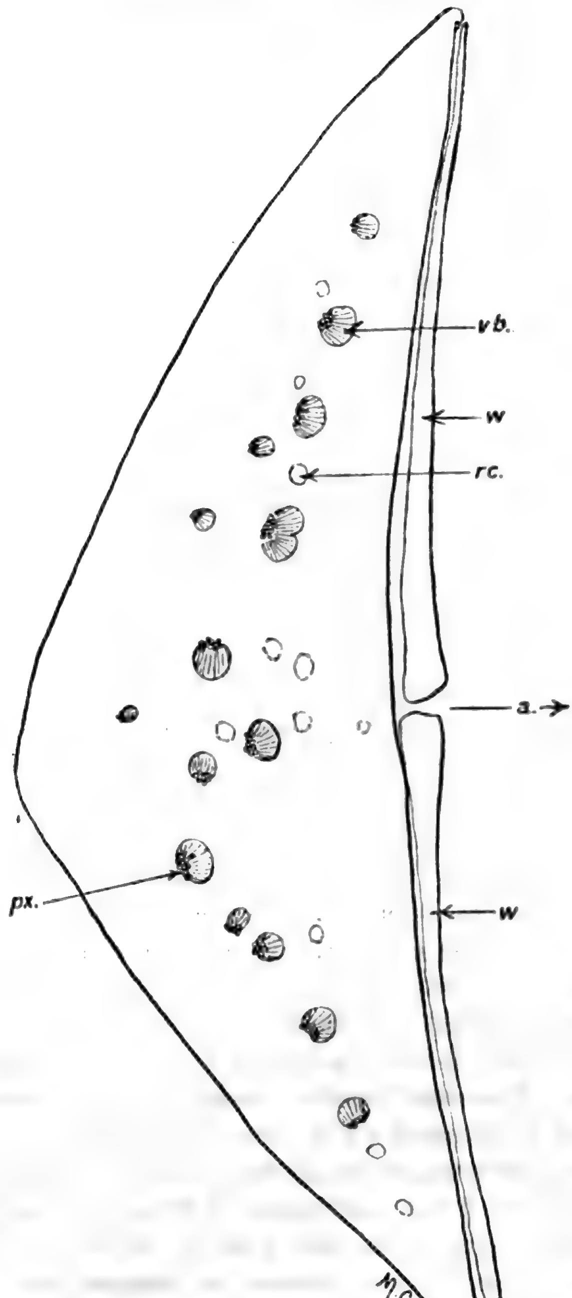
The *axis*, which can be seen at the base of the cone projecting as a short broken-off stalk 4 mm. in diameter, is slender for the size of the cone. It is not seen in longitudinal view, and in transverse section of the seed-bearing part of the cone, where, though the tissues are locally well preserved, the centre is so much macerated that the general plan of the vascular system cannot be made out. Portions of strands of small tracheids can be seen, and several large round resin-canals. The larger series of canals probably stood in a circle round the axis, as is the case in the beautifully petrified Tertiary cone *Pinus ovata*, L. & H. The ground-tissue of the axis consists of large roundish cells with much thickened and sclerised walls resembling those found in great numbers in the scales (Pl. XI, fig. 3, *scl.*).

The *scales* overlap, and leave exposed an area roughly 2 cm. in tangential direction and 1·3 cm. in vertical extent; and they curve strongly, having a crescent-shaped edge which appears to be thickened somewhat, but without a definite umbo. The scales leave the axis at an acute angle, and appear to measure about 4 cm. from tip to attachment. In transverse section (Pl. X, fig. 4; text-fig. 30) they have an approximately triangular outline. As there are no longitudinal sections, it is impossible to determine whether the bract-scale persists separately from the large ovuliferous scale.

Lying against the upper surface of the scales, towards the inside of the cone, two symmetrically placed, narrow, scale-like structures can be seen (Pl. X, fig. 4, *w.*; text-fig. 30, *w.*), evidently the massive wings of the seeds, which must have been already ripe and almost ready for dispersal at the time of petrifaction. The tissues of the scales are perfectly petrified in some cases, and consist of large roundish cells, the majority of which have much thickened and sclerised walls (Pl. XI, fig. 3, *scl.*); towards the edge of the scales they are much smaller and form a somewhat irregular limiting layer, the original epidermis being apparently disintegrated. Between the limiting layer of the inner surface of the scale and the two wings, which are generally free from it, two rows of smaller softer cells can be seen in a few places, showing that they originally formed part of the same tissue.

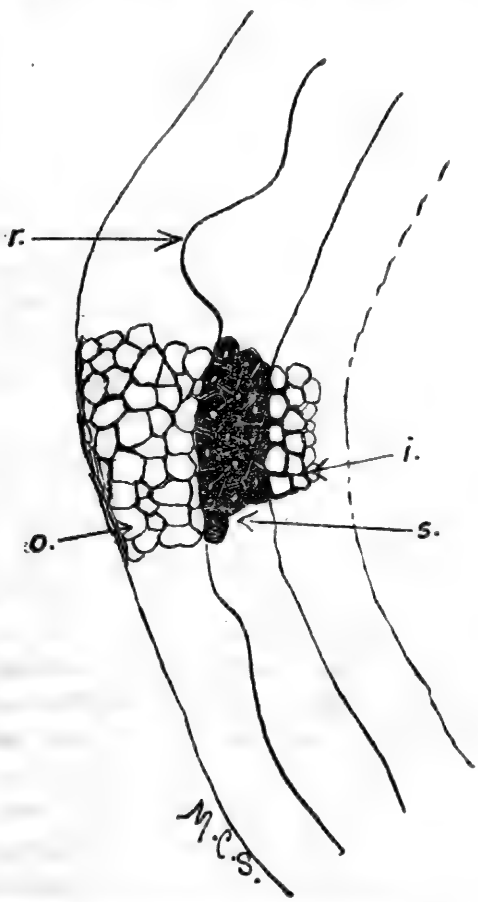
Resin-canals of some size are irregularly scattered throughout the tissues of the scales (Pl. XI, fig. 3, *r.c.*; text-fig. 30). The *vascular bundles* of the free outer part of the scales are numerous, bi-lateral, with some tendency to be curved, and, in a few cases, almost circular. Their arrangement can be seen in Pl. XI, fig. 3, *v.b.*, and in the text-fig. 30, where it will be noted that toward the middle of the scale the bundles are in an irregularly double series, oriented at a variety of angles toward each other. The main bundles, however, are so oriented that their xylem is directed away from the inner face of the scale, which is thus its morphologically lower surface. The significance of the anatomy of the cone-scales of *Pinus* has been discussed by van Tieghem (1869), Eichler (1881), Worsdell (1900), and others; and it will be of interest to compare the theoretical consideration of living species in these papers with the details of this, the oldest, *Pinus*-like fossil in which the vascular anatomy of the scale is known.

At the base of the scale, near the attachment of the ovules, the bundles are united to form two flat bands, oriented so that



Text-fig. 30.—*Pinostrobus sussexiensis* (Mantell). Scale in transverse section, showing the arrangement of the vascular bundles and principal resin-canals. *a.*, direction of axis; *vb.*, vascular bundles, in which are *px.*, the protoxylems; *rc.*, resin-canals; *w.*, *w.*, wings of seeds detached from scale. No. V. 3349 *a*.

the protoxylems face away from the axis. The *seeds* are borne at the bases of the scales, two on the inner side of each. One pair of them can be seen attached to the parent scale at *s.* in Pl. X, fig. 4. They are 4 mm. in diameter and 1 cm. long. In all the seeds cut in the sections, there only remain the layers of the testa with part of the outer tissues; most of the inner



Text-fig. 31.—*Pinostrobus sussexiensis* (Mantell). Part of the testa showing the irregular outline and ridges (*r.*) of the stone (*s.*). *i.*, cells of inner integument; *o.*, cells of outer integument, which merges with the wing. No. V. 3349 *a.*

layers of the testa as well as the nucellus, endosperm, and embryo leave no trace. In section, the stony layer of the testa is much indented and is irregularly star-shaped in outline (text-fig. 31), which appears to represent surface-corrugations.

How far these are natural and how far petrifact, the sections do not afford data to determine. Outside the sclerised zone of the testa is a layer of 4 or 5 cells, roundish and not very thick-walled, which resembles the texture of the scales; within the stone-layer also are a few cells of rather thinner-walled tissue. The general plan of these structures may be compared with the testa of *P. Strobus* given in Tubeuf, 1892, fig. 1, though the detailed proportions of the cells differ.

Affinities.—When first described by Mantell, the specimen was known only from its exterior, and was placed in the recent genus *Zamia*. A model of it was submitted to Ad. Brongniart, who wrote to Mantell concerning it:—"Le modèle en plâtre du cone que vous m'avez envoyé est assez difficile à juger sans avoir vu l'échantillon lui-même, et par conséquent mon opinion ne peut être que fort hasardé, mais je serai plutôt porté à penser que c'est une jeune tige de Cycadée qu'un fruit de conifère. Ce pourrait aussi être *un fruit de Zamia*; mais l'examen de l'échantillon en nature, et surtout sa coupe transversale, serait nécessaire pour avoir une opinion positive."

Mantell says (p. 52): "But although at first sight this fossil, as M. Brongniart remarks, might be taken for the stem of a young Cycadeous plant, the situation and small size of the stalk at the base, and the appearance of the scales seem to warrant the conclusion that it is the fruit of a *Zamia*."

Carruthers (1866 b, p. 541) puts the cone in the genus *Pinites*, and says (p. 542): "The fossil certainly belongs to the *Pinus* division of the genus, and is near to *Pinus Strobus*, L."

The further details now afforded by the sections of the tissues do not invalidate the opinion formed so long ago by Carruthers. There is no doubt that the cone belonged to a *Pinus*, so similar to living members of the genus that one might almost be justified in using the generic name of the living forms for it.

As the ripe cone of a large woody species is difficult to cut into thin microscope-sections, the details of the anatomy of such tissues have been but little studied. As a consequence, the rather curious position arises that the botanist can see the details of the scales and their vascular anatomy more easily in the fossil than in the recent cones.

The external appearance, so far as it is preserved, is very like, but not identical with, that of *Pinus Strobus*. The fossil seems to me to lie midway, in general aspect, between *P. Strobus* and *P. excelsa*.

V. 3349. Type-specimen, Pl. X, figs. 2, 3. Figured, Mantell, 1846, pl. ii, fig. 1; Carruthers, 1866 B, pl. xx, fig. 5, and 1867, pl. lviii, fig. 5 [same plate]. The lower half of the cone, split into two unequal portions. In one of these the stalk at the base can be well seen still, though evidently the smaller basal scales have been broken away. The crescent-shaped, somewhat thickened edges of the scales are very clear on one face. The cone is irregularly split in a tangential direction, which leaves a surface passing partly through the axis of the lower 3 cm. Here the attachments of some of the scales can be imperfectly seen. The scales appear to measure from 3 to 4 cm. from attachment to tip. Toward the middle of the break, the angle bends abruptly, so that the tangential surfaces of the split scales are exposed, the central one having the broken-open empty testas of two seeds adhering. The upper end of the specimen shows the cone-scales, seeds, and axis irregularly broken across (Pl. X, fig. 3).

V. 3349 a. Figured, Pl. X, fig. 4; Pl. XI, fig. 3; text-figs. 30 & 31. Transverse section of part of the above cone. In this the overlapping thick scales show particularly clearly. Two seeds attached to their scale can also be seen at the upper part of the section (Pl. X, fig. 4, *s.*). All the details of the anatomy, as described above, can be made out in this section. The scale marked *z* in the figure being particularly good for the vascular anatomy, and the scale marked *x* for the tissues of the wings.

V. 3349 b. A poorer and rather pulverised transverse section, similar to the above. Two of the scales on the left hand of the section show their tissues, as well as the wings, in a good state of preservation.

K

V. 3349 c. A thick and imperfect transverse section, as above. Towards the centre a crumpled scale, with portions of two ovules associated, shows the vascular tissue in two bands, oriented with the protoxylems away from the ovules.

39115. Cast of the above specimen before cutting, and as it was figured by Mantell, 1846, pl. ii, fig. 1. The cast is not clear or good, but gives a general idea of the cone. It is probably the cast sent to Ad. Brongniart (see p. 128, *ante*).

Lower Greensand, near junction of Gault; Selmeston, Sussex. *Mantell Coll.* [also in *Robert Brown's Coll.* for some time].

Pinostrobus Benstedi (Mantell), comb. nov.

[Plate X, fig. 1; Plate XI, figs. 1, 2; text-figs. 32, 33.]

1843. *Abies Benstedi*, Mantell, Proc. Geol. Soc., vol. 4, p. 34.
1844. *Abies Benstedi*, Mantell, Medals of Creation, p. 166.
1846. *Abies Benstedi*, Mantell, Quart. Journ. Geol. Soc., vol. 2, p. 52, pl. ii, figs. 2, 2 *b*, 2 *c*.
1847. *Pinites Benstedi*, Endlicher, Synop. Conif. Foss., p. 19.
1850. *Abietites Benstedi*, Goeppert, Foss. Coniferen, p. 207.
1866. *Pinites Benstedi*, Carruthers, Geol. Mag., vol. 3, p. 541.
1867. *Pinites Benstedi*, Carruthers, Journ. Bot., vol. 5, p. 12.
1870. *Cedrus Benstedi*, Schimper, Traité Paléont., vol. 2, p. 300.
1886. *Abietites Benstedi*, Gardner, Rep. Brit. Assoc., 1885, p. 246; Geol. Mag., dec. 3, vol. 3, p. 499.

Diagnosis.—Mantell does not give a diagnosis in his original description, and Carruthers diagnosed it in 1866 as follows:—"Cone oval; scales broad and thin at the apex, leaving the thick axis at a right angle, then ascending beyond the seed." To this should now be added:—Cone about 4 cm. long, by about 2·8 cm. in its broadest part, rounded above and below. Scales very numerous and closely overlapping, the exposed portion measuring approximately 1 cm. in tangential extent and ·3–·4 cm. in ventral extent, though in the upper part of the cone many of the scales are much smaller. The axis is very solid, being 1 cm. and more in diameter. Ovulifero and bract scales separate and both well developed; the seeds, two on each ovuliferous scale, are about 6 mm. long by 3 mm. broad. The cone, however, is immature.

HORIZON.—Kentish Rag, Lower Greensand.

LOCALITY.—Iguanodon Quarry, near Maidstone.

TYPE.—39107; and slides 39107 *a*–39107 *d*, cut in 1912; British Museum (Nat. Hist.).

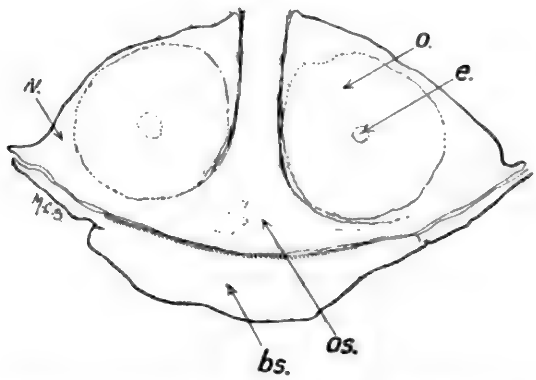
FINDER.—W. H. Bensted, Esq., about 1834.

DESCRIPTION.—The small oval cone is seen split open and illustrated in natural size, Pl. X, fig. 1. The outer surface of the cone is much worn and a little broken, but the contours of a few of the scales can clearly be seen, and they overlap in the same way as those of a *Cedrus* or *Abies* cone, the ends of the scales apparently being thin. The exposed portion of the scale is twice as long tangentially as it is vertically. Mantell in his original description states that "one seed is imbedded within the base of each scale," but the sections recently cut show some scales in an oblique tangential direction and demonstrate that *two* seeds were borne on each ovuliferous scale.

The cone was unripe, as is shown by the internal tissues of the seeds, which were not fully developed, and by the very slight sclerification of the massive axis. The measurements given in the diagnosis, therefore, are not of true specific value, save for other cones in a like state of unripeness. The "remains of the embryo," which Mantell mentions as being seen in some seeds, are really the undeveloped endosperm, which, with the very soft broken-down central zone and broad outer zones of cells, does to some extent resemble an embryo with split cotyledons when seen without proper microscopic sections. Reference should be made to Pl. XI, fig. 1, *end.*, which shows a seed cut across, with testa and partly developed endosperm, in which a small central area has broken down owing to the incomplete wall-formation at the time of petrifaction.

Carruthers (1866 B, p. 541) considered this cone to be very like that of a modern Cedar, but he had only the external poorly preserved features on which to base his judgment. The structures shown in the sections are more suggestive of the genus *Abies*.

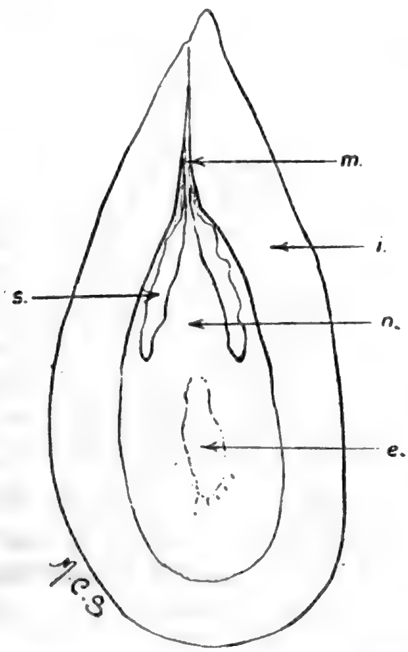
The *axis* is remarkably massive for the size of the cone, measuring 10–12 mm. in diameter (Pl. XI, fig. 2, *a.*). This is particularly noticeable if comparison be made with *P. macrocephalus*, for instance, where a cone of about four times the size has an axis only 5 mm. in diameter. The cellular tissue of the axis is not very well preserved, but the outline of the large soft cells composing it can be seen; they appear to have been slightly thickened, but not sclerised as the cells of a mature cone would be. There are no transverse sections of the cone, but from the longitudinal section it can be recognised that in the axis there was a slender hollow cylinder of vascular tissue, giving off strands to the scales. A few small elements with fine scalariform thickening can be seen, but the secondary wood-elements are not well enough petrified to show the character of their pitting.



Text-fig. 32.—*Pinostrobus Benstedi* (Mantell Tangential section showing: *os.*, ovuliferous scale; *bs.*, bract-scale; and *o.*, the two ovules on the ovuliferous scale. Somewhat diagrammatic: *e.*, broken-down endosperm; *w.*, wing. × about 8. No. 39107 *d.*

The *scales* are double, a large bract-scale bearing on its upper surface an ovuliferous scale with two basal ovules on its upper surface. In longitudinal section these can be well seen in Pl. XI, figs. 1 & 2, *o.*, *os.*, *bs.* These cone-sections are slightly oblique, and so cut the upper scales almost in a tangential direction, in which direction the relation of the parts is as in text-fig. 32, which is drawn from a purely tangential section of the cone.

The *ovules* are far from mature, and the tissues of the endosperm had evidently not yet quite fully differentiated at the centre at the time of petrifaction; the small irregular space left by the breakdown of their walls can be seen in the photographs of those ovules which are cut across in the middle—for example, *end.* in Pl. XI, figs. 1 & 2, shows this quite clearly, particularly if examined with a lens. This central space is indicated in the text-fig. 32, *e.* The ovules were inverted, lying with their micropyles directed towards the cone-axis. This is indicated on the right-hand side of Pl. XI, fig. 2. Some of the ovules are cut nearly in median longitudinal section, and in them the nucellar tissue and the massive free tip of the nucellus can be seen, as is indicated in text-fig. 33. In these sections the



Text-fig. 33.—*Pinostrobus Benstedi* (Mantell). Outline sketch of ovule in slightly oblique longitudinal section showing: *m.*, micropyle; *s.*, space between integument *i.* and the free upper part of nucellus *n.*; *e.*, inner broken-down tissue of the incompletely developed endosperm. No. 39107 *a.*

tissues are all fairly well petrified, and demonstrate the immaturity of the cone.

Affinities.—So far as I am aware, no fossil cone so well petrified, similar to this or in the same young stage of its development, has been described. On the other hand, a considerable number of abietinean cones, externally more or less like it, have been recorded from the Cretaceous and Tertiary deposits. Comparisons of doubtfully preserved exteriors, however, with well-preserved interiors are so unprofitable that I will attempt no comparison with the numerous species it might resemble, were all the facts known.

The likeness to the modern genus *Pinus*, however, is apparent in several features, though in the equally massive and separate development of the bract and ovuliferous scales the cone is more like *Abies*. Cones of *Abies* are seldom preserved as fossils, probably because the ripe cone sheds its scales; but in an immature condition a cone of *Abies* is just as likely to be preserved whole as that of any other genus. While this cone is not absolute proof that the genus *Abies* was evolved in Aptian times, it is highly suggestive of that conclusion.

39107. Type-specimen. Figured, Pl. X, fig. 1; Mantell, Quart. Journ. Geol. Soc. vol. 2, 1846, pl. ii, figs. 2, 2 *b*, 2 *c*. The small cone, measuring about $4 \times 2{\cdot}8$ cm., is split in an oblique longitudinal direction, showing the axis and the scales with the ovules attached, some in radial and some in tangential view. Externally the abraded apex of the cone can be seen, and also the worn edges of the scales. The second half of the cone was entirely cut up to make the following sections.

39107 a. Figured, Pl. XI, fig. 2; text-fig. 33. Longitudinal section, nearly median except at the top, where the scales and ovules are cut tangentially. The double scale and the attachment of the ovules can be seen very clearly.

39107 b. Figured, Pl. XI, fig. 1. Tangential section, showing the vascular strands in many of the scales and the ovules attached to the scales in others.

39107 c. A smaller, more oblique section, nearer the exterior of the cone, cut tangentially so as to show the two ovules clearly attached to the double scale as in text-fig. 32.

39107 d. Figured, text-fig. 32. A smaller tangential section, similar to the above, in which the ovules are very well preserved.

Kentish Rag, Lower Greensand; Iguanodon Quarry, Maidstone. *Mantell Coll.*

Pinostrobus oblongus (Lindley & Hutton), comb. nov.

[Text-fig. 34.]

1835. *Abies oblonga*, Lindley & Hutton, Fossil Flora Gr. Brit., vol. 2, p. 137, pl. cxxxvii, figs. 1, 2.
1845. *Elate oblonga*, Unger, Synop. Plantarum foss., p. 199.
1847. *Pinites oblongus*, Endlicher, Synop. Conif. Foss. p. 20.
1850. *Pinites oblongus*, Unger, Gener. Spec. Plantarum Foss., p. 358.
1850. *Abietites oblongus*, Goeppert, Foss. Coniferen, p. 207.
1866. *Pinites oblongus*, Carruthers, Geol. Mag., vol. 3, p. 541.
1867. *Pinites oblongus*, Carruthers, Journ. Bot., vol. 5, p. 12.
1886. *Abietites oblongus*, Gardner, Rep. Brit. Assoc., 1885, p. 246, and Geol. Mag., dec. 3, vol. 3, p. 499.
1887. *Pinites oblongus*, Williamson, Mem. Manchester Lit. & Phil. Soc., ser. 3, vol. 10, pp. 189–194, pl. ix, figs. 1–2.

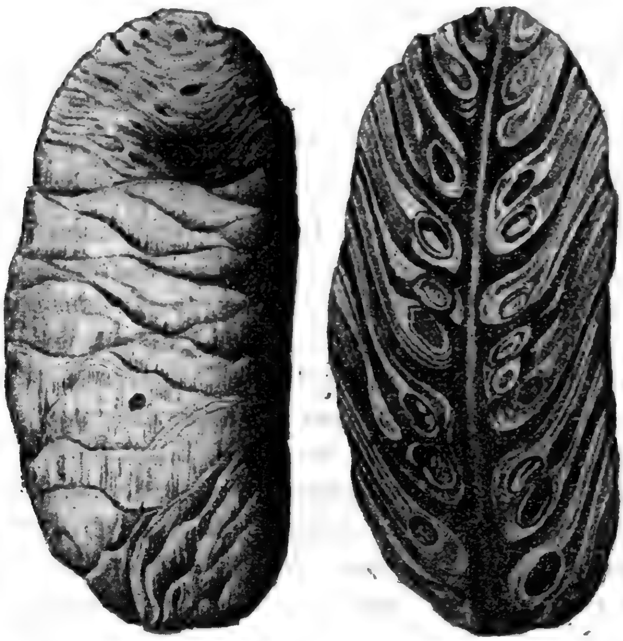
Diagnosis.—None is given by the original describers, but Goeppert (1850) diagnosed the species as follows:—"Abietites strobilo cylindrico, utrinque obtuso, squamis dense imbricatis, late ovatis, margine repandis." A short diagnosis is given by Carruthers (1866 B): "Cone cylindrical; scales broad and thin at the apex, with the seeds very near the base; axis slender." To this should be added that the cone is about 6·5 cm. long, but incomplete, and 3 cm. in diameter at its thickest part. There is composing the cone a relatively small number of overlapping scales, each apparently about 2 cm. in tangential extent and about 1 cm., more or less, in vertical extent, but they are rather variable.

Horizon.—Thought by Dr. Buckland to be washed out of the Greensand.

Locality.—Lyme Regis, on the shore of about 1850.

Type.—University Museum, Oxford.

The cone is illustrated by Lindley & Hutton (1835), and their figures are reproduced in text-fig. 34. A comparison of this with the species *P. Leckenbyi* of Carruthers will suffice to show their differences. While the present species *may* be allied to the living *Cedrus*, it is much less like it than is *P. Leckenbyi*. In 1887, Williamson described further some of the details of its internal anatomy from a second specimen of this species, also washed out on the shore and supposed to be of Lower Greensand age. It is, however, to my mind, not quite clear that the specimens do belong to the same species, for *P. oblongus* is generally put among cones of *Cedrus*-affinity, while Williamson's specimen is clearly of *Pinus*-affinity, for, as he says, the scales show "a slight thickening of those extremities resembling what is seen in *Pinus Strobus* and *P. Cembra*." Williamson also demonstrated that the seeds had large wings and were borne two on each scale, but his illustrations of the sections are very diagrammatic.



Text-fig. 34.—*Pinostrobus oblongus* (Lindley & Hutton). Exterior of the fossil, and the same split open medianly. Nat. size. After Lindley & Hutton.

I think there is very little doubt that this cone is really allied to *Pinus*, and is not a *Cedrus*, so that the inclusion of the true *Cedrus*-like cones from France in this species by Fliche (1896) is best abandoned (see p. 145).

[Many specimens from different localities have been ascribed to this species, but I do not feel sure that they really belong to to it (see, for instance, p. 143).]

Pinostrobus patens (Carruthers), comb. nov.

[Text-fig. 35.]

1866. *Pinites patens*, Carruthers, Geol. Mag., vol. 3, p. 543, pl. xxi, fig. 4.
1867. *Pinites patens*, Carruthers, Journ. Bot., vol. 5, p. 15, pl. lix, fig. 4.
1870. ? *Abietites patens*, Schimper, Traité Paléont., vol. 2, p. 308.
1886. *Pinites patens*, Gardner, Rep. Brit. Assoc., 1885, p. 245, and Geol. Mag., dec. 3, vol. 3, p. 499.

Diagnosis.—Given by Carruthers as follows:—"Cone ovate-acuminate; scales leaving the slender axis at a right angle, and supporting large seeds."

Text-fig. 35.—*Pinostrobus patens* (Carr.), comb. nov. Nearly nat. size. After Carruthers. No. 46655.

To this should be added:—Axis 3·5 cm. long; the small cone is only 1·8 cm. at its widest part, narrowing down rapidly.

Horizon.—Kentish Rag, Lower Greensand.

Locality.—Iguanodon Quarry, Maidstone.

Type.—No. 46,655; British Museum (Nat. Hist.).

Only one specimen of this cone appears to have been found, and, as Carruthers says, it "shows only a longitudinal section through the axis, and is sufficiently different from the last species [*Pinites Mantellii*, see *Cedrostrobus Mantellii*, p. 145] to warrant its being separated as distinct. The seeds are large, and in section of an oblong form."

As will be realised from text-fig. 35, it is almost impossible to compare this specimen with *Cedrostrobus Mantellii* (see p. 145) from the same locality. There appears to be no proof that they really differ, but one is represented by a cast of the outside and the other by a poorly preserved cone split open down the centre. It is less confusing to retain the original names than to unite them.

46655. Figured, Carruthers, Geol. Mag. vol. 3, pl. xxi, fig. 4; also text-fig. 35. A block of hard Kentish Rag (5 × 4 × 4 cm.) in which the small cone lies split open centrally. The plant-tissue more or less remains in a friable and broken-up condition. Iguanodon Quarry (Kentish Rag); Maidstone.

[*Probably from W. H. Bensted, Esq.*]

Pinostrobus cylindroides (Gardner), comb. nov.

[Text-fig. 36.]

1886. *Pinites cylindroides*, Gardner, Rep. Brit. Assoc., 1885, p. 245, pl. vii, figs. 2, 2 *a*.
1886. *Pinites cylindroides*, Gardner, Geol. Mag., dec. 3, vol. 3, p. 499.
1895. *Pinites cylindroides*, Seward, Cat. Wealden Flora, vol. 2, pp. 193, 194.

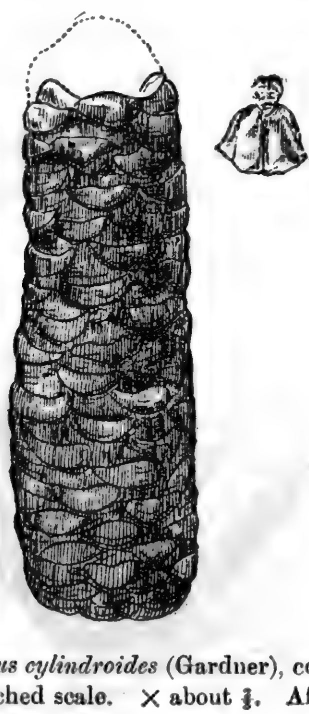
Diagnosis.—The description given by Gardner is as follows:—"This is an almost perfectly cylindrical specimen, being very slightly thickened towards the base, 7 centimetres in length and 22 millim. in diameter, composed of about 96 scales, arranged in 12 rows from left to right, and 8 rows from right to left, the arrangement thus being $\frac{8}{12}$. The scales are short and at right angles to the axis, with a smooth, flat, half-moon-shaped apophysis or scale-head, now gaping, but evidently imbricated before the seeds were shed. The scales become very small towards the base. The summit is abraded, exposing the end of a somewhat slender axis. Certain grooved lines on the sandy matrix between the scales show that the cone was furnished with foliaceous bracts, and the marks of a boring insect are visible."

HORIZON.—Lower Greensand.

LOCALITY.—Potton.

TYPE.—Sedgwick Museum, Cambridge.

Gardner continues his description to point out that "the specimen, which is quite distinct from any other fossil or recent cone, is singularly elongated and cylindrical, scarcely tapering at all from the base upward." His figure is reproduced in text-fig. 36, where it will be seen that a detailed description or comparative account of the specimen is not practicable.



Text-fig. 36.—*Pinostrobus cylindroides* (Gardner), comb. nov. View of the cone and a detached scale. × about ⅔. After Gardner.

That this specimen is really a Lower Greensand, and not an older derived form, is vouched for by Gardner, who says, "it is fortunately in excellent condition, certainly not derived from any older beds, like so many of the Potton fossils." Seward, on the other hand, says (1895, p. 193): "An inspection of the type specimen .... 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."

Pinostrobus pottoniensis (Gardner), comb. nov.

[Text-fig. 37.]

1886. *Pinites Pottoniensis*, Gardner, Rep. Brit. Assoc., 1885, p. 245, pl. vii, fig. 3.
1886. *Pinites Pottoniensis*, Gardner, Geol. Mag., dec. 3, vol. 3, p. 499.
1895. *Pinites Pottoniensis*, Seward, Cat. Wealden Flora, vol. 2, p. 193.

Diagnosis.—The description given by Gardner is as follows:— "The fragment figured, though much mutilated, fortunately

Text-fig. 37.—*Pinostrobus pottoniensis* (Gardner), comb. nov. Base of cone, showing scales and seeds. × about $\frac{3}{4}$. After Gardner.

shows the characteristically winged seeds of *Pinus* in the most perfect manner, entirely removing any lingering doubt as to the occurrence of representatives of true *Pinus* as low down as the Neocomian. The scales were set at an acute angle with slightly thickened recurved apophyses, the form of which cannot clearly be made out, though they appear to have been narrow, keeled, and mucronate."

Horizon.—Lower Greensand (?), probably derived Wealden.

Locality.—Potton.

Type.—Sedgwick Museum, Cambridge.

The illustration of the species given by Gardner is reproduced in text-fig. 37, from which it will be judged that, beyond establishing its *Pinus*-like nature, little can be made of the fossil.

Pinostrobus sp. [indet.]. ? Cf. *Pinus longissima*, Velenovsky.

[Text-fig. 38.]

1885. *Pinus longissima*, Velenovsky, Gymnosp. Böhm. Kreideform., p. 29, pl. i, figs. 14–17.

The specimen in the Kentish Rag, as can be judged from text-fig. 38, is not well enough preserved to allow of its diagnosis as a new species. It can only be compared provisionally with the Bohemian specimen, for the important characters, such as the shape and type of edge to the scale, the size and character of the seeds, etc., are not preserved. The British fossil is, however, very slender, and was apparently much longer than the upper part of it now preserved, and it is more like *P. longissima* than any other described cone of approximately the same age. *Pinites Dunkeri*, with which it might also be compared, is larger in diameter than the Lower Greensand form and is of Wealden age.

1771. Text-fig. 38. The part of the specimen preserved is 9·5 cm. long by 2 cm. in diameter, and appears to be only the upper part of a much longer cone. It lies partly embedded in the matrix, so that the outer surfaces of the scales are concealed. It is broken through the middle irregularly, and shows fragments of broken scales and seeds, and part of the poorly preserved axis in the upper end (see text-fig. 38). Kentish Rag, Lower Greensand; Iguanodon Quarry, Maidstone. *Presented by W. H. Bensted, Esq.*, 1839.

Text-fig. 38.—*Pinostrobus* sp. (indeterminable, cf. ? *Pinus longissima*, Vel.). Specimen lying in matrix. $\frac{8}{9}$ nat. size. No. 1771.

Genus **CEDROSTROBUS**, nov.

Diagnosis.—Fossil, ♀ cones with overlapping broad scales, having a very definite and recognisable likeness to the recent genus *Cedrus*.

In one sense this genus may be looked on as a section of the wider genus *Pinostrobus* (see p. 122), but it is confined to specimens which are so well characterised that there is no doubt of their similarity to, if not complete identity with, the living genus *Cedrus*. It is interesting to note that Cedar-like cones, described by various writers frankly under the modern generic name of *Cedrus*, are among the very early remains of the Abietineæ [see, for example, *Cedrus Lennieri* described from the Upper Neocomian by Saporta in 1880, and the beautiful casts from the Albian greensands described by Fliche (1896, p. 200, pl. viii)]. From English Aptian deposits two species are described, one of which is founded on a fine specimen. The genus is very rare in the American Lower Cretaceous, Berry (1911) describing only one example, *Cedrus Leei*; and it is not impossible that it may have originated in the East.

Woods described as referable to various species of *Cedroxylon* are not very common, but several species have been determined, some apparently belonging to *Cedrus* in a true sense, and thus representing the parent-trees of these cones.

Cedrostrobus Leckenbyi (Carruthers), comb. nov.

[Text-fig. 39.]

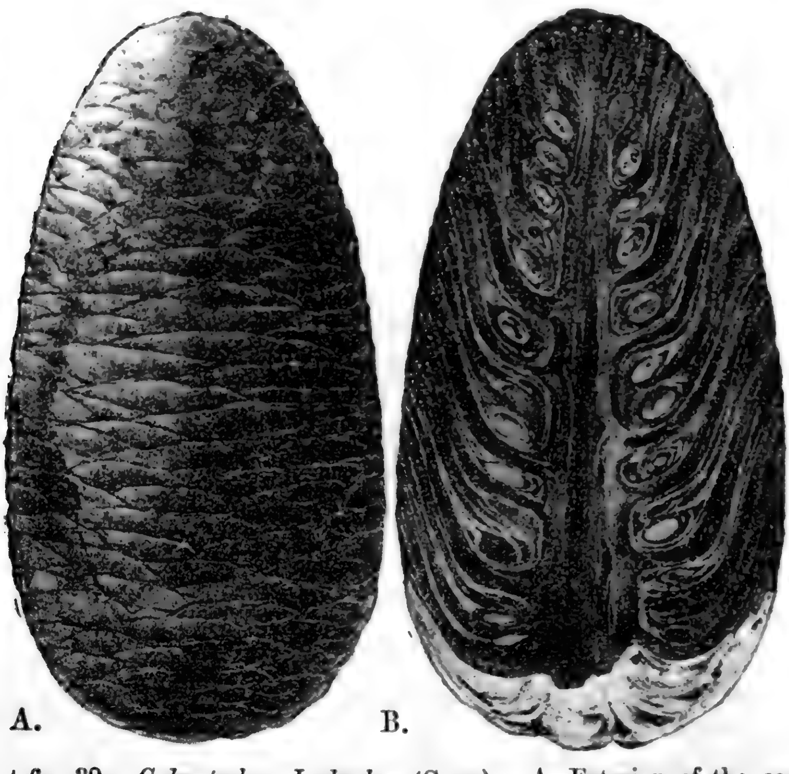
1869. *Pinites Leckenbyi*, Carruthers, Geol. Mag., vol. 6, p. 2, pl. i, figs. 1–5.
1870. *Cedrus Leckenbyi*, Schimper, Traité Paléont., vol. 2, p. 299.
1886. *Pinites Leckenbyi*, Gardner, Rep. Brit. Assoc., 1885, p. 246, and Geol. Mag. dec. 3, vol. 3, p. 499.
1896. *Cedrus oblonga*, Fliche, Bull. Soc. Sci. Nancy, vol. 14, p. 200, pl. viii, figs. 1–5.

Diagnosis.—Given by Carruthers is as follows:—"Cone oblong-ovoid, with an obtuse or subtruncate apex; scales very broad, not thickened at the apex; seeds small, ovoid." To this should now be added:—Cone 10 cm. long by 5 cm. broad, slightly tapering, and rounded at both ends. Scales very numerous, broadly extended and overlapping, so that the exposed part of each scale measures about 2–3 cm. tangentially and ·4–·6 cm. vertically; the scales at the base of the cone smaller than this. The scales vertically finely striated and greatly resembling those of *Cedrus*.

HORIZON.—Lower Greensand.

LOCALITY.—Shanklin, Isle of Wight.

TYPE.—Originally in the collection of John Leckenby, Esq., of Scarborough, now in the Sedgwick Museum, Cambridge.



A. B.

Text-fig. 39.—*Cedrostrobus Leckenbyi* (Carr.). A. Exterior of the cone showing the closely overlapping scales. B. Section through the middle of the cone showing axis and seeds on the scales. Nat. size. After Carruthers.

This well-preserved cone is figured both externally and in section by Carruthers (see text-fig. 39). He says: "The affinity between this cone and the recent cedars is so obvious, that it would be wasting words to dwell upon it; but it may be interesting to remark that this group of pines .... formed a striking characteristic of the Cretaceous Flora."

According to Carruthers, within the seeds, some of which are very well preserved, lie the embryos, "and in one the section is so made as to show divisions of the cotyledons."

While this cone bears some likeness to *Pinostrobus oblongus*, the two seem generically distinct, as will be evident on comparing the illustrations of the originals. In the latter species, for instance, the shape and relative dimensions of the exposed part of the scale differ greatly from those in *C. Leckenbyi*, and resemble *Pinus*.

There appears to me to be a likeness so close as to amount to identity between this cone and those, also beautifully preserved, described as *Cedrus oblonga* by Fliche (1896). In his pl. viii he figures examples of these fossil cones, some a little smaller, and one rather larger, than the type of *P. Leckenbyi*, which are exactly like it in all other particulars discernible. The French specimens are from the Albian Greensands, and, though identified by Fliche as the same species as the *Abies oblonga* of Lindley & Hutton, I have no hesitation in including them in *Cedrostrobus Leckenbyi*, which they much more closely resemble.

Cedrostrobus Mantellii (Carr.), comb. nov.

[Text-fig. 40.]

1866. *Pinites Mantellii*, Carruthers, Geol. Mag., vol. 3, p. 543, pl. xxi, fig. 3.
1870. *Abietites Mantellii*, Schimper, Traité Paléont., vol. 2, p. 308.
1886. *Pinites Mantellii*, Gardner, Rep. Brit. Assoc., 1885, p. 245.
1886. *Pinites Mantellii*, Gardner, Geol. Mag., dec. 3, vol. 3, p. 499.

Diagnosis.—Small oval cone, not less than 4·5 cm. long, probably rather more, and about 2 cm. in diameter. Scales arranged in a close spiral, overlapping so as to expose about 1·5 cm., more or less, in a tangential direction and about 3–5 mm. in a vertical direction. The scales apparently thinning out at the edge and without an umbo, externally striated in a vertical direction.

Horizon.—Kentish Rag, Lower Greensand.

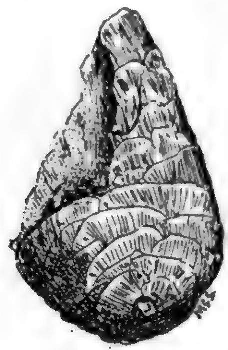
Locality.—Iguanodon Quarry, Maidstone.

Type.—No. 1765 *a*; British Museum (Nat. Hist.).

Carruthers' original description is as follows:—"Cone ovate-acuminate; scales broad, flat, and thin at the apex; axis slender; seeds roundish. The cone is about an inch and three-quarters long by fully three-quarters broad. The specimen is fragmentary, but the form of the cone is preserved in the matrix. The apex of the scale is very broad and thin. This cone was found in the Iguanodon Quarry at Maidstone, Kent, and formed part of the Mantell Collection, now in the British Museum."

The type-specimen (1765 *a*, B.M. Coll.) is little more than the external cast of the cone, with two or three imperfect scales and a scrap of the axis at the base preserved in imperfect relief—of this Carruthers (1866 B) gives a not very accurate drawing.

A better specimen of the cone, now in the Maidstone Museum, was found in the same quarry and presented to the Maidstone



Text-fig. 40.—*Cedrostrobus Mantellii* (Carr.). Drawing of the Maidstone specimen. Base of the cone showing the overlapping *Cedrus*-like scales. Nat. size.

collections by Mr. W. H. Bensted. This consists of the basal part of the cone, showing the axis and lower scales, and is figured in text-fig. 40. On comparing this specimen, and the cast it leaves in its matrix, with Carruthers' type, there is no doubt that the two cones are of the same species. The Maidstone specimen is of the same size as the type, and fits into the hollow of the original cast described by Carruthers.

As none of the internal tissues are preserved, it is not possible to determine whether the cone is young or mature. Thus, comparison with described species is not very satisfactory, but the fossil recently re-described by Berry (1911, p. 411, pl. lxx, figs. 4, 4 *a*) under the name *Cedrus Leei*, agrees with it closely in size and form. Berry notes that "except for its smaller size, which may be due to immaturity, [his specimen] .... is very close to the European species" of fossil cones of *Cedrus*; and the "*Cedrus lotharingica* which Cornuel (1882, p. 262, pl. vii, figs. 2 & 3) describes from the Lower Gault of Houpette (Meuse), France, is strikingly similar to the Potomac form." As he remarks, this French species was later (in 1896) included by Fliche in the species known as *Abies oblonga* of Lindley & Hutton, and put by the French in the genus *Cedrus*. As I have already pointed out (p. 145), Fliche's French cones should not be included in this species, but rather in *Cedrostrobus Leckenbyi* (Carr.). It is also doubtful whether Cornuel's *Cedrus lotharingica* should be included in the same species as those of Fliche. That it belongs to *Cedrostrobus* seems clear, but the similarity claimed for it with both the American and the other French species seems overestimated.

1765 a. Figured, Carruthers, Geol. Mag., 1866, pl. xxi, fig. 3. A slab (9 × 10 cm.) of coarse matrix with shells and the cast of the cone, in which, towards the base only, are a few scales imperfectly preserved, with broken seeds attached to them. Iguanodon Quarry, Lower Greensand; Maidstone. *Mantell Coll.*

Genus **CEDROXYLON**, Kraus.

[In Schimper's Traité Paléont. Végét., 1870, p. 370.]

Diagnosis.—That given by Kraus is as follows: "Lignum stratis concentricis distinctis, rarius obsoletis, latioribus; cellulis prosenchymatosis porosis, poris magnis, rotundis, uni- vel pluriserialibus oppositis; cellulis ductibusque resiniferis nullis; radiis medullaribus simplicibus." Kraus continues: "Ce type comprend les bois dont la structure coïncide avec celle des bois d'*Abies* et de *Cedrus*, et exclut tous ceux qui par leurs conduits résinaux se rattachent au genre *Pinus* proprement dit."

Gothan (1905) devotes a special section to the consideration of *Cedroxylon*, and its separation from *Cupressinoxylon*, which is not always an easy matter, since the two woods resemble each other very closely in many cases. The older writers used the absence of resin-parenchyma cells among the tracheids in *Cedroxylon* and their presence in *Cupressinoxylon* as the leading diagnostic character for the separation of the two "genera," but more recent work has all tended to show the variability possible among individuals of a single species in this respect.

Gothan, however, lays great stress on the character of the pittings of the medullary ray-cells. He says: "In zweifelhaften Fällen—bei Seltenheit des Holzparenchyms—ist bei der bisherigen Bestimmungmethode aus den im Vorigen genannten Gründen die Frage, ob *Cupressinoxylon* oder *Cedroxylon*, überhaupt nicht zu beantworten. Es ist daher nötig, sich nach einem weiteren—möglicht durchgreifenden—Merkmal umzusehen, das eine Verwechselung beider Typen ein für allemal ausschliesst. Ein solches besitzen wir in *der Markstrahlzellenwandtüpfelung*. Bei abietoiden Hölzern (*Cedroxylon*) bietet die Markstrahlzelle im Radialschnitt durchweg ein Bild . . . wo es sind sowohl die horizontalen als die vertikalen Wände stark getüpfelt . . . die Tüpfel sind kreisrund." In his figure 7 *a* he illustrates this kind of pitting, which he designates as "abietinean-pitting" "Entgegen dem besitzen die Cupressineen . . . durchweg glatte Markstrahlzellwände."

His diagnostic characters for the separation of *Cedroxylon* are as follows:—"Hoftüpfel rundlich, grösser, nicht gedrängt; wenn mehrreihig, meist gleichhochstehend. Hydrostereïden ohne Spiralverdickung. Abietineentüpfelung vorhanden; Harzparenchym bei einigen ständig am Ende des Jahresrings, bei diesen (ob auch sonst? *Abies balsamea*?). Harzgänge fehlend. Tangentialtüpfel im Spätholz häufig. Quertracheïden vorkommend."

If sufficiently well preserved, all specimens of *Cedroxylon* should show the "abietinean pitting" in their ray-cells. There are, however, forms like the living *Juniperus* which have "abietinean pitting" and yet belong to the Cupressineæ.

From various horizons in the Cretaceous about a dozen species of *Cedroxylon* have been described [see, for instance, Fliche (1896 & 1900), Lignier (1907), and others listed in Part I of this Catalogue (Stopes, 1913, p. 80)]. In nearly all, however, the ray-cells are very inadequately petrified, except in two species described by Gothan (1907).

Cedroxylon maidstonense, sp. nov.

[Plate XII, figs. 1 & 2; text-figs. 41, 42, 43.]

Diagnosis.—Coniferous wood with well-marked annual rings, tracheids, regularly arranged in series, up to about 50–80 μ in diameter; bordered pits circular, generally in one row, a few in adjacent pairs; Sanio's rims well marked. Wood-parenchyma absent or exceedingly scarce. Resin-canals absent. Medullary rays principally 4–6 tracheids distant, nearly all uniseriate, a few partly biseriate. Rays principally low, very few above 10 cells high. In tangential section "abietinean pitting" of end-walls of ray-cells can be seen (but the pitting is not well enough preserved to show in radial section); in the radial walls there are several small pits per tracheid-field, chiefly 4–6 or more. These small pits are oval or circular, but some seem slit-like and with a border.

Horizon.—Kentish Rag, Lower Greensand.

Locality.—Iguanodon Quarry, Maidstone.

Type.—Secondary wood of oldish trunk, nos. 1769, and slides 1769 *a*–1769 *c* cut from it in 1912; British Museum (Nat. Hist.).

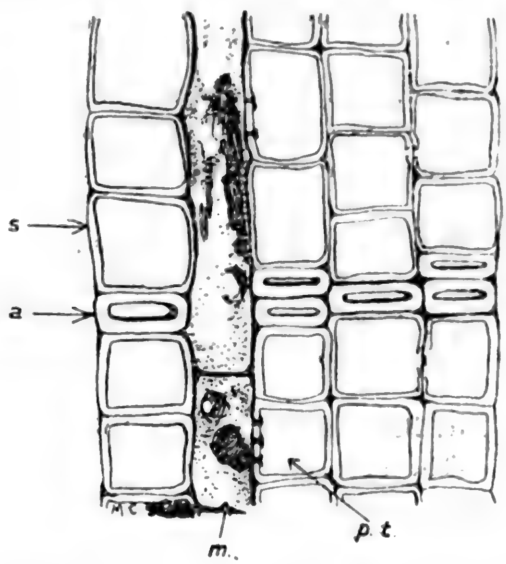
Finder.—W. H. Bensted, Esq., before 1850.

Description.—The new species is represented by a portion of secondary wood, which appears to have been toward the outer region of a fair-sized trunk, because of the remains of branch bases and "knots," which still remain on one side of its outer surface. The block is about 12 cm. long, by 5 × 4 cm. thick; the irregular core is well silicified and black in texture; the outer coating, in which the cell-structure is not petrified, though the woody appearance is retained, is whitish grey.

Topography of the Stem.—*Secondary wood* alone is present. In this *growth-rings* are well seen and are sharply marked (Pl. XII, fig. 1). The mass of the wood, however, is almost entirely spring wood, the zone of autumn wood being exceedingly narrow (as can be clearly recognised in the photograph, Pl. XII, fig. 1, *a*), and consisting of from 1 to 4 elements, while the spring wood consists of from 9 to 34 elements in each growth-ring, the maximum thickness of the rings being 2 mm.

The *wood* is regular in texture, the elements squarish and large, adjacent elements often lying on the same tangent, so that the rounding at the corners of the tracheids is very slight. No normal *resin-canals* and no *traumatic canals* are present. In transverse section, a few tracheal elements scattered through the wood have blackened contents, which may be the remains of resin. I have not been able to find any evidence of true resin-parenchyma.

The *uniseriate medullary rays* are fairly numerous, principally 4–6 tracheids distant, in transverse section their tangential



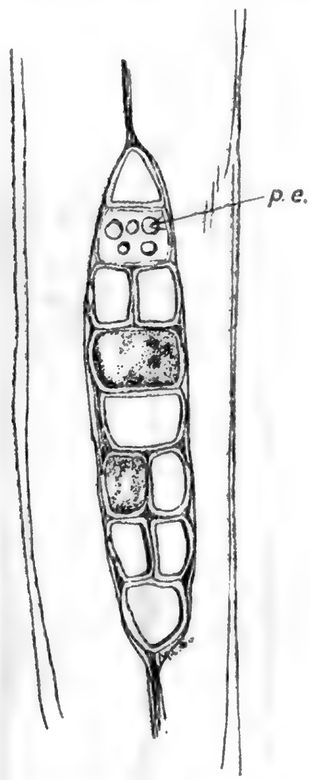
Text-fig. 41.—*Cedroxylon maidstonense*, sp. nov. Transverse section of small part of two annual rings, to show the very narrow thick-walled autumn wood, *a.*; *s.*, spring wood; *m.*, medullary ray; *p.t.*, tracheid adjacent to medullary ray showing several pits. No. 1769 *a.*

measurement is rather less than that of the adjacent tracheids. In height the rays are principally 1–3 cells high, but a few are well over 20 cells high. The proportion is roughly :—

Rays of 1–3 cells high, 26 in number.
,, between 4 and 10 cells high, 19 in number.
,, above 20 cells high, 4 in number.

Among the rays a fair number show a slightly *biseriate* character (text-fig. 42). These rays do not otherwise differ from the uniseriate rays, and contain no resin-canals.

Details of Elements.—Owing to the smallness of the narrow bands of autumn wood, the mass of the wood consists of *tracheids* the size of the spring wood, which averages about 40–50 μ by 50–80 μ, with comparatively thin walls. The one or two rows of narrow autumn elements are about 50 $\mu \times 15\ \mu$, with walls as thick as the lumen or with the lumen reduced to a mere slit (text-fig. 41). In transverse section, bordered pits are evident in many of the radial tracheid-walls; those tracheids adjacent to



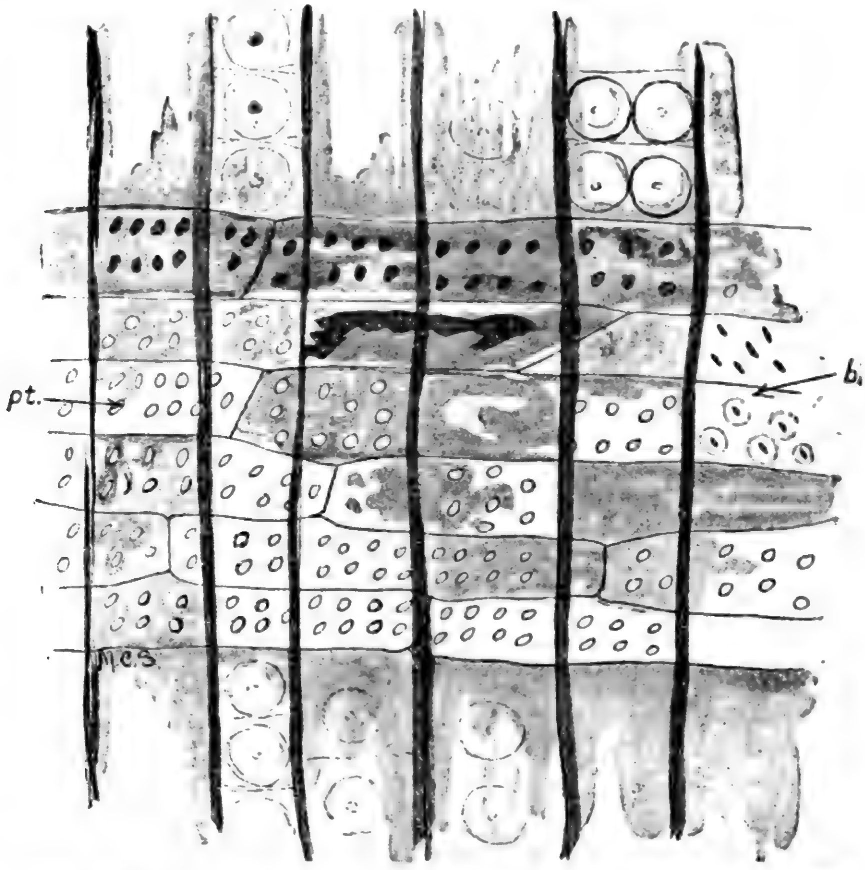
Text-fig. 42.—*Cedroxylon maidstonense*, sp. nov. Tangential section of medullary ray, showing the uniformly thick-walled cells, *p.e.*, showing a pitted end-wall. Notice that the ray is partly biseriate. No. 1769 *b*.

the medullary rays show several small pits in one wall (text-fig. 41, *p.t.*). I have detected pits in the tangential walls of only a few of the autumn wood-elements. In radial view the tracheid-pits are round, the border being only half, or less, of the diameter of the tracheid. The pits are in a single row, separated by their own diameter, or near together, but seldom adjacent or flattened (Pl. XII, fig. 2). The remains of "Sanio's rims" are often apparent—for example, at *s.* in Pl. XII, fig. 2.

Wood-parenchyma appears to be absent, for I have not been able to detect any in the sections.

Apart from a few scattered and unspecialised tracheids with blackened contents, there appear to be no special *resin-cells.*

Resin-canals are entirely absent.



Text-fig. 43.—*Cedroxylon maidstonense,* sp. nov. Radial section showing the character of the medullary ray-cells, and their groups of many small pits per tracheid-field. *pt.*, rounded, apparently simple pits; *b.*, doubtfully bordered pits. Owing to the preservation, the pitting of the end-walls is not shown in this view (*cf.* text-fig. 41, *p.t.*). No. 1769 *c.*

Medullary rays in transverse section correspond to from 2 to 6 tracheids in radial sequence, and are about 20 μ in tangential diameter. In all cases the walls are somewhat thickened and pitted, the pits between the ray and the adjacent tracheids showing very clearly in many cases in transverse view (text-fig. 41, *p.t.*). Owing possibly to the petrifaction being slightly imperfect, it is impossible to be certain whether or not the end-walls have typical "abietinean pitting." That the end-walls are pitted is seen in the tangential view (text-fig. 42, *p.e.*). In text-fig. 43 the outline and the pitting in relation to the tracheids are all that can be clearly shown. The rays consist of uniform cells, as is shown in text-figs. 42 and 43, and are entirely devoid of ray-tracheids.

AFFINITIES.—The absence of xylem-parenchyma and the pitting of the end-walls of the ray-cells, which can just be seen in some cells of the tangential section (text-fig. 42), prove the type to be a *Cedroxylon*. The tendency to form partly biseriate rays is found rather more characteristically in *Cupressinoxylon* than in *Cedroxylon*, but it is of secondary importance, and is sometimes found in *Cedroxylon*—as, for example, in *C. cedroides*, Gothan.

Unfortunately, the preservation of our fossil is such that, though the pits are well seen in the radial walls of the medullary ray-cells, the end and horizontal walls are not well petrified and do not show their pitting. That they had typical "abietinean pitting" when alive seems proved by the few end cell-walls seen in tangential section, in which the characteristic pits occur.

I do not know any described fossil with which our new species entirely corresponds; in many respects it comes nearer to *Cedroxylon cedroides* (see Gothan, 1907, p. 23) than to any other. Gothan's species, however, has typically larger and much fewer pits than in ours, in which the number of pits per tracheid-field is particularly high. *C. cedroides* also has well-developed xylem-parenchyma, which is lacking in our wood.

There is no British fossil with which one can compare the new species, and I name it after the neighbourhood in which it was found—already famous for the number of Aptian fossil plants it has yielded.

1769. Type-specimen. A portion of secondary wood $11 \times 6 \times 5$ cm., and small segments cut from it for sections. The exterior of the splint of wood is nearly free from matrix and is weathered, showing the wood-fibre, and is very irregularly broken out from the trunk and teredo-bored to some extent. The exterior is weathered to a whitish-grey colour, but the inner zones of the wood appear quite black when cut across, and a rich brown in transparent section.

1769 a. Figured, Pl. XII, fig. 1; and text-fig. 41. Transverse section from the above, showing a large number of very well preserved annual rings, as described in the account of the species, *ante*.

1769 b. Figured, text-fig. 42. Tangential longitudinal section of the same, partly very well preserved, and showing not only the height and size of the medullary rays, but also, in a few cases, the pitting in the end-walls, as is illustrated in text-fig. 42.

1769 c. Figured, Pl. XII, fig. 2; and text-fig. 43. Radial longitudinal section of the above, showing the pittings in the tracheid-walls and in the medullary rays. The small round pits in the radial walls of the medullary rays can be seen in numerous places. In many of the tracheids also the rims of Sanio are quite apparent.

Kentish Rag, Lower Greensand; Iguanodon Quarry, Maidstone.

Presented by W. H. Bensted, Esq., 1839.

Cedroxylon pottoniense, sp. nov.

[Text-fig. 44.]

Diagnosis.—Incomplete, owing to the unsatisfactory preservation of the specimen. The species founded on a twig originally about 3·5 cm. in diameter. Coniferous wood with well-marked annual rings, tracheids in regular series, somewhat rounded, up to about 30–40 μ in diameter. Wood-parenchyma fairly plentiful, particularly in summer wood. Resin-canals absent. Medullary rays principally 4–15 tracheids distant, uniseriate, and low. Walls of ray-cells much thickened, and showing very typically the "abietinean pitting" both in horizontal and end walls.

Horizon.—Lower Greensand [not derived?].

Locality.—Potton.

TYPE.—Twig about 2·4 cm. in diameter; block, and some sections cut from it in 1912 in the Sedgwick Museum, Cambridge; also sections V. 13197 *a* to V. 13197 *c*, British Museum (Nat. Hist.).

The specimen on which this "species" is founded is a decorticated twig, now about 2·4 cm. in diameter, but which could not have been less than 3·5 cm. when alive. It is stained with the reddish-brown colour which is characteristic of the Potton material, and the preservation of the tissues is so blurred that they cannot be satisfactorily described. A second, still more poorly preserved, specimen is here provisionally associated with it.

DESCRIPTION.—*Pith* is preserved and measures 1 mm. in diameter; it is roughly circular, with irregular bays of primary wood projecting into it. The *secondary wood* is close-grained and regular, and has well-marked growth-rings up to 3 mm. in extent. The elements of the spring wood are all considerably thickened. The zone of autumn wood is broad, the elements rather rounded and very thick-walled, but not excessively compressed radially.

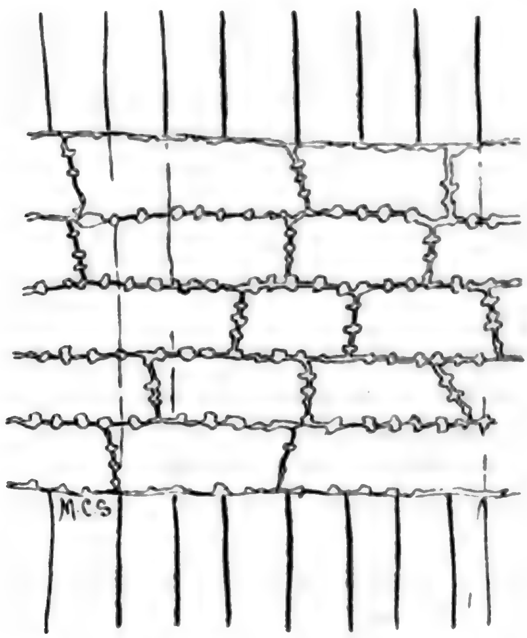
Throughout the wood the elements are considerably rounded off, and alternate to fit into each other, but even so leave considerable intercellular spaces; they measure up to about 30–40 μ in diameter. The pitting of the tracheids is very obscure, but seems to consist of round bordered pits in one row.

Resin-canals are absent, resin-containing (?) wood-parenchyma seems to be present in small quantities, and in the summer wood are a good many parenchyma-cells with horizontal cross-walls at short intervals.

Medullary rays are fairly conspicuous, 4–15 tracheids distant, the cells as wide or slightly less than the adjacent tracheids. The rays are all uniseriate and principally from one to a dozen cells high. There seems to be no differentiation into ray-tracheids or specialised cells. The walls of the medullary ray-cells are better preserved than the rest of the tissues and show true "abietinean pitting." A false appearance, somewhat similar, is present in most of the tracheid-walls, but in the medullary rays the true thickening and pitting of the walls can also be made out (text-fig. 44). The pitting of the radial walls cannot be detected in any of the sections.

The medullary ray-cells are higher than the width of the adjacent tracheids in many cases, and many of the cells are radially short, corresponding to about 2 or 3 tracheids. The end-walls are vertical or at a very slight angle or curve. The radial section of the medullary ray offers the only distinctive feature in this wood.

The one well-preserved feature of the specimen, viz., the abietinean thickening and pitting, particularly of the end-walls



Text-fig. 44.—*Cedroxylon pottoniense*, sp. nov. Radial section of the medullary ray, showing shape and arrangement of the cells and the "abietinean pitting" of their walls. No. 13197 *b*.

of the ray-cells, is a feature very seldom described in fossil woods, and I do not know of any described species entirely like the new fossil. In some respects probably *Cedroxylon cedroides*, Gothan (1907, p. 23), comes nearer to it than other known forms.

V. 13197 a–c. Type-specimen. Three sections cut from the specimen in the Sedgwick Museum, Cambridge.

V. 13197 a. Transverse section of the type-specimen showing all the described details. The cells are considerably blurred by the opaque nature of the petrifying medium.

V. 13197 b. Figured, text-fig. 44. Radial section of the above, in which the abietinean thickening and pitting of several of the ray-cells can be well seen.

V. 13197 c. Tangential section of the above, in which the height of the rays can be seen.

Lower Greensand; Potton.

Presented by the Sedgwick Museum, Cambridge, 1915.

V. 13196 a–c. Transverse, radial, and tangential sections of the second specimen in the Sedgwick Museum, Cambridge, which is—rather doubtfully—included in the same species as the above. The transverse section shows the pith and primary wood fairly well, but the longitudinal sections are very poor. Lower Greensand; Potton.

Presented by the Sedgwick Museum, Cambridge, 1915.

Genus **ABIETITES**, Hisinger.

[Lethæa suecica, 1837, p. 110.]

This generic name may be used in the sense in which *Pinites* has long been employed in relation to foliage. It covers a wider range, however, and includes doubtful Gymnosperms from rocks of many ages.

Endlicher's generic name *Pinites*, used in this sense by Gardner, Seward, and other writers, is antedated by Witham's *Pinites*, which was diagnosed in quite another sense; and in any case the suggestion of the name *Pinites* is narrower and more definite than is often warranted by the specimens for which it is employed. I therefore follow Berry (1911, p. 403) in reverting to the older name.

Abietites cf. **Solmsi** (Seward).

1895. *Pinites Solmsi*, Seward, Cat. Wealden Flora, vol. 2, p. 196, pl. xviii, figs. 2 & 3, pl. xix.

Diagnosis.—That given by Seward is as follows:—"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*."

HORIZON.—Type is Wealden; the described specimen, Kentish Rag, Lower Greensand.

LOCALITY.—For type, Ecclesbourne; described specimen, Maidstone.

TYPE.—Several twigs, nos. V. 2169, V. 2255, V. 2146 [no definite type-specimen is chosen by Seward]; British Museum (Nat. Hist.).

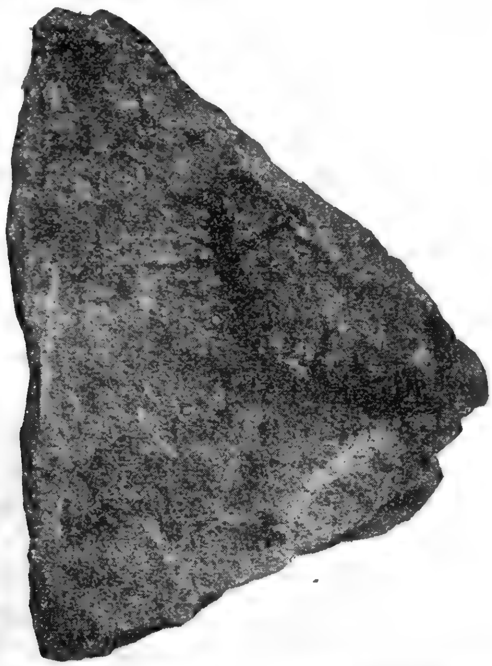
The specimen does not show anything but the vegetative twig and leaf bases, and cannot form the basis for any change in the diagnosis of the form with which it is only uncertainly associated. Seward's type-specimens, however, seem to me much more like *Larix* than the other genera he mentions.

The association of this Lower Greensand specimen, of which the fructification is unknown, with Seward's type depends entirely on vegetative similarity and is therefore most uncertain. Vegetatively our specimen agrees perfectly with the Wealden form, however, and it would not be justifiable to make it the basis of a new determination. Several American Lower Cretaceous species may be compared with it (see Berry, 1911, p. 404).

41408. A twig 12 cm. long, tapering from 1 cm. to ·5 cm. in diameter, bearing the bases of three short shoots. The whole surface is covered, as in *A. Solmsi*, by the rhomboidal scars of the decurrent leaf-cushions. Iguanodon Quarry, Maidstone. *Mantell Coll.*

Abietites sp.

Foliage twigs are very rare in the British Lower Greensand, so that reference should be made to the small piece of twig from the Iguanodon Quarry near Maidstone, shown in text-fig. 45. Its specific determination cannot be attempted, but it recalls several already-described fossils, particularly *Pagiophyllum crassifolium* as recorded from the British Wealden by Seward (1895, p. 212), and also parts of his *Sphenolepidium Kurrianum* (p. 200) of the same age. As this fragment cannot be definitely correlated with the cone-bearing forms, I think it may be referred to the comprehensive genus *Abietites*.



Text-fig. 45.—*Abietites* sp. Small foliage twig embedded in Kentish Rag matrix. Maidstone Museum. Photo by Mr. H. Elgar, 1912. ⅘ nat. size.

Abietinean or Taxodinean Tree of Uncertain Affinity.

"The Dragon-Tree."

"Benstedtia Condition" *of Coniferous Trunk*.

[Pls. XIII, XIV; text-figs. 46, 47.]

1843. *Dracæna Benstedii*, König MS. in Morris, Cat. Brit. Fossils, p. 7.
1851. *Dracæna Benstedi*, Mantell, Petrif. & their Teachings, p. 49.
1854. *Dracæna Benstedii*, Morris, Cat. Brit. Fossils, ed. 2, p. 8.
1862. *Dracæna Benstedii*, Mackie, Geologist, vol. 5, pp. 401–404, pl. xxii.
1868. *Dracæna Benstedii*, Carruthers, Geol. Mag., vol. 5, p. 154.
1895. Cf. *Dracæna Benstedtii*, Seward, Cat. Weald. Flora, vol. 2, pp. 169–172, pl. xii, figs. 4 & 5.

1896. *Benstedtia* sp., Seward, Ann. Bot., vol. 10, pp. 219, 220, pl. xiv, fig. 3.
1911. Ref. "*Coniferocaulon Benstedii*," Stopes, Geol. Mag., dec. 5, vol. 8, p. 59, text-fig.
1911. *Benstedtia Benstedi*, Knowlton, Geol. Mag., dec. 5, vol. 8, p. 468.

No *diagnosis* of this form can be given, for, as I have demonstrated (1911, 1911 A), the specimens do not represent a true or recognisable species.

Horizon.—Kentish Rag, Lower Greensand.

Locality.—Iguanodon Quarry, near Maidstone.

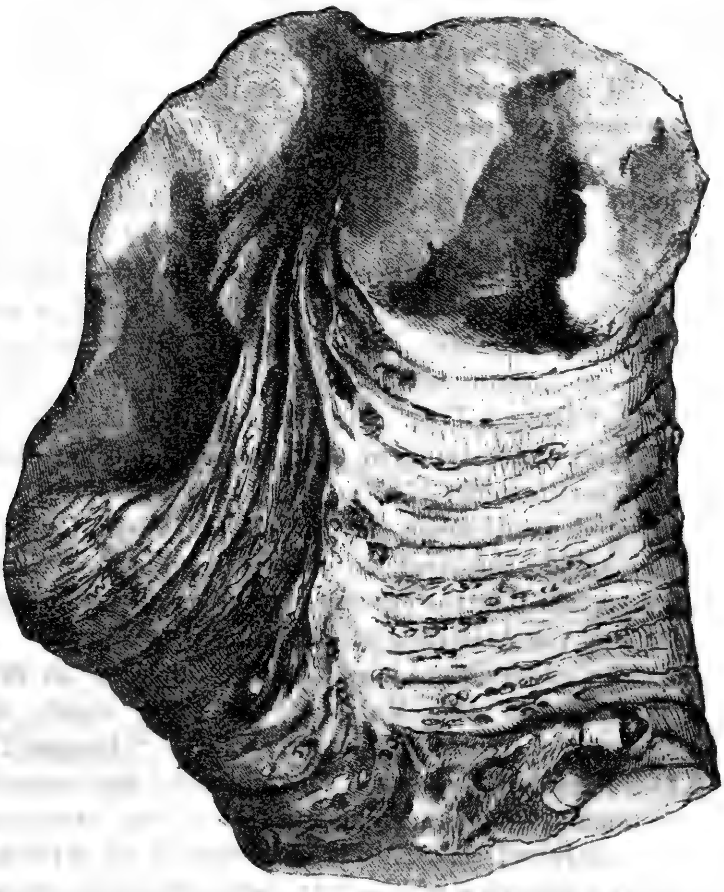
Type of the Form.—Nos. 1764, also 1765, 8357, and V. 9572, parts of same trunk ; British Museum (Nat. Hist.).

Finder.—W. H. Bensted, Esq.

Description.—This fossil, if it had not early received the sensational name of the "Dragon-Tree," would probably have remained unnoticed, for its real nature is commonplace. The principal specimen is in several portions, which are scattered, part being in the British Museum, part in Maidstone, and part in Paris. There are also other fragments which, while they may not be part of the same axis, must have belonged to the same or a similar tree.

The portion of the original trunk now in the British Museum is about 62 cm. long and has a diameter of 13–15 cm. × 9 cm., and is broken into five parts, and one of these, more massive than the rest, is partly embedded in the hard matrix of the Kentish Rag. This specimen is flattened and has a central cavity which is large and irregular, and in which fragmentary and powdery remains of secondary wood can be seen. At the other end of the trunk the hollow centre closes up, being filled with fragmentary wood interspersed through the matrix. This part of the trunk is illustrated in Pl. XIII, fig. 1. All the specimens composing this "species" are horizontally ribbed rather irregularly, as can be seen in Pls. XIII & XIV, and also in text-fig. 46, which is taken from Mackie's original description of the plant. Lying in and between these horizontal corrugations are small circular and oval papillæ which have been variously described (see Seward, 1896 B). A possible and simple interpretation of them is that they are the curved ends of casts of small borings, a view which Pl. XIII, fig. 2, seems to support. On the other hand, some such structures as this are seen in the decorticated and knotty wood of irregularly-grown conifers, and appear to bear some relation to suppressed branchlets or leaf-traces.

The specimen of the Dragon-Tree originally figured showed in addition to these features a curious curving upwards towards



Text-fig. 46.—"The Dragon-Tree." Drawing of the bifurcating specimen. After Mackie, 1862. × ⅓. No. 1764.

an apparent bifurcation. This was illustrated by Mackie in 1862, and again by Seward (1896) (see also text-fig. 46).

As will be seen in the illustration, and still better in the specimen, the part above the bifurcation where the branches should separate, shows none of the plant-structure, but is merely a mass of matrix. That the trunk was branching at this point is possible; but it appears to me that contortion of the semi-decayed wood prior to petrifaction is an equally good explanation of this appearance. That it has any profound significance is unlikely, as will be realised when it is demonstrated that the specimen is only the decayed trunk of an abietinean tree.

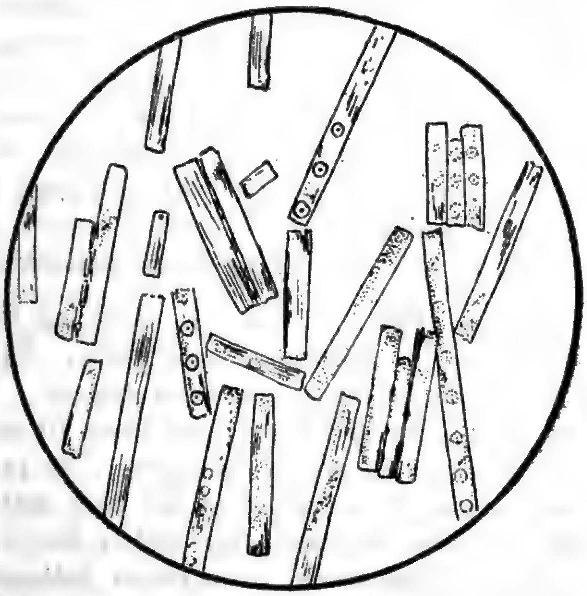
All the specimens in the Museum show fragments of very friable and semi-decayed wood, which is really largely composed of tracheids, though it was taken for mineral matter by previous writers. "I have found, however, that if one selects a portion of the specimen free from matrix, the point of a sharp pen-knife will free with the slightest touch some of the fibrous powder of the wood. If this powder is then mounted on an ordinary slide, and soaked in water for a short time under a cover-glass, it will be found that it consists of short lengths of individual tracheids, generally separate from each other or lying in pairs" (Stopes, 1911). These can be cleared with glycerine, acid, or other clearing medium according to circumstances. In the wood of the "Dragon-Tree" the tracheids thus obtained show circular bordered pits lying in a single row at some distance from each other (text-fig. 47).

Such wood-elements prove the plant to have been Coniferous, apparently exclude the Araucarineæ or Taxaceæ, and leave it practically certain that the specimen represents a semi-decayed trunk of one of the Abietineæ or Taxodineæ.

After these observations were made, I noticed an illuminating specimen in the Maidstone Museum, which shows all the ordinary characteristic features of the "Dragon-Tree" (Pl. XIV, figs. 1 & 2) with, in addition, the beautifully preserved remains of a branch identical with the branch of an ordinary coniferous tree. This is well seen in Pl. XIV, fig. 2, which shows a side-view of the flattened specimen illustrated in fig. 1. The appearance of this branch affords conclusive support for the view that the "Dragon-Tree" is a coniferous tree, and disposes finally of the possibility of its being a Cycad or some other unusual plant.

The Maidstone specimen further demonstrates that the horizontal ribbing of the stem, which has hitherto been taken as a true character, is merely a feature of successive surfaces of decorticated wood which might have peeled or rotted off in layers, for it shows *internal horizontal corrugations identical* with those supposed to be external. These internal corrugations bound the large hollow space which was at one time interpreted as pith, and which in my view is merely central wood which decayed before petrifaction. The end-view of this specimen showing the internal corrugations can be well seen in Pl. XIII, fig. 2.

This same specimen also settles another disputed point—the nature of the external papilla-like markings which lie in the



Text-fig. 47.—The wood of the "Dragon-Tree," showing the separate tracheids with round bordered pits obtained in the pulverising remains imperfectly embedded in the matrix. After Stopes.

corrugations. Vertically running ends of small casts of teredo-borings can be well seen in the inner part of one end of the specimen, and these agree in size and appearance with a number of the external papillæ (Pl. XIII, fig. 2, *t.*). In addition to these large papillæ there are smaller ones which may very well correspond to the leaf-traces and suppressed branches which are sometimes visible in decorticated woods.

Affinities.—It is thus evident that the "Dragon-Tree" is a decorticated and largely decayed woody trunk of a coniferous tree, probably a member of the Abietineæ, possibly of the

Taxodineæ. Owing to the imperfect preservation of the specimen, it is impossible to discuss any generic relationship for the plant.

1764. Text-fig. 46. This is the original specimen figured by Mackie in 1862, Geol. Mag. pl. xxii, and again by Seward in 1896, Ann. Bot. pl. xiv, fig. 3. It is a cast in a coarse firm matrix, and shows a short length of the corrugated trunk, 11 cm. long by about $9 \times 10{\cdot}5$ cm. in oval diameter. The upper end of the specimen appears to bifurcate and merges with the matrix. The corrugated surface of the specimen is almost clean; a few greyish scraps of mineralised matter, however, adhere to it, and in these traces of tracheids can be detected. Internally, no remains of the wood are to be seen. Kentish Rag; Iguanodon Quarry, Maidstone.

Found and presented by W. H. Bensted, Esq., 1839.

8357, V. 9572, & 1765. Text-fig. 47. That all these pieces belong to the same trunk seems likely. That V. 9572 and 1765 are one specimen is certain. Placed together the whole forms a mass about 70 cm. long and $13–15 \times 9$ or 10 cm. in diameter. The part labelled 8357 is partly embedded in the hard matrix of the Kentish Rag, and the other end is almost free from matrix. The trunk is somewhat flattened and the larger end is hollow, the cavity is lined by a wood-like mineral deposit, but also shows a number of fragments of pulverising wood from which the tracheids can be mounted (see text-fig. 47). One face of V. 9572 has been cut across and polished, and it shows only the decaying scraps of wood on one side and the mineral matrix. This specimen shows two zones of corrugated surface separated by about 1 cm. of matrix, which strongly suggest that the apparently external corrugated surface is only a decorticated view of the wood. This interpretation is further confirmed by the Maidstone specimen. 1765 (Pl. XIII, fig. 1), which has been cut from V. 9572, shows the inner imperfectly preserved axis of wood sloping up to break through the corrugated outer surface. This part of the specimen was at one time in Mantell's collection. Kentish Rag; Iguanodon Quarry, Maidstone.

Presented by W. H. Bensted, Esq., 1839, *& Mantell Coll.*

V. 5506. Small fragments of pulverising wood, which tends to break down to short lengths of tracheids, said to belong to the "*Dracæna Benstedi.*" So far as they go, the scraps seem to agree with the wood in the large specimens. Probably from the Kentish Rag; Iguanodon Quarry, Maidstone.

Collected 1868, *probably by W. H. Bensted, Esq., and transferred from the Botanical Dept.*

V. 13202. Original figured, Pl. XIII, fig. 2; Pl. XIV, figs. 1 & 2. Cast of the specimen in the Maidstone Museum. It measures 20 cm. in length, and 12 × 4–5 cm. in transverse section, being considerably compressed. It shows the transverse corrugations very well, and also a number of the small papillæ which are noticeable in the other specimens of the form. In this case the identity of many of the papillæ with the casts of borings is established, for within the upper hollowed-out end they can be seen running vertically. This specimen is also important, for it shows the base of a lateral branch of coniferous character (see Pl. XIV, fig. 2). Kentish Rag; Iguanodon Quarry, Maidstone.

Made in the Museum, 1914.

Incertæ sedis.

Semi-petrified Woods of probable Abietinean Affinity.

V. 5454. A small piece of teredo-bored secondary wood (1·5 × 2 × 9 cm.) entirely decorticated. It is partly pulverising, and these detachable tracheids show a single row of round bordered pits fairly near, but not adjacent, to each other. Lower Greensand; Woburn.

Transferred from the Botanical Dept.

V. 6453. A piece of a branch about 4 cm. in diameter and 13 cm. long, embedded in a coarse iron-stained matrix. The exposed end of the wood, which is broken across transversely, shows several well-marked annual rings of secondary wood round the central axis. At the other end of the specimen the wood is extremely friable, so that a fine brown powder can be readily detached. This powder is principally composed of short lengths of isolated tracheids. Under the microscope these can be rendered transparent, and they then show a single row of round bordered pits along their walls. Locality unknown.

Transferred from the Botanical Dept.

1767. The specimen at first sight appears to be a pith-cast, in some degree resembling the *Bucklandia* type of fossil. The cast is of some size, measuring as much as 6 × 18 cm. On either side of the cast there are some imperfect remains of secondary wood, in a white pulverising condition. Small portions of this wood can be detached, and they break up into a fine white powder which largely consists of short lengths of isolated tracheids. In some of these, microscopic examination reveals the presence of round bordered pits lying in a single row, which is characteristic of the higher Gymnosperms. It is therefore hardly likely that the pith would have been as much as 6 cm. in diameter, and the cast probably represents not the pith but the inner zones of wood, which must have been decayed before the petrifaction took place. Kentish Rag; Iguanodon Quarry, Maidstone.

Presented by W. H. Bensted, Esq., 1839.

6049. A small piece of black carbonised wood (5·5 × 4 cm.), partly embedded in the coarse sandy matrix. The wood is very friable, and the detached and suitably treated tracheids show a single row of round bordered pits on their walls. Locality unknown.

Mantell Coll.

Family CUPRESSINEÆ.

In the fundamental characters of their anatomy, the Cupressineæ are closely allied to the Abietineæ and Taxodineæ. They differ from the other Conifers in their external morphology, and have a *cyclic* arrangement of leaves and cone-scales (often reduced to alternating pairs) as opposed to the spiral arrangement common to the other groups. The cones of the Cupressineæ are seldom large, and often very small and reduced even to the limit of two fertile scales only in a cone composed of very few pairs of scales. The number of seeds per scale varies in different genera, and in some a single scale bears a large number of small seeds.

No specimens of foliage-impressions or petrifactions, or of cones, of the Cupressineæ appear to be recorded from the British Lower Greensand deposits.

As has already been pointed out, the pseudogeneric name *Cupressinoxylon* covers woods from a variety of families, some of which are not Cupressinean in a modern sense. For the present, however, secondary woods of "*Cupressinoxylon*" anatomy are most conveniently classified here. We have therefore no certain proof that any true Cupressineæ were represented in Britain by Aptian times. Foliage-impressions, such as *Frenelopsis*, *Widdringtonites*, etc., have been described from different parts of the world from various Cretaceous deposits. In his recent revision, Berry (1911) includes species of these genera definitely in the Cupressineæ from the Maryland equivalents of the Aptian and Albian beds.

Genus **CUPRESSINOXYLON**, Goeppert.

[Monog. Foss. Conif., 1850, p. 196.]

Diagnosis.—Coniferous wood composed of tracheids and xylem-parenchyma only. In the tracheid-walls the pits are generally round, bordered, and isolated, in one row; if in two rows the pits stand in adjacent pairs and are not alternating or compressed—Sanio's rims often conspicuous. Normal resin-canals entirely absent. Resin-containing xylem-parenchyma present, generally in large quantities, and scattered all through the wood. Medullary rays uniseriate, a few may be partly biseriate.

The cells of the rays all alike, generally smooth-walled, and without abietinean pitting (which is present in a few species); pits in the radial walls of the rays generally circular or oval, simple, small, and in groups of 1 to 6, seldom more, per tracheid-field.

The original diagnosis given by Goeppert is as follows:—"Truncorum structura fere Cupressinearum viventium. Trunci ipsi e cortice, ligno et medulla magis minusve centrali formati. Corticis pars fibrosa cellulis quadrangulis perisphericis, lignum e stratis concentricis angustis distinctis, strati zona exteriore plerumque angusta e cellulis pachystichis compressa, interiore multo latiore e vasis leptotichis formata, medulla ipsa e cellulis paucioribus pachytichis composita. Cellulæ ligni prosenchymatosae, porosae ductibus resiniferis simplicibus interjectis. Pori rotundi in simplici, in truncis annosioribus quoque duplici interdum tri- vel quadruplici serie in eodem plano horizontali juxtapositi, in iis plerumque tantum cellularum parietibus, qui sibi oppositi et radiorum medullarium paralleli sunt vel in parietibus radiis medullaribus obversis interdum nonnulli vel etiam plurimi tamen minores in omnibus inveniunter. Radii medullares similares minores simplici cellularum parenchymatosarum porosarum serie. Parietes earum superiores et inferiores poris minutis, laterales majoribus instructi. Ductus resiniferi plerumque simplices cellulis elongatis subquadrangulis superpositis formati inter ligni cellulas imprimis angustiores inveniuntur."

Kraus revised and rediagnosed the genus in 1864, and again in 1870, in Schimper's 'Paléontologie' (p. 374), where he changed the generic name to *Cupressoxylon*. His diagnosis was then as follows:—"Lignum stratis concentricis distinctis, angustis; cellulis prosenchymatosis porosis, poris magnis, rotundis, uni-vel pluriserialibus oppositis; cellulis resiniferis creberrimis, ductibus resiniferis nullis; radiis medullaribus simplicibus."

The "genus" is, of course, composite, containing the representatives of various living groups, and it is very large, perhaps the largest of all the genera of petrified woods, numerous species having been described from the Mesozoic and Tertiary strata from all parts of the world. Among the earlier records, reference should be made to Mercklin's (1855) fine illustrations of species of *Cupressinoxylon* from deposits varying from Jurassic to Tertiary in age. While his descriptions are somewhat antiquated, his observations and illustrations are not excelled by more recent work.

Cedroxylon and *Cupressinoxylon* are alike in having no normal resin-canals. The older criterion of separation used to be the absence of xylem-parenchyma in the former, and its presence in the latter genus. It has been found, however, both in living and fossil woods that even those species in which the wood-parenchyma is generally absent may show some cells in portions of their tissue, so that the distinction no longer holds. Nevertheless, *Cupressinoxylon* is still distinguished from *Cedroxylon* by normally having very much greater amounts of xylem-parenchyma. Mercklin (1855, pl. xii, fig. 3) and others illustrated well the minute details of the characteristic wood-parenchyma of *Cupressinoxylon*, with its approximately horizontal cross-walls.

A more reliable feature in the separation of this genus from *Cedroxylon* lies in the characteristic presence of "abietinean pitting" in the latter genus and its normal absence in the former. Some species of *Juniperus*, however, show typical "abietinean pitting," so that the criterion is not final in all cases.

Cupressinoxylon vectense, Barber.

[Plate XV; text-figs. 48, 49, 50.]

1898. *Cupressinoxylon vectense*, Barber, Ann. Bot., vol. 12, p. 337, pls. xiii, xiv.

Diagnosis.—Pith about ·9 mm. in diameter, walls rounded, pitted, with large intercellular spaces. Primary bundles entirely centrifugal. Secondary wood composed of small regular tracheids up to about 25 μ in diameter. Bordered pits generally round, isolated, and in one row, sometimes adjacent and the row partly doubled. Tangential pits in autumn wood. Annual rings well marked, conspicuous, "composite"; some with three or four irregularly amalgamated zones in each. Medullary rays mostly uniseriate, a few partly biseriate; cells all alike, walls smooth; pits in radial walls 1–2 per tracheid-field; each pit smallish and irregularly oval or round. Resin-parenchyma abundant, scattered all through the wood, with approximately rectangular cross-walls.

The species is based on branches from 2–8 cm. in diameter, often showing pith, and on parts of much larger trunks.

Horizon.—Lower Greensand.

Locality.—Shanklin, Isle of Wight.

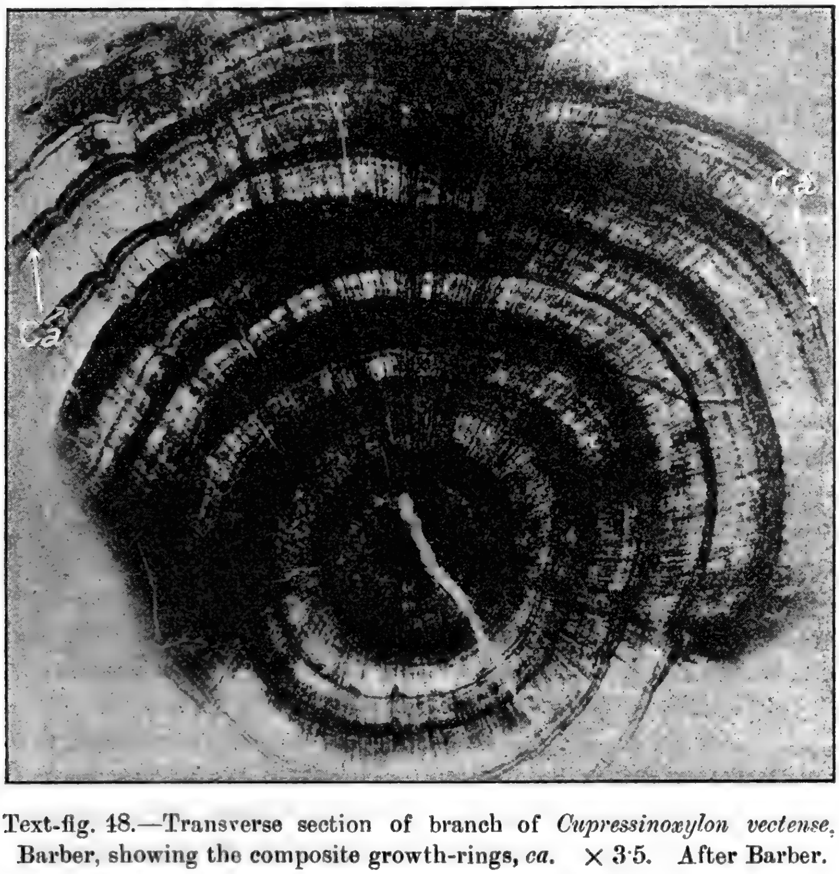
Type.—Barber's description is based on a large number of slides of several small stems and pieces of older ones, sections of which are in Dr. D. H. Scott's private collection, East Oakley, Hants, and in the Botany School, Cambridge. From among these (which appear to represent not only *Cupressinoxylon vectense*, but possibly also another species) Barber does not specify any actual type-specimen. Slide marked "C.A.B.I., A.C.S. 6" (Barber, pl. xxiii, fig. 1) is most characteristic and may be regarded as the type-specimen, and is in Cambridge.

Description.—The species is based on a number of stems and roots (?) described by Mr. Barber, averaging 2–5 cms. in diameter, and parts of the secondary wood of much larger stems. Many of these show the pith and primary wood, as well as rings of secondary wood; others consist only of portions of secondary wood. All are preserved in the coarse green-grained matrix which is characteristic of the Lower Greensand deposit at Shanklin; the silicified portions of the wood are dark brown. In addition to Mr. Barber's specimens, other examples of the species are contained in the British Museum collections, and will be referred to in the following description.

Topography of the Stem.—The *pith* in those stems in which it is preserved is ·9 mm. in diameter, approximately circular-stellate, due to the projection of the primary bundles into it. The elements comprising it are large, rounded, and apparently uniform in structure, the size of the cells increasing towards the centre. *Primary bundles* form about 15 well-marked groups round the pith.

In the *secondary wood* the *growth-rings* average 1–2 mm. wide. These thicken at the exit of a branch (see Pl. XV, fig. 1), are very sharply marked, and have the peculiarity, on which much stress was laid by Barber, of being composite. Thus the narrow dark bands of "autumn" elements are duplicated or triplicated in groups. This can be seen at *ca.* in text-fig. 48, which is a reproduction of Barber's type, and in Pl. XV, fig. 3, in a more recently-discovered specimen in the Museum.

The *wood* is uniform, small-celled, and adjacent elements on the same tangent alternate so as to fit into each other. *Resin-canals* are entirely absent in the type-specimen; but *resin-containing zylem-parenchyma* is remarkably abundant and conspicuous (see Pl. XV, fig. 2). In a specimen I found at Luccomb (V. 13193) a large number of *traumatic resin-canals* lie in a close series extending about halfway round the annual ring. In another section of the same specimen, in addition to this half-circle of canals, there are several series of resin-canals in the wood-rings just in front of an outgoing branch.

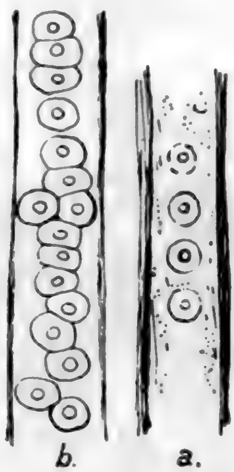


Text-fig. 48.—Transverse section of branch of *Cupressinoxylon vectense*, Barber, showing the composite growth-rings, *ca*. × 3·5. After Barber.

Medullary rays are numerous, fairly conspicuous, and from 1 to 10 tracheids distant, principally 4–6. The rays are *uniseriate*, 1 to 16 cells high, by far the greatest number being from 2 to 4 cells high.

Details of Elements.—The large rounded elements of the *pith* vary from 10 to 50 μ in diameter according to Barber; my measurements of the larger elements in his sections, however, give about 90 μ as the average for the larger pith-cells, which lie towards the centre. Between their rounded walls are triangular intercellular spaces. A small group of cells forms a medullary sheath round the projecting primary bundles. The pith-cells are all thick-walled and pitted.

The *primary bundles* of the *wood* form small well-marked groups. The protoxylems appear to be spiral. There is no evidence of the existence of centripetal xylem. *Secondary wood* consists entirely of tracheids and wood-parenchyma. The largest of the spring tracheids measures only about 17×25 μ, the majority rather less than this, while the



Text-fig. 49.—*Cupressinoxylon vectense*, Barber. Radial views of tracheids to show pitting. *a.*, pits in a single row; *b.*, adjacent pits in a single row, which is occasionally doubled. After Barber.

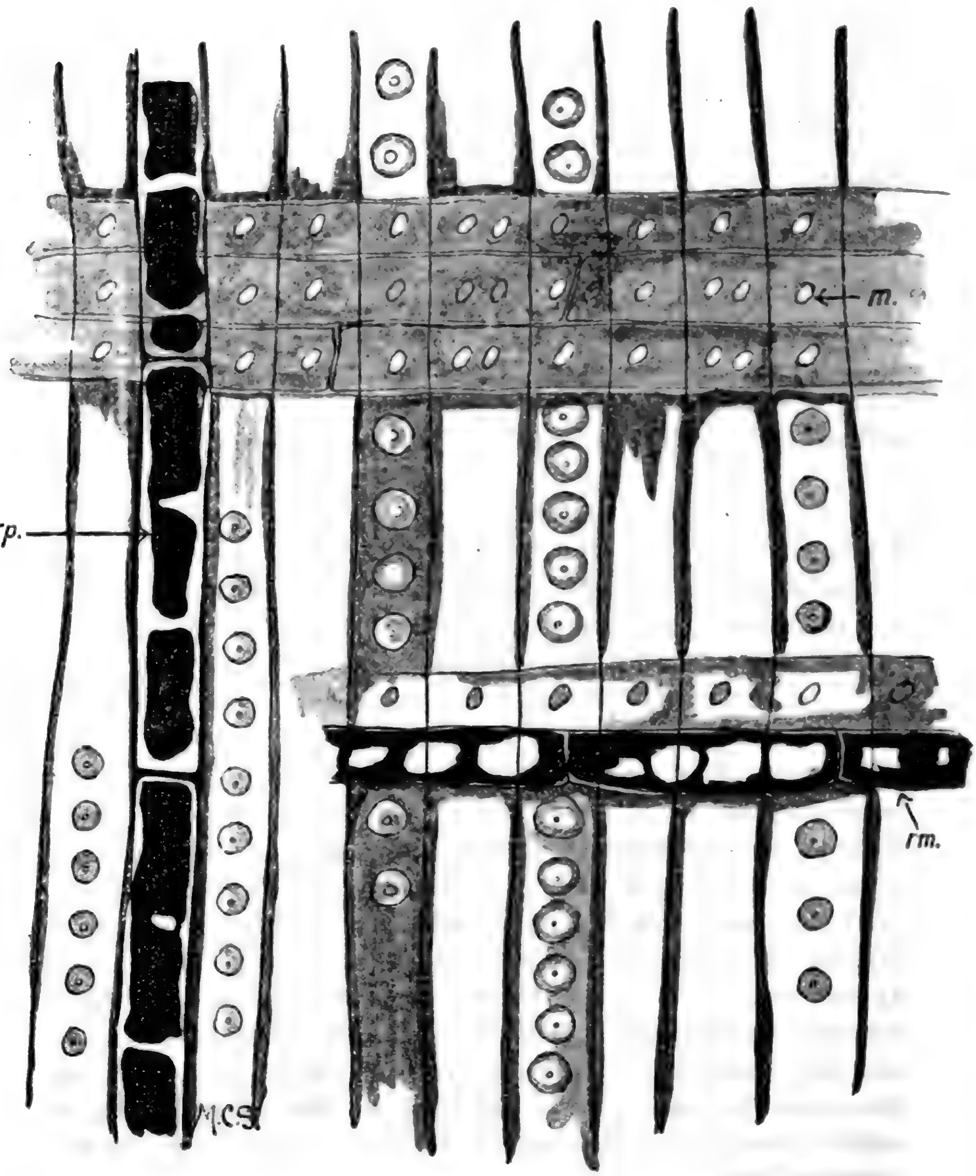
autumn elements average about 10–11 μ. Thus the wood is seen to be very small-celled. Mr. Barber made large numbers of very minute measurements of the size of these elements (see pp. 345–348, Barber, 1898); the systematic importance of the size of the elements, however, is much less than was at one time supposed. The walls, even of the spring wood, are much thickened; as an average of 80 measurements Mr. Barber gives a range of wall-thickness of from 4 μ to 14 μ. The *bordered pits* in the tracheid-walls are inconspicuous in transverse section, in radial section they lie, as a rule, in a single row, the round pits often being separated from their neighbours by a distance nearly as great as their own diameter. In other cases the pits lie so close together as to be somewhat crushed, and there is an occasional doubling of the row as in text-fig. 49, *b*. The pit-pore is circular and sometimes very large, 3–5 μ. The average diameter of the bordered pits is given by Barber, after numerous measurements, as 13–14 μ. Bordered pits are present in the tangential walls of the autumn wood.

Wood-parenchyma containing large quantities of black resinous remains is very conspicuous. In transverse section the elements lie isolated among the tracheids, and are of about the same size, both radially and tangentially, as the elements adjacent to them. In radial view the transverse walls are horizontal, with a slight constriction just at the division of the cells (text-fig. 50). In tangential section these cross-walls are seen to lie at a low angle, the terminal walls of a cell-row being acutely pointed and resembling a tracheid, but for the absence of pitting in the wall.

Resin-canals, normally, are entirely absent. In a specimen I found in 1912, however, *traumatic* canals are numerous.

Medullary rays consist of uniform elements, without any ray-tracheids. In transverse section the tangential diameter of the rays is rather less than that of the adjacent tracheids; in radial extension the elements correspond to from 2–6 tracheids. Barber observed pits on the radial walls, but does not figure them; he says—"In both radial and tangential sections these [pits] were seen to be simple. In shape they were oval and obliquely placed, usually two or one per cell, occasionally three or more, rarely four. The higher numbers were, as usual, on the outer cells, the middle cells having frequently one pit each. This is in accordance with the *Sequoia* type of wood." As since the time this was written it has been recognised that the pitting of the medullary ray-cells is perhaps the most important single feature in a wood, I am giving an illustration of these pits in the type-specimen, the sections of which were kindly lent me for the purpose by Prof. Seward (text-fig. 50).

Roots of this species are described by Barber as having a pith ·3–·4 mm. in diameter. The primary wood in the specimens Barber considers as roots is not in definite bundles, but passes directly into the pith. Trifling differences in detail between the secondary wood of the roots and the branches are described by Barber, but, on the whole, the secondary wood is identical with the specimens of stems.



Text-fig. 50.—*Cupressinoxylon vectense*, Barber. Radial section of Barber's type-specimen, showing the pitting of medullary ray-cells, *m.*; the longitudinal resin-containing wood-parenchyma, *rp.*; and the resin-containing cells of ray, *rm.*

Barber does not give an actual diagnosis, but summarises his elaborate description as follows:—"Specimens 1–2 inches in diameter, with distinct central or excentric pith. Rings of growth well marked, averaging 1–2 mm. wide, composite, each with 2–6 bands of narrow, dark, summer elements. From the arrangement of the cells in the rings, the specimens are considered to be young branches and roots. Pith well preserved, diameter in branches ·9 mm., in roots ·3 mm. to ·4 mm., cells increasing in size towards the centre, 10 μ to 50 μ in diameter, copiously pitted, with large triangular intercellular spaces 5–15 μ across. Medullary sheath: in the roots the rows of tracheides pass directly into the cells of the pith, in the branches they terminate in small groups of cells irregularly arranged. Spring tracheides not differing much in branch and root, tangential width 12–25 μ, radial 17–22 μ; summer tracheides in the branches, radial diameter 10–11 μ, averaging 4–6 rows, in the roots radial diameter 12 μ, averaging 2–4 rows. Bordered pits in a single row (rarely double in roots), free and rounded in branches, often touching and compressed in roots, outer diameter 7–14 μ, inner 3–5 μ. Tangential pits frequent, occurring in 2–7 rows of summer cells, outer diameter 5–7 μ, inner 2–3 μ. Medullary rays simple, usually one, occasionally two cells broad, 1–16 cells high, the average being 2–3. Cells of ray 15–20 μ high, 12–16 μ broad, radial length various, covering 2–6 tracheides. Proportion of medullary ray-tissue to the rest of the wood about 1 : 30. Resin-tissue, consisting of isolated rows of parenchymatous cells, abundant, equally distributed. Length of cells various, tangential width 19–28 μ, radial 11–20 μ."

The author adds:—"It has not been found possible to place this wood under any species of *Cupressinoxylon* already described. The peculiarity of the rings of growth is probably in itself sufficient to establish a new species. Besides this, however, the youth of the specimens and the detailed examination to which they have been subjected leave few points of comparison with known fossils. From the frequent occurrence of this type of wood in the Lower Greensand of the Isle of Wight, I have decided to call it *Cupressinoxylon vectense*."

The "composite rings," while they are particularly well marked and very characteristic of *C. vectense*, are not entirely confined to this species, and they occur to a lesser extent in several living and fossil forms of various affinities. For instance, pl. 2 in Penhallow's 'Monograph' (1907) shows the coalescence of two rings in the living *Torreya taxifolia*, which gives an appearance very like the fossil, though on a smaller scale and more local. In another species, now described for the first time (see p. 180), from the Isle of Wight, similar "composite" rings are present. Furthermore, *Cupressinoxylon Delcambrei*, described by Viguier & Fritel (1912), appears to have had "composite" annual rings exactly like those in *C. vectense*; and comparison should be made between their fig. 1, p. 299, and Pl. XV, fig. 3. The illustration given of the pitting of the ray-cells in *C. Delcambrei* is too obscure to show the necessary detail, and, according to the description, they do not coincide with those of *C. vectense*.

The outline drawings of *Cupressinoxylon McGeei*, Knowlton (1889 A, pl. iii, fig. 3), indicate that in the pitting of the radial walls of the medullary rays there is considerable likeness between this species and *C. vectense* of Barber; Knowlton's description, however, is too meagre to allow a comparison of all the important features in the two plants. Knowlton's plant evidently did not show the "composite rings," for they are not mentioned. Further, Barber's specimens all appear to be parts of small trunks or branches, and Knowlton's is part of a large trunk 40 ft. long and 2 ft. in diameter, so that in any case comparison would be difficult, while in addition Knowlton's specimen is Lowest Cretaceous or Jurassic in age, and is therefore considerably older than our Aptian species. The pitting of the rays being such an important point, the likeness between the two species is worth noticing.

Cupressinoxylon vectense appears to be a well-established species, and is extremely common in the deposits in the neighbourhood of Luccomb Chine and Shanklin, Isle of Wight, though no specimen of this wood has so far been recognised in any other part of the British Lower Greensand.

V. 13193, & V. 13193 a, b, & c. Specimen consisting of a short length of a branch 4 × 5 cm. in diameter, embedded in coarse granular matrix. The centre of the main axis is preserved, and is surrounded by about 26 annual rings of growth. On one side a small branch is being given off. The dark silicified medium preserves the tissues well.

V. 13193 a. Figured, Pl. XV, figs. 2 & 3. Transverse section of the above stem showing part of the pith and primary xylem well preserved. The general character of the wood, with the numerous dark resin-parenchyma cells, is well seen (Pl. XV, fig. 2). The "composite" zones of autumn wood are also well seen in this section (Pl. XV, fig. 3). Extending about halfway round the outer part of the eighth growth-ring is a long line of *traumatic resin-canals*, as well as several other groups of resin-canals just outside the outgoing branch. The presence of such resin has not been described for this type of wood before.

V. 13193 b. Longitudinal tangential section of the above stem. The section is well preserved, and the distribution of the low small medullary rays can be well seen.

V 13193 c. Longitudinal radial section of the above stem. The size and arrangement of the ray-cells can be very well seen, and their radial pits can be made out, though they are not very clear. The distribution and character of the resin-containing parenchyma are well shown. The large traumatic resin-canals appear in several places in the section.

Lower Greensand; Luccomb Chine, Isle of Wight.

Found and presented by Dr. M. C. Stopes, 1912.

V. 13192, V. 13192 a, b, & c. Specimen consisting of a small part of the base of a forking branch, just where the branches are separating. The wood is clean of matrix and is waterworn. The tissues are well petrified in a dark silicified medium.

V. 13192 a. Figured, Pl. XV, fig. 1. A transverse section of the central part of one axis and the outgoing branch, the area of the section being about 3×3·8 cm. In the main axis the pith is fairly well preserved, and round it are the remains of a good deal of the primary wood, though it is partly broken away. The rings of secondary wood round the centre of the main axis show the "composite" zones of autumn wood and other features characteristic of the species. Round the outgoing branch the wood-rings get very wide and irregular.

V. 13192 b. Longitudinal radial section of the above, partly oblique, so as to show a tangential view of the rays. In the section the end-walls of the resin-containing xylem-parenchyma are well seen. The lateral pits on the medullary ray-cells can be made out, but are rather obscure.

V. 13192 c. Longitudinal tangential section of the above, in which the low medullary rays and the slightly sloping end-walls of the xylem-parenchyma can be well seen.

Lower Greensand; Luccomb Chine, Isle of Wight.

Found and presented by Dr. M. C. Stopes, 1912.

V. 8269, V. 8270, V. 8271 (S. 2936, 37, 38). Three sections apparently cut from the same specimen. The slides only, without any history, are available. V. 8270 is a transverse section showing several rings of growth of secondary wood; some of these are typical "composite" rings. V. 8269 is a longitudinal tangential and V. 8271 a longitudinal radial section, which show most of the characteristic features of *C. vectense* as described above. Lower Greensand; Shanklin, Isle of Wight.

Transferred from Botanical Dept.

V. 8265 (S. 2932). Transverse section of several rings of growth of secondary wood, partly embedded in coarse granular matrix. The section is typical of the species, but as there are no other sections of the specimen, the determination is uncertain. Lower Greensand; Shanklin, Isle of Wight. *Transferred from Botanical Dept.*

V. 8266, V. 8267, V. 8268 (S. 2933, 34, 35). Two radial and a tangential longitudinal section, the corresponding transverse sections being unknown. They are poorly preserved, but characteristic of the species so far as observable. Lower Greensand, Shanklin ; I. of Wight.

Transferred from Botanical Dept.

V. 8280 (S. 2947). Isolated radial longitudinal section. The resin-cells and the pits on the radial walls of the medullary ray-cells show fairly well. Lower Greensand ; Shanklin, Isle of Wight.

From Prof. Sedgwick (?), transferred from Botanical Dept.

V. 8281, V. 8282, V. 8283 (S. 2948, 49, 50). These three sections are presumably cut from the same specimen. V. 8283 is a transverse section of a branch about 3 cm. in diameter, with a central pith and primary xylems surrounded by rings of secondary wood. In each of these rings the amount of autumn wood is small; some of the rings are composite. In this section the primary wood can be very well seen, and is grouped in primary bundles round the pith, the cells of which are also preserved. V. 8281 is a poorly-preserved radial longitudinal section. V. 8282 is a tangential longitudinal section, which shows one or two dwarf-shoot traces. As it is uncertain that this section belongs to the transverse section, and consequently it is uncertain whether it does actually belong to this species, deductions must not be drawn from it. Lower Crioceras bed; Sandown, Isle of Wight.

From Dr. Bowerbank (?), transferred from Botanical Dept.

V. 11518, V. 11518 a–c. A small specimen of secondary wood enclosed in granular matrix, and three sections cut from it. The wood-elements are rather larger than in the type of *C. vectense*, but the specimen shows no other feature to distinguish it from this species. In transverse section the characteristic "composite" rings of autumn wood are well seen. The longitudinal sections are poorly preserved, and show no feature of interest. Lower Greensand ; Luccomb Chine, Isle of Wight.

Transferred from Botanical Dept.

The following specimens are doubtfully referred to this species:—

V. 7840. An isolated, poorly-preserved, radial section, probably *C. vectense.* Lower Greensand; Shanklin (?), Isle of Wight. *Transferred from Botanical Dept.*

V. 5635 & V. 5782. Parts of the same polished specimen, a small stem of wood about 5 cm. in diameter showing the centre of the axis and well-marked annual rings. The granular Greensand matrix in which it lies, as well as the texture and colour of the petrified wood, are identical with specimens of *Cupressinoxylon vectense*, and it is probable that it is a specimen of this wood, though, as it is without any history, it did not seem worth cutting.

Transferred from Botanical Dept.

V. 7076. A small wedge-shaped piece of wood not worth cutting, but very like the other blocks of *C. vectense* in general texture. Lower Greensand; Shanklin, Isle of Wight. *Transferred from Botanical Dept.*

Cupressinoxylon luccombense, sp. nov.

[Text-figs. 51, 52, 53.]

Diagnosis.—Pith about ·6 mm. in diameter, composed of ordinary rounded cells, with somewhat thickened walls and stone-cells. Primary bundles entirely centrifugal. Secondary wood composed of tracheids very variable in size and in arrangement, up to about 50 μ in diameter; sometimes arranged in very regular radial series, and elsewhere in irregular groups. Bordered pits round, isolated, and in one row. Annual rings conspicuous, a few of them "composite," like those in *C. vectense.* Medullary rays uniseriate; cells all alike; walls apparently smooth; pits in radial walls in groups, principally 3–4, largish, irregularly round or oval, the pits in a group differing greatly in size. Resin-parenchyma abundant, scattered all through the wood, cross-walls rectangular.

Species founded on woody branch not less than 5 cm. in diameter when alive, now decorticated; pith present.

HORIZON.—Lower Greensand.

LOCALITY.—Luccomb Chine, Isle of Wight.

TYPE.—Woody branch, no. V. 13195 and slides V. 13195 *a* to V. 13195 *c* cut from it; British Museum (Nat. Hist.); also slides SD. *e*, *d*, & *f*, Stopes coll., cut from the same block.

FINDER.—M. C. Stopes, 1912.

DESCRIPTION.—The type and only specimen is a portion of a branch 3·5 cm. in diameter, of which a length of 6 cm. is well petrified in a dark siliceous medium. Externally the decorticated woody texture shows through fragmentary remains of the coarsely granular matrix. As the wood is entirely decorticated, it is not certain whether it represents a small lateral branch or the core of an older stem. As the pith is excentric to the present diameter, it indicates that the branch when living could not have been less than 5 cm. in diameter.

TOPOGRAPHY OF THE STEM.—*Pith* is preserved in the centre of the axis, and is about ·6 mm. in diameter. It is torn away from the surrounding primary wood, and the outer cells are mostly destroyed. The main mass of the pith is composed of two types of cells, viz. roundish cells with somewhat thickened walls and also very much thickened stone-cells.

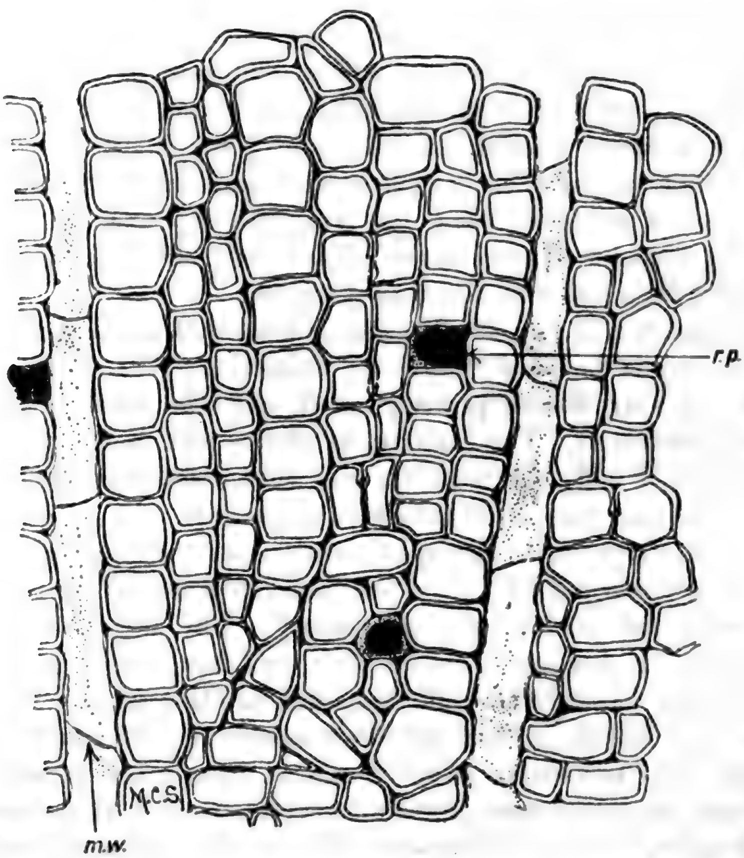
The *primary wood* is grouped in inconspicuous bundles.

The *secondary wood* shows well-marked growth-rings, a few of which are double or "composite." The wood is rather irregular in texture (text-fig. 51), and has numerous resin-containing parenchyma-cells scattered all through its extent. The rings consist of from 25–80 tracheids in radial series, the larger rings measuring about 2 mm. in extent, the number of specially narrow autumn elements varying from 4–10. *Normal resin-canals* are entirely absent; one or two traumatic canals lie near a closed-over wound or branch exit.

Medullary rays in transverse section are fairly numerous and conspicuous. They are *uniseriate*, and lie from 1 to 12, principally 2–5, tracheids distant. The rays are 1–10 cells high, the great majority being 2 cells high. While uniseriate rays are the rule, here and there a small ray is partly biseriate, but the elements are all alike and the rays undifferentiated.

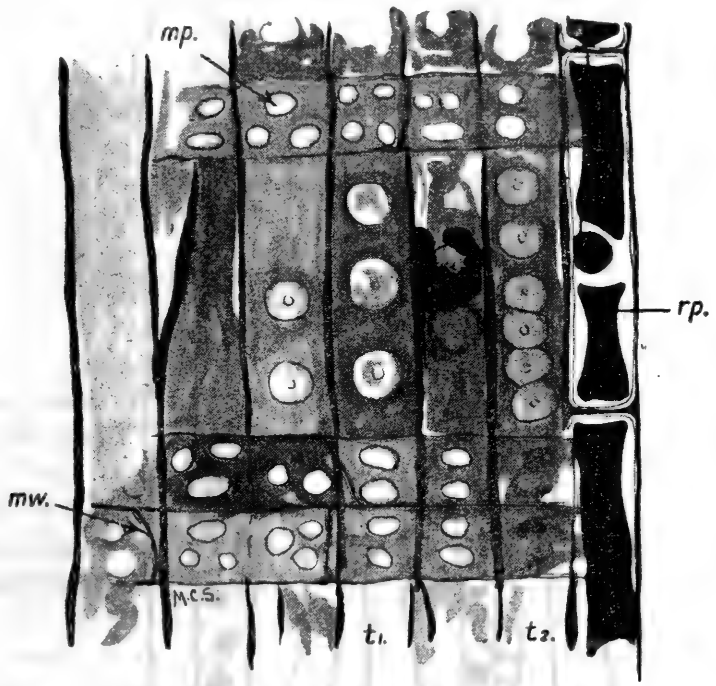
The section shows a small branch being given off.

Details of Elements.—The rounded elements of the *pith* all show rather thickened walls, with pits. The rounding off of the cell-walls leaves small, triangular, intercellular spaces between the elements. The elements increase towards the centre, the diameter of the largest being about 80 μ. Somewhat larger than these are the stone-cells, up to 95 μ in diameter, with very thickened walls. A small number of these lie grouped among the pith-cells.



Text-fig. 51.—*Cupressinoxylon luccombense*, sp. nov. Transverse section of a small part of the secondary wood, showing the irregular size and arrangement of the tracheids. *r.p.*, the resin-containing wood-parenchyma; and *m.w.*, the sloping end-walls of the medullary ray-cells. No. 13195*a*.

The small flat bundles of *primary wood*, with very few protoxylems, do not show any special feature in the sections available. The *secondary wood* consists of regular radial series and, locally, rather irregularly arranged tracheids which vary very much both in size and shape even in adjacent elements (see text-fig. 51). The larger and more regularly arranged tracheids average about 30×40–$40 \times 50\ \mu$. Even in the first-formed spring wood the walls are rather thickened, and measure about 3–5 μ. The autumn wood measures 12 μ in radial diameter as a rule, the lumen of the cell often being narrower than the walls. Pits in the radial walls are often visible in transverse section, and in radial section are seen to be principally

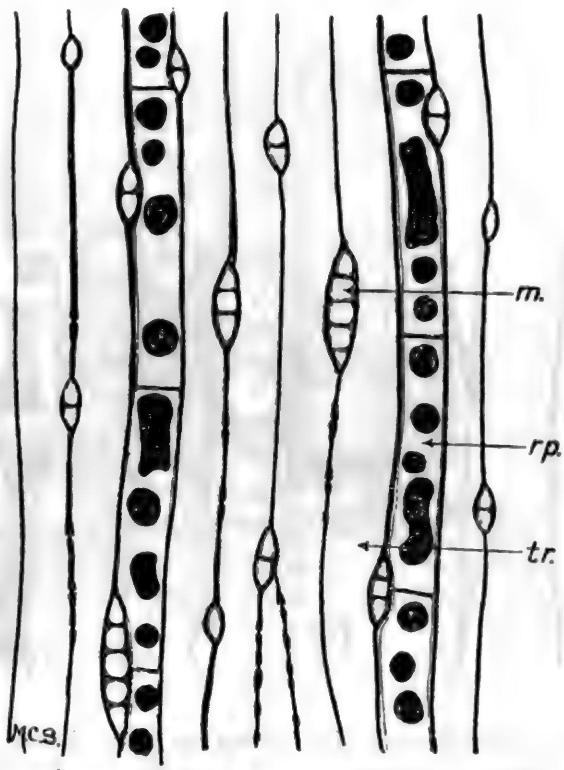


Text-fig. 52.—*Cupressinoxylon luccombense*, sp. nov. Radial longitudinal section showing tracheids, *t* 1; a tracheid with the bordered pits adjacent, *t* 2; *rp.*, resin-containing wood-parenchyma; *mw.*, the medullary ray-cells with curved end-walls; *mp.*, the groups of irregular roundish pits per tracheid-field. [Slide SD. *c*, Stopes coll.]

in one row. A few irregular double rows may be detected. As a rule, the round bordered pits are separate from each other, a few may lie in adjacent rows (text-fig. 52, *t* 2).

Wood-parenchyma is common all through the wood. The horizontal walls in both tangential and radial sections are rectangular (text-figs. 52 & 53, *rp.*). In the radial direction there is a slight lateral constriction. Most of these cells contain much blackened resinous remains.

Medullary rays show up very clearly in transverse section (text-fig. 51, *m w.*). The cross-walls lie at an angle or are curved. The tangential diameter of the ray-cells is equal to or rather less than the adjacent tracheids. The radial extent of a cell equals 2 or 3 to 6 tracheids. In radial section the pitting of the ray-cells shows up well, and consists of an irregular



Text-fig. 53.—*Cupressinoxylon luccombense*, sp. nov. Tangential section showing tracheids, *tr.*; medullary rays, *m.*; and resin-containing wood-parenchyma, *rp.*, with rectangular cross-walls. No. 13195 *c.*

number, from 1–5, of roundish pits. The commonest number is 2 to 3 per tracheid-field (text-fig. 52, *mp.*). The outline of these pits is a little irregular, and the size varies greatly, two small ones and a large one, or *vice versa*, forming a group. The ray-cell is vertically of about the same size as the tracheids it crosses; the end-walls are rather irregular and curve or slope (text-figs. 51 & 52, *mw.*). The ray-cells appear to be all alike, and there is no sign of differentiation into tracheids.

Affinities.—In many respects this species comes very near to *C. vectense*, Barber (see p. 169), and, indeed, superficially the resemblance appears very strong, because both have the well-marked "composite" rings on which Barber laid so much stress, but these have been found in several other forms (see *e. g.* Viguier & Fritel, 1912).

The principal differences which distinguish the new fossil from *C. vectense* are: the well-marked stone-cells in the pith, the larger size of the tracheids and their tendency to form irregular groups (text-fig. 51), and the type of pitting in the radial walls of the medullary rays. In *C. vectense* the ray-pits are principally 1, sometimes 2, or perhaps 3 per tracheid-field of definite uniformly-sized pits. In *C. luccombense* the pits vary greatly in size and shape in the same tracheid-field, and form typically groups of three or four.

While no one of these differences is final as a diagnostic character, taken together they constitute a good specific difference in the present state of our knowledge, and I name the species after the place in which it was found.

With the Lower Cretaceous species *C. Lennieri*, described in detail by Lignier (1907), there appears to be a true affinity. Lignier mentions that there are from 3 to 6 small pits per tracheid-field in the medullary rays of his species. Judging from his rather diagrammatic figure, these also vary in size in each group, as they do in our fossil. Probably the French and this new English species find their nearest allies in each other.

The species *C. erraticum*, described and well illustrated by Mercklin (1855, pl. xiv), has irregularly-placed groups of three or four small roundish pits, which in some degree resemble our fossil, though in Mercklin's fossil the pits are much smaller in proportion to the area of the tracheid-field. It is not likely on other grounds that this doubtfully Tertiary species is identical with the Lower Greensand form. Also the ray-pitting in the Tertiary fossil described as *Calloxylon Hartigii* by Andrä (1848) is rather like that of our new fossil. Several other species of *Cupressinoxylon* with groups of pits in the radial walls of the ray, have been described by Knowlton and others, which to some extent resemble our fossil, but they are generally too imperfectly petrified or figured to make detailed comparison profitable.

V. 13195. Type-specimen. A short straight length of the petrified woody branch from which the sections have been cut. The specimen is 3·5 cm. in diameter and 4·5 cm. long. The cut end shows the central axis and regular rings of secondary wood.

V. 13195 a. Figured, text-fig. 51. Transverse section of the above, in which the pith-cells, primary xylem, and secondary wood can all be well seen. On one side of the axis a branch is beginning to go out. The resin-containing wood-parenchyma and the medullary ray-cells are well preserved in this section.

V. 13195 b. Radial longitudinal section of the above. In this the pitting of the tracheids, the cross-walls of the xylem-parenchyma, and the radial pitting of the medullary ray-cells can all be well seen.

V. 13195 c. Figured, text-fig. 53. Tangential longitudinal section of the above. The details of the numerous low rays and the cross-walls of the xylem-parenchyma can be well seen.

Lower Greensand; Luccomb Chine, Isle of Wight.

Found and presented by Dr. M. C. Stopes, 1912.

Cupressinoxylon cryptomerioides, sp. nov.

[Plates XVI, XVII; text-figs. 54, 55.]

Diagnosis.—Coniferous wood without resin-canals, though large canals are present in the cortex. Pith about 1 mm. in diameter. Primary bundles numerous, entirely centrifugal. Secondary wood close-grained, composed of regular small tracheids, up to about 25 μ in diameter. Bordered pits round, isolated in a single row. Tangential pits in autumn wood. Annual rings present, but not very strongly differentiated. Medullary rays uniseriate, mostly 2–8 tracheids distant, low; cells all alike, walls apparently smooth, but irregular in shape; pits in radial walls 2 per tracheid-field, rather large, nearly round, and standing one vertically above the other. Resin-parenchyma abundant, scattered throughout the wood; cross-walls rectangular.

Species founded on small branches, about 1·3 cm. in diameter and about nine years old, with both pith and cortex.

Horizon.—Kentish Rag, Lower Greensand.

Locality.—Iguanodon Quarry, Maidstone.

Type.—Small branches, nos. V. 13208 and V. 13208 *a–e*, slides cut from it; in the British Museum (Nat. Hist.), part of the specimen (No. 15) in the Maidstone Museum.

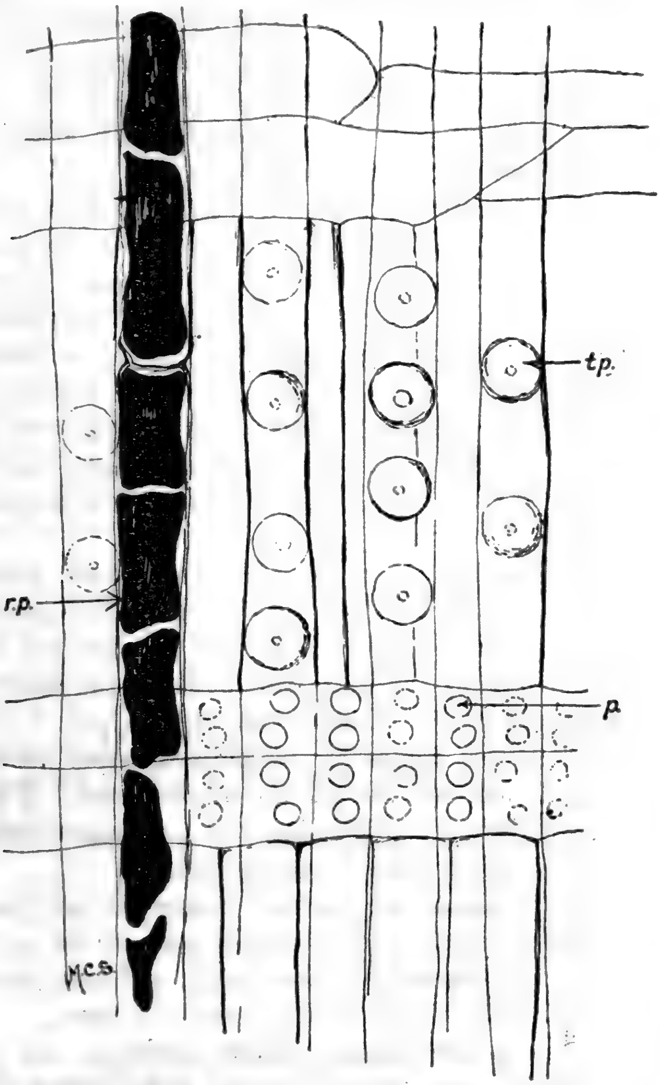
Description.—The type-specimen in the Maidstone Museum (No. 15) consists of a long piece of a small twig about 1·3 cm. in diameter, of which about 10 cm. in two pieces was presented to the British Museum and sections from it were cut. The twig is interesting as being the only Conifer among the Lower Greensand specimens on which I have worked which shows part of its cortex. The phloem and cortex are both partly preserved outside the wood, and in the cortex are large resin-passages (Pl. XVI, fig. 2). The pith is also present, and there are 8 or 9 very faintly marked annual rings in the wood, so that we are clearly dealing with a twig about 9 years old. It will be observed in the other woods described, that the age and complete size of the material were very uncertain. The twig must have been broken from the tree and preserved in the late summer, for the last tracheid or two before the cambium begins show tangential pits, which are usually only developed in the late summer and "autumn" wood.

Topography of the Stem.—The *pith* is about 1 mm. in diameter; it is a little crushed, but was probably roughly circular, with a crenulated outline due to the bays of primary wood. It is composed of large roundish elements, and I am uncertain whether or not there are stone-cells among them (Pl. XVI, fig. 1, *p.*) in the type, though they are clear in the second specimen (text-fig. 55). The *primary wood* projects sharply into the pith in 20 or more rather irregular bundles (Pl. XVI, fig. 1, *p.x.*). The *secondary wood* consists of close-grained uniform tracheids, in which the rings of growth are very faintly marked. The compression of the autumn tracheids is slight—indeed, so slight as to be barely recognisable or measurable in some cases—though the walls of the autumn wood are rather thicker than in the spring wood, and the tangential pits can be very clearly seen even in transverse section. *Resin-canals,* both normal and traumatic, are absent. *Resin-containing xylem-parenchyma* cells are exceedingly numerous and conspicuous in the wood (Pl. XVI, figs. 1 & 2, *r.p.*).

The *medullary rays* are also numerous and fairly conspicuous; they are all *uniseriate,* 2–8 tracheids distant in the greater part of the wood, but as much as 14 or so tracheids distant in some parts of the outer rings. The cells appear all alike, and in tangential section the rays are low, principally 2–3, and up to 5–6 cells high. The *cambium* is normal, and is partly preserved between the phloem and xylem (Pl. XVI, fig. 2, *c.*). The *phloem* is very much crushed, but appears to be quite normal (Pl. XVI, fig. 2, *ph.*). Mingled with the soft cells are thickened stone-cells. The *cortex* is very partially preserved, but shows numbers of large resin-canals throughout those portions which are present (Pl. XVI, fig. 2, *r.c.*).

Details of Elements.—The *pith* consists of roundish cells, varying up to 40–50 μ in diameter. They fit into each other without leaving much intercellular space, and their walls are slightly thickened and pitted (Pl. XVI, fig. 1, *p.*). In longitudinal section the elements are not much elongated, and are chiefly squarish in outline. Owing to obscurities in the petrifaction I cannot feel certain whether or not stone-cells are present.

The *primary wood* forms irregular small bundles of what appears to be entirely centrifugal wood. In radial section the protoxylems can be seen, and a few of them seem to have scalariform and spiral elements; but most of them are covered by very minute roundish pits (Pl. XVII, fig. 2, *p.x.*), in which a strand of protoxylem lies in the centre of the field, and to the right are the small secondary tracheids with their larger round-bordered pits. Leaf-trace strands of these small-pitted elements pass out in the medullary rays. The *secondary tracheids* vary somewhat; the largest of them measure up to 25 μ in diameter, but most of them are considerably less than this. In the inner zones of the wood they are much rounded at the corners, and in the outer zones they are squarer and more regular, as can be seen by an examination with a lens of the two figures in Pl. XVI. The longitudinal sections show large, round, isolated, bordered pits, the diameter of the border being nearly equal to that of the



Text-fig. 54.—*Cupressinoxylon cryptomerioides*, sp. nov. Radial longitudinal section, showing the tracheid-pitting, *tp.*, the outline of the medullary rays, and the pitting on their radial walls, *p.*, as well as the resin-parenchyma, *r.p.* No. 13208 *c.*

tracheid-wall in which it lies (Pl. XVII, fig. 1, *t.p.*, & text-fig. 54, *tp.*). In the autumn wood the pits are relatively rather smaller. In transverse section the preservation is such that the bordered pits show up remarkably well both in the radial walls throughout and in the tangential walls of the autumn wood.

Resin-containing xylem-parenchyma cells are very numerous as can be seen in transverse and longitudinal sections (Pls. XVI & XVII, *r.p.*). They may be radially narrower or equal in size to the adjacent tracheids. In longitudinal section the cross-walls of the series of cells lie horizontally with a slight constriction where the septum comes (text-fig. 54, *r.p.*).

Medullary rays are all uniseriate, and the cells composing them are about one-half up to the same size in tangential diameter as the adjacent tracheids. They appear conspicuous in transverse section owing to the blackened contents which fill many of them. In transverse section the end-walls are placed at a rather variable angle. In radial section, as can be seen in Pl. XVII, fig. 1, the rays are principally two or three cells high, and the shape and angle of the walls vary considerably (see also text-fig. 54), so that the cells are rather irregular and wavy in outline.

Although otherwise the preservation of this fossil is good, the medullary ray-cells do not show the pitting on their radial walls in most cases. In one place, however, the pits can be very clearly seen, and they are there round sharp-cut pits, two per tracheid-field, one above the other (text-fig. 54, *p.*).

The walls of the ray-cells, as petrified, seem to be very delicately thickened, and the pits are not bordered. I have not been able to detect any thickening or "abietinean pitting" on the end-walls or other walls of the ray-cells.

The *phloem* elements are not well preserved, but those cells of the soft tissue which are not crushed seem to be as large as the tracheids. A few isolated stone-cells, and some stone-cells with very thick walls in radial series, are to be seen.

The *cortex* cells are largish, loosely arranged, and rounded elements. There are no special features in the cortex visible in the small portions of it which are preserved, except the large resin-canals (Pl. XVI, fig. 2, *r.c.*), of which the lining seems to have consisted of several layers of flattened cells, but is too poorly preserved to show very clearly.

Affinities.—The preservation of both pith and cortex in petrified woody branches of Conifers is exceedingly rare, and I do not know another similar wood in which they have been described or figured. In the present specimen only a small part of the cortex is preserved, but enough to show a number of large resin-canals running through it. In this feature, as well as in the details of the wood, and particularly in the ray-cells with their vertical pairs of large pits per tracheid-field in the radial walls, there are points of close likeness to the living genus *Cryptomeria*. Indeed, I hesitated before keeping this species in the non-committal "genus" *Cupressinoxylon*, when its structure is in several ways so suggestive of the living genus *Cryptomeria*, a plant which, though it is now a monotypic genus confined to Japan, occurs in the British Tertiary deposits, represented by undoubted leafy twig- and cone-impressions. Nevertheless, the identity of this fossil with *Cryptomeria* cannot be conclusively settled from the material available, and so it seems better to retain it in *Cupressinoxylon*; all the more so since Schenk (1890 A in Zittel) illustrates *Cryptomeria japonica*, the living species, as his type for *Cupressinoxylon*-wood. In all essentials his fig. 411 is identical with text-fig. 54.

In the Cretaceous the only undoubted *Cryptomeria*-fossils of which the anatomical structure is known are *Cryptomeriopsis antiqua*, Stopes & Fujii (1910), and *C. mesozoica*, Suzuki (1910). These are both very minute foliage-bearing twigs, which cannot be exactly compared with the larger woody branch now recorded, which is so much older both biologically and geologically.

V. 13208. Type-specimen. Fragment of twig 7·5 cm. long and about 1·4 cm. in diameter, a little crushed. Externally part of the woody texture is visible and part is covered by fragments of the coarse matrix. From another part of the same twig the following sections were cut.

V. 13208 a. Figured, Pl. XVI, figs. 1 & 2. Transverse section of whole twig, showing pith, primary xylem, secondary xylem with feebly marked annual rings, and part of the phloem and cortex with large resin-canals. The bordered pits on the transversely cut tracheid-walls show remarkably well.

V. 13208 b. Two further sections, similar to the above, in which the annual rings are seen a little more clearly, as the sections are slightly thicker and the contrast more marked.

V. 13208 c. Figured, Pl. XVII, figs. 1 & 2; text-fig. 54. Median radial longitudinal section through the pith, in which the pith-cells are largely marked by black mineral granules. The protoxylems show very well in several places. The exit of a leaf-trace through the wood, which runs horizontally through a medullary ray, can also be seen. The medullary ray-cells are clearly seen in outline, but only show their pits in a small area towards the middle of the section. The bordered pits on the tracheids are to be seen in many places.

V. 13208 d. Oblique tangential section, showing the exit of a small branch. In this, though they are not satisfactorily preserved, the low medullary rays can be well seen.

V. 13208 e. Another rather similar section to the above, showing the rays partly radially and partly tangentially. Several small leaf-traces cut in tangential section can be seen.

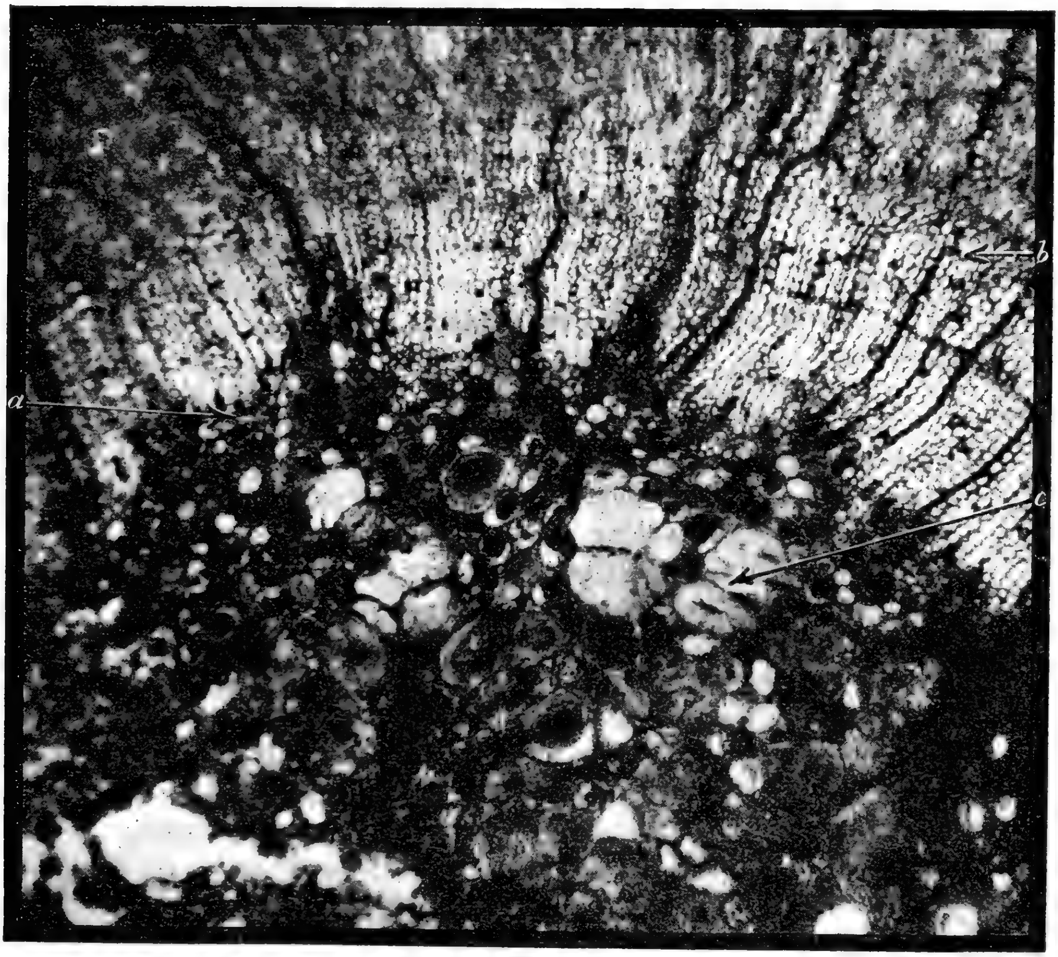
Kentish Rag; Iguanodon Quarry, near Maidstone.

Presented by the Committee of the Maidstone Museum, 1912.

Included in the above species should probably be a second small twig from the same locality, in which, however, the structure is less well preserved and there are no remains of the cortex. The twig is about 1 cm. in diameter. From the small piece given by the Maidstone Museum sections were cut, which show that the *pith* is the best-preserved feature of the twig. In the pith are large, very much thickened stone-cells (text-fig. 55, *c*.). This makes it difficult to compare with the type, because the pith is there the least well-preserved part, and I am doubtful whether stone-cells are present in it. The other features of the present specimen, however, all agree with those of *Cupressinoxylon cryptomerioides*, so far as they are observable.

Of the small piece given to the Museum, the whole was cut up into the following sections :—

V. 13200 a. Figured, text-fig. 55. Uncovered transverse section in which the pith-cells are very well seen. Surrounding this are the bundles of primary wood. Numerous resin-cells in the secondary wood resemble those described for the type.



Text-fig. 55.—(?)*Cupressinoxylon cryptomerioides*, sp. nov. Central part of stem, showing stone-cells of large size (*c.*) in the pith. *a.*, primary bundles of xylem round the pith, and *b.*, resin-parenchyma in the secondary wood.

V. 13200 b & c. Two thinner transverse sections similar to above.

V. 13200 d & e. Median radial sections through the pith. All the tissues preserved in these diaphanous sections agree with the type, so far as they can be seen.

V. 13200 f. Oblique longitudinal section, showing a few medullary rays in radial and a few in tangential section. The latter are low, only 2–3 cells high, as in the type.

V. 13200 g. A radial section in which most of the tissue is ill-preserved. In one place a leaf-trace making its exit through a medullary ray can be well seen, because it is locally stained with iron.

Kentish Rag; Iguanodon Quarry, near Maidstone.

Presented by the Maidstone Museum, 1912.

Cupressinoxylon Hortii, sp. nov.

[Plate XVIII; text-figs. 56, 57, 58.]

Diagnosis.—Secondary wood composed of large squarish tracheids up to 60 μ in diameter. Round bordered pits chiefly in one row, separated some distance from each other, a few almost adjacent or touching. Tangential pits in autumn wood. The vertical course of the tracheids is very wavy to fit round the medullary rays. Annual rings clearly marked, but very small amounts of thickened elements. Medullary rays uniseriate to multiseriate, the same ray varying at different heights. Rays exceedingly numerous, often only 1 tracheid distant, and very high, running up to 80 cells in vertical series. Walls of ray-cells smooth; pits in radial walls chiefly 1, may be 2, per tracheid-field, large, oval or circular. Resin-parenchyma abundant, scattered all through the wood; cells very large, with a distended appearance in vertical sections, and considerably constricted by their horizontal walls.

Species founded on large woody trunks, secondary wood only known.

Horizon.—Fuller's Earth in Lower Greensand.

Locality.—Woburn Sands.

Type.—Large woody trunk, no. V. 11847 and slides

V. 11847 *a*–V. 11847 *c* cut from it; British Museum (Nat. Hist.).

Description.—Four large specimens and some smaller splints of wood were found near together, and possibly form part of a large trunk. One of the pieces was cut, and the species is described from sections, cut from this block, roughly measuring $9 \times 10 \times 12$ cm., including only secondary wood. The woody texture is apparent on the external surfaces of the specimen, and the grain is very gnarled and knotty. The infiltration of the petrifying medium has been irregular, so that the large masses tend to split up. The whitish mass of the fossil is in parts very much iron-stained. Another specimen in the older collections of the Museum (V. 5659) appears to be identical, in all essentials, with this species.

Topography of the Stem.—*Secondary wood* only is preserved. In this the *growth-rings* are well marked. The number of elements comprising a ring varies greatly, running up to 200 in radial series, the maximum thickness of a year's growth being as much as 8 mm. The autumn wood is very small in amount, consisting of only 3–5 narrow elements, whose walls are not excessively thickened. The wood is uniform, the elements large and squarish, adjacent elements often being on the same tangent. *Resin-canals* are entirely absent. Resin-containing wood-parenchyma is scattered all through the wood.

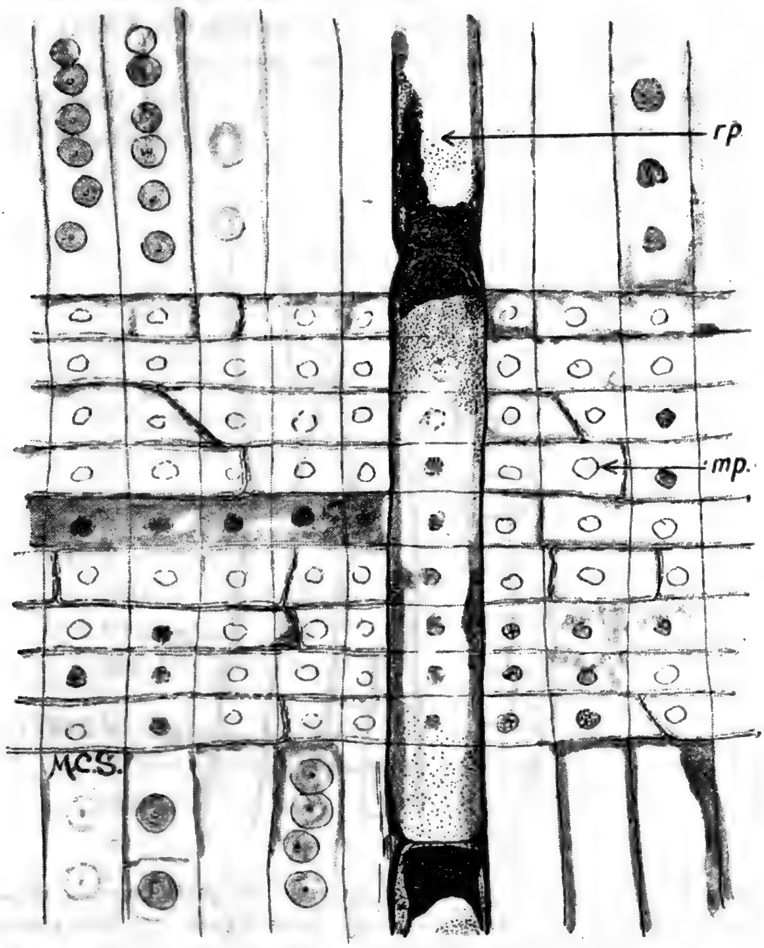
The *medullary rays* are the salient feature of this species, and are very remarkable for a Conifer. They are exceedingly numerous, and most are *bi-* or *multiseriate* in part (Pl. XVIII, fig. 2). The rays are often 1 tracheid distant, and seldom more than 4 tracheids distant, in which case it is only for a short vertical course, for they quickly approach another ray only 1 or 2 tracheids away. The photo. (Pl. XVIII, fig. 2) illustrates this extraordinary ray-structure very well. That it is normal for this wood seems proved by the nature of the specimens from which the sections were cut; good-sized sections were taken from a mass of petrified wood of such a size as to indicate that it was part of a tree-trunk of many years' growth. The very low rays of 1–3 cells high, so common in the majority of Coniferæ mingled with taller rays, are in this fossil absent in parts of the wood, where uniseriate up to multiseriate rays as much as 70–80 cells high are common.

Details of Elements.—The great majority of the wood *tracheids* have the size and character of the spring wood, since the zone of autumn wood is narrow and the rings of growth are wide. These tracheids measure about 30×40 up to $50 \times 60\ \mu$ in transverse area; their walls are not much thickened and very little rounded at the corners. The autumn wood, of which there is but a small quantity, consists of elements with the same tangential diameter and about half the radial diameter of the spring wood, *i. e.* about 30×12 to $40 \times 15\ \mu$; the walls are about 5–7 μ thick in the last-formed autumn wood. In transverse section the large-bordered pits are very noticeable; due apparently to a peculiarity of petrifaction or of decay before petrifaction, the round border is blown up, like a half balloon. This appearance is also seen in the tangential longitudinal sections (text-fig. 57).

In radial section (text-fig. 56) the pits are seen to lie in a single row, generally separated from each other by some distance. The pits in the tangential walls of the autumn tracheids can be seen in transverse section in several places. *Wood-parenchyma* cells of large size, with thin walls and, as a rule, with blackened resinous contents, are apparent throughout the wood. In transverse diameter they are as large or even larger than the tracheids. In radial section the cross-wall slightly constricts the element; this is not the case in the tangential section, where the walls also run transversely (text-figs. 56 & 57). The end-cells of a cell-row have pointed terminations which fit into the tracheids. I have not observed any special pitting in the walls. *Resin-canals* and specialised resin-tracheids are absent.

The *uniseriate* and *multiseriate medullary rays* are not different in kind, and the same ray may be uniseriate for some part of its vertical extension, then biseriate, and then again uniseriate and then again biseriate. Much variety in the build of the rays can be seen in Pl. XVIII, fig. 2. The end-walls of the ray-cells are slightly sloped or curved; the radial extension of a ray-cell equals from 2 to 8 or 9 tracheids. The tangential diameter of the ray-cells is rather less than or equal to the adjacent tracheids. The cells all have slightly thickened walls, but the petrifaction does not show whether they have any true "abietinean pitting" or not. The only pitting visible is the series of single, large, roundish pits in the radial walls of the rays, one for each tracheid-width (text-fig. 56, *mp.*).

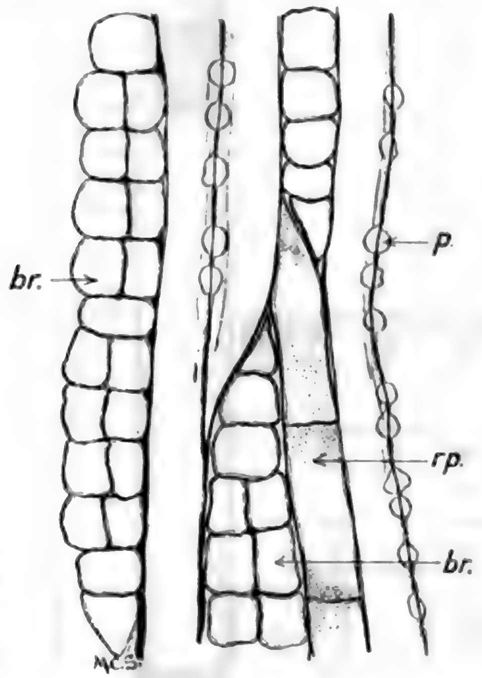
Affinities.—The extraordinary broad, high, and irregular medullary rays find no parallel, so far as I am aware, in any Conifer, either living or fossil. It is true that a tangential



Text-fig. 56.—*Cupressinoxylon Hortii*, sp. nov. Radial section, showing pitting of tracheids and medullary ray. *mp.*, pits of medullary ray-cells; *rp.*, resin-containing wood-parenchyma. No. V. 11847 *b.*

section which almost cuts the pith in all Conifers will show multiseriate rays, but this is only just at the centre of the stem where the broad primary rays are fusing with the pith. In the secondary wood, even in the second year, rays of this sort do not occur in any of the higher Gymnosperms, though there are multiseriate rays in several of the Palæozoic forms of the Cordaitean and *Poroxylon* affinities. In our specimen the large size of the pieces of petrified wood from which the sections were cut, coupled with the curve of the annual rings, etc., indicate that we are dealing with outer zones of wood from a large trunk, so that the remarkable appearance illustrated in Pl. XVIII, fig. 2, must be normally characteristic of the species.

As has been noticed by many, there is a slight tendency for species of *Cupressinoxylon* to have rays in which one or two of



Text-fig. 57.—*Cupressinoxylon Hortii*, sp. nov. Tangential section, showing biseriate rays, *br.*; resin-containing parenchyma, *rp.*; and tracheids in which the bordered pits on the radial walls (*p.*) have been curiously petrified. No. V. 11847 *c*.

the cell-rows are biseriate; so it seems best, at present at any rate, to include this anomalous species in the genus *Cupressinoxylon*, more especially as it has numerous large resin-parenchyma cells scattered through its wood, though the exceptionally large single pits in the radial walls of the medullary rays are very suggestive of *Podocarpoxylon*.

The isolated, round, bordered pits in the tracheids are those of a typical Abietinean Conifer, and there is no abnormal character in the wood except the broad rays and consequent loose texture of the wood and the rather erratic course of the large tracheids. The plant was evidently a tree of some considerable girth, and consequently of fair height. Of the Cupressinean woods now described it is least like any modern type, and the discovery of its fructifications would be of great interest.

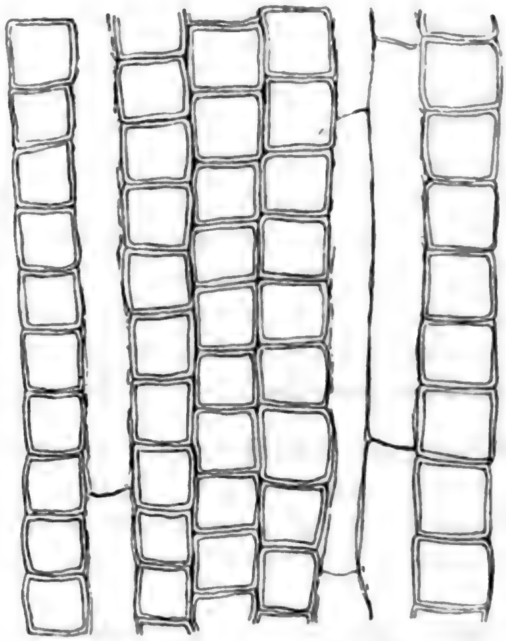
V. 11847 [**V. 11848** & **V. 11849** probably part of the same trunk]. Type-specimen. Part of a large trunk consisting only of an irregularly broken-out mass of secondary wood, $12 \times 9 \times 8$ cm. The specimen is almost free from matrix, and shows the woody texture very clearly; one exterior face is much teredo-bored, and the texture of the wood is eaten out in high relief in a white friable form. Internally the petrifying medium is very hard and close-grained, and locally preserves the wood extremely well. It is of a rich cream-colour, much iron-stained in patches.

V. 11847 a. Figured, Pl. XVIII, fig. 1. Transverse section of part of the secondary wood. In this the wide annual rings can be well seen, also the large square tracheids and the broad multiseriate medullary rays.

V. 11847 b. Figured, text-fig. 56. Longitudinal radial section of the above. The large and constricted resin-parenchyma cells are very conspicuous in this. Locally, where the iron-stain shows up the detail, the pitting of the tracheids and the radial walls of the medullary ray-cells can be well seen.

V. 11847 c. Figured, Pl. XVIII, fig. 2; and text-fig. 57. Longitudinal tangential section of the same. In this, as illustrated in Pl. XVIII, the enormous mass of the medullary rays is very conspicuous. The rays, cut in tangential section, are exceedingly high in many cases, and are uniseriate, biseriate, and multiseriate in different parts of their height in the same section, and they sometimes bifurcate so as to fit in between the very irregularly running tracheids. Some such appearance might be expected from the very heart of the wood, just near the pith, but the block from which the section is cut proves it to come from the outer regions of a large woody trunk.

Fuller's Earth in the Lower Greensand; Woburn Sands, Bedfordshire. *Presented by the Rev. F. F. Hort*, 1910.



Text-fig. 58.—*Cupressinoxylon Hortii*, sp. nov. Transverse section to show a small portion of the secondary wood with uniseriate (*m.*) and biseriate medullary rays (*m* 2). No. V. 5659 *a*.

V. 11848 & V. 11849. Other large pieces, from 15×12×8 cm. downwards, all apparently part of the same trunk as V. 11847, and found together. Fuller's Earth in the Lower Greensand; Woburn Sands.
Presented by the Rev. F. F. Hort, 1910.

V. 5659, V. 5659 a–c. A wedge-shaped portion of secondary wood, 5×2×9 cm. in size. The wood is entirely decorticated, and shows externally the woody texture.

It is petrified in a creamy silicified medium, which preserves the tissues fairly well, but they were evidently macerated and softened before petrifaction, as the wood-cells are mostly a good deal crushed and distorted.

V. 5659 a. Text-fig. 58. The crushing of the tissues renders much of this section obscure, but there are parts where the large square tracheids, the xylem-parenchyma, and the medullary rays can be well seen. The *bi-seriate rays* are very well preserved in parts, and are illustrated in text-fig. 58. The details of this wood agree with those described for the type.

V. 5659 b. Radial longitudinal section of the above. The preservation is poor.

V. 5659 c. Tangential longitudinal section of the above. While the preservation is poor, the great height of the rays and their partly biseriate nature can be seen (*cf.* Pl. XVIII, fig. 2).

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept., 1898.

Cupressinoxylon, sp. indet.

V. 5450. A small branch of decorticated wood, 6 cm. long by 3×2 cm. in diameter, weathered at one end and showing something of the woody texture.

V. 5450 a. Transverse section of the above. The petrifaction is very poor, the small tracheids with numerous resin-canals are all that can be recognised.

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept., 1898.

Coniferous wood—probably CUPRESSINOXYLON *sp.*

52908. A decorticated branch showing its central axis and concentric annual rings, 3·5 cm. in diameter and 25 cm. long. Externally it shows the woody texture, but is partly covered by the coarse sandy matrix. A second specimen adheres to the branch, cemented on by the matrix. The dark close-textured petrifying medium has probably preserved the cell-structure very well, and it is likely that the specimen would show good tissue if sections of it were cut. Labelled as from "Junction of Gault and Lower Greensand, Ventnor, Skanklin."

Presented by Hon. Robert Marsham-Townshend, 1877.

V. 4444. A small piece of secondary wood, 6·5 × 2 cm., completely embedded in very coarse granular matrix. The wood is petrified in a hard, dark, silicified medium, and would probably show its structure fairly well if sections were cut. Luccomb Chine, Isle of Wight (?).

Transferred from the Botanical Dept.

Family TAXINEÆ.

This is a rather unnatural family composed of two sharply separated sub-families, the Taxaceæ in the Northern Hemisphere and the Podocarpaceæ in the Southern. The grouping of these two families under the one, Taxineæ, seems to me to be very artificial, though it is the classification at present current. In their anatomy, their vegetative habit, the details of their reproductive morphology, and their geographical distribution the two groups are unlike: they agree, however, in having large seeds (solitary or in pairs) surrounded by fleshy and often brightly coloured coverings, borne, or when ripe having the appearance of being borne, isolated among the foliage branches, while all the other Coniferous families have definite cones bearing dry woody seeds. The ♂ fructification in both groups consists of small cones.

The separation of the two sub-families is well marked in their wood-anatomy, the Taxaceæ (represented in wood-fossils by *Taxoxylon*) having spiral thickening in their secondary tracheids, the Podocarpaceæ (represented by *Podocarpoxylon*, including *Phyllocladoxylon* of Gothan) being without spiral thickening, but having characteristic pitting in their medullary ray-cells.

Several Tertiary and Cretaceous representatives of the family are known. For an account of *Stachyotaxus* and references to what are probably the earliest reliable records of the family, Nathorst's paper (1908) should be consulted.

Sub-family *TAXACEÆ.*

This sub-family contains less than twenty living species, principally grouped in three genera, viz. *Taxus*, distributed in Europe, North America, and Asia; *Cephalotaxus* in China and Japan; and *Torreya* in North America, China, and Japan. The forms resemble each other vegetatively in having spirally attached leaves, which are oriented so as to spread from the branch in two series, simulating a flattened pinnate leaf. The plants are principally bushes, shrubs, and shrubby trees, and the wood is peculiar in having tertiary spirals in the secondary tracheids. The ripe female fructification consists of a single seed or a pair of seeds attached to the ends of foliage twigs. This, however, results from extreme cone-reduction, and the reduced cones are to be seen in young stages of the fructification. The ripe seed is large, orthotropous, and surrounded by a fleshy envelope, either integument or aril. In some respects the massive seeds are more comparable with the Cycads than with those of the other Gymnosperms.

Genus **TAXOXYLON,** Unger (revised by Kraus).

[Unger, Chloris protog., 1847, p. 33.]

Diagnosis.—" Lignum stratis concentricis distinctis. Radii medullares simplices 1–15 cellulis parenchymatosis superpositis formati. Vasa poroso-spiralia subangusta, versus radios una serie pororum disciformium " (*Unger*).

In Kraus' (1870) revision of the genera of fossil woods he diagnoses the genus as follows:—" Lignum stratis concentricis distinctis; cellulis prosenchymatosis poroso-spiralibus; poris magnis, rotundis; filis spiralibus sinistrorsis, raro pluribus; cellulis ductibusque resiniferis nullis; radiis medullaribus simplicibus." He adds: " Il est souvent difficile de reconnaître les bois fossiles appartenant à ce groupe, parce que les fibres spiralaires peuvent facilement être confondues avec les stries spiralaires, surtout quand le bois était en voie de décomposition avant sa fossilisation."

The difficulty of distinguishing between the spiral markings and splitting of semi-decayed tracheid-walls, which can be seen in any conifer, and the true tertiary spirals characteristic of the Taxaceæ, has led to a number of determinations among fossils which cannot be accepted. Schimper & Schenk (1890, p. 849) point out how few of the described species of *Taxoxylon* can remain in the genus. In Gothan's recent work (1905) he devotes a section to a consideration of the Taxaceæ, and retains Unger's *Taxoxylon*, ex parte, for all the forms in which true spiral thickening in the secondary tracheids can be recognised.

The number of such fossils is small, the "genus" *Taxoxylon* being very much smaller than the other four major genera of coniferous woods (see p. 64). The species on which any reliance can be placed are of Tertiary age, though a few Cretaceous Taxoxylons have been described, e. g. *Taxoxylon cretaceum*, Unger (1859, p. 231), which was put in *Cedroxylon* by Kraus. I do not know of any well-petrified fossil wood of Lower Cretaceous age which can certainly be placed in this genus. Foliage impressions, however (see p. 209), have been described which are reliably identified as *Taxus*, *Cephalotaxus*, and other Taxaceous genera, proving the family to be well represented by Lower Cretaceous times.

Taxoxylon anglicum, sp. nov.

[Plate XIX, figs. 1–3; text-fig. 59.]

Diagnosis.—Coniferous wood of regular texture; resin-canals entirely absent. Annual rings fairly well marked; zone of autumn wood narrow. Tracheids very regularly arranged, up to 40 μ in diameter; cell-walls, even of spring tracheids, rather thick, and walls rounded off at the corners. Bordered pits round, isolated, in one row, with circular pores; rims of Sanio evident. Fine spiral thickenings on the walls of tracheids. Resin-containing xylem-parenchyma apparently absent. Medullary rays uniseriate; cells apparently all alike, though some have more resinous contents. Walls somewhat thickened, but apparently smooth and without abietinean pitting, end-walls curved or at an angle. In the radial walls are small groups per tracheid-field of 2–4 pits with large definite borders. Connecting rays which lie near to each other are short tracheids, sometimes exceedingly irregular in shape, and with small circular bordered pits.

Species founded on a twig which cannot have been less than 4 cm. in diameter when alive.

Horizon.—Lower Greensand.

Locality.—Woburn Sands, Bedfordshire.

Type.—Twig, no. V. 5459 and V. 5459 *a–d*, slides cut from it in 1912; British Museum (Nat. Hist.).

Description.—The specimen is a length (8 cm.) of decorticated woody stem at present about 2·5 cm. in diameter, but of which the size must have been greater, as the pith is preserved very much to one side, making the diameter when living and corticated probably about 4 cm. Externally the woody texture is weathered out and the surface is considerably teredo-bored. It is well petrified, with a close hard texture, dark centrally, and whitish round the edges.

Topography of Stem.—The *pith* and *primary wood*, to the extent of about 1 mm., are entirely disintegrated. *Secondary wood* is formed of regular series of close-grained elements, with well-marked growth-rings, the larger of which measure about 2 mm. in radial extent and are composed of a variable number of tracheids up to 90 in radial sequence. The zone of compressed autumn tracheids is narrow, averaging from 5–10 elements, which have very thick walls.

Resin-canals, both normal and traumatic, are absent. *Resin-containing xylem-parenchyma* is very sparsely developed, even if present, a point about which I am in some doubt, owing to the difficulty of determining whether end-walls are present in the cells in the radial section which appear to be resin-containing. The numerous dark cells in the transverse section are due to petrifact*.

Details of Elements.—*Medullary rays* are fairly conspicuous, averaging 2 to 10 tracheids distant. They are all uniseriate, and in tangential section the cells seem all alike. Some of the rays appear very close together and are connected by very short tracheids, which almost merge into ray-tracheids. In tangential

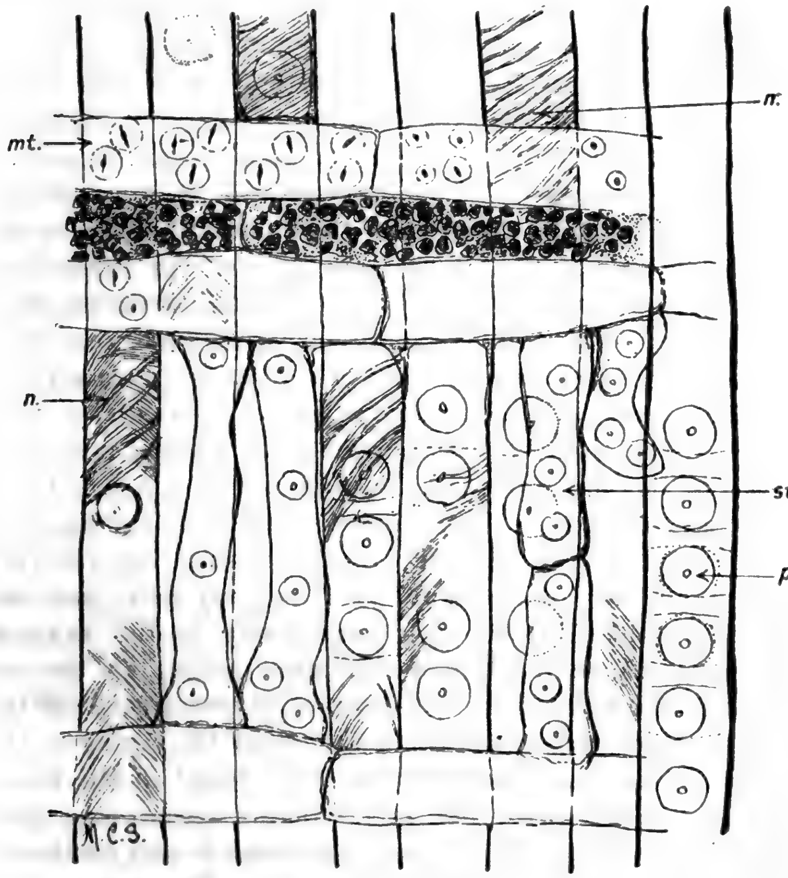
* See Stopes, 1912, footnote, p. 94, for the first use of this word.

section many of the ray-cells are blocked with black contents. The rays are principally 2–10 cells in height, 2 and 3 being the commonest number.

The *secondary tracheids* vary, the larger first-formed elements averaging from about 25×30 to $30 \times 40\ \mu$. In proportion to their size, the cell-walls even of the first-formed elements are rather thick, measuring as much as 4–6 μ. The compressed autumn elements often have a wall so thickened as almost to obliterate the lumen, which is a narrow slit-like space. The individual elements in the wood are considerably rounded off, and adjacent elements lie on alternating tangents so as to fit into each other; but even so there are noticeably large intercellular spaces between the corners of many of the tracheids. The radial walls are pitted with round bordered pits (Pl. XIX, fig. 3, and text-fig. 59). The pits nearly all lie in a single row, isolated by at least a distance equal to their own border. The diameter of the border is about equal to $\frac{2}{3}$ the diameter of the tracheid-wall in which it lies. In several cases the border appears to be double, with an inner and an outer circular zone—but this may be petrifact, as the tissues are rather diaphanously preserved. Sanio's rims are clearly to be seen in many cases, and there are in addition exceedingly fine reticulations over the surface of the tracheids (text-fig. 59, *n.*). Under the microscope these are very different from the fine cracks which are often seen in semi-decomposing walls and are highly suggestive of true, delicate, tertiary spirals, such as are seen, more coarsely developed, in living Taxaceæ.

Resin-containing *xylem-parenchyma* cells at first sight appear to be frequent, but after careful examination I have not been able to find any cells which satisfy me that they are true parenchyma. The blackened contents, which are so deceptive in transverse section, are due apparently to mineral granules.

Medullary rays are all uniseriate, and the cells composing them are from one half up to the same tangential width as the adjacent tracheids. In transverse section the end-walls are at a low angle or slightly curved. In radial section the walls are still more curved, and some of the elements are rather irregular or slightly spindle-shaped. The walls appear (as preserved in this specimen) to be very delicately thickened, and so it is not easy to determine whether they have the so-called "abietinean pitting," but I can detect no signs of it. In radial section in the lateral walls there are small circular or oval pits, from 1–6 per tracheid-field, which are very delicately bordered. In some cases it is difficult to detect the borders, but in a number of cases I have been able to recognise clear round borders (text-fig. 59, *mt.*), so that it is probable that these ray-



Text-fig. 59.—*Taxoxylon anglicum*, sp. nov. Radial section showing two rays connected by very short irregular tracheids, *st*. *p.*, bordered pits of tracheids between which are seen Sanio's rims. Small groups of bordered pits, *mt.*, lie in each tracheid-field of the rays. *n.*, the extremely fine spiral thickening of the tracheids. No. V. 5459 *c*.

elements represent more or less well-developed ray-tracheids. In some of the other cells of the rays large simple pits, one to each tracheid-field, can be seen, but I cannot feel sure that these are not due to the eating out of fungi or bacteria, and are therefore not a true character. A number of the cells of the ray are packed with dark granules, which may partly represent resinous contents. Other cells have a very delicate granular content centreing round what has every appearance of being a nucleus.

In several cases two rays come very close to each other, and are then connected by extremely short, irregularly shaped tracheids. These can be seen in Pl. XIX, figs. 2 & 3, and perhaps more clearly in the text-figure. Here they are so short and specialised that they almost merge into ray-tracheids. Their presence in this ancient fossil is interesting in connection with various published views on the origin of the ray-tracheids (see Thompson, 1910, Holden, 1913, etc.). Once more the older fossils undermine rather than support the conclusions drawn from the study of more recent fossils and living plants.

Affinities.—This fossil is doubtless a *Taxoxylon* closely allied to the living *Taxus* and *Torreya*, though there appear to be no other records of true *Taxoxylon*-wood at so early a date. The spiral thickening of the tracheid-walls, while it is delicate and has to be sought for with the high power, is clearly to be seen in several places in the longitudinal sections. The bordered pits in groups of three or four per tracheid-field are also very clearly to be seen in many of the medullary ray-cells; and both these important features point conclusively to the Taxaceæ when coupled with the lack of abietinean pitting in the end and horizontal walls of the ray-cells. The arrangement of the pits in tracheid- and ray-cells, and the spiral thickening of the tracheids in the fossil, are very like those found in the living *Pseudotsuga macrocarpa*, but in this living species true abietinean pitting of the end and horizontal walls is well developed.

A Senonian *Taxoxylon* was described by Hosius & von der Marck (1880, p. 194) as *T. halternianum*, but comparison with our fossil is not possible, because the only critical feature figured or described is a minute fragment showing spiral thickening of the tracheid-walls.

I know of no other Cretaceous woods with which one can compare the new fossil. There are, however, many foliage and even fruit impressions which have been attributed to *Taxus* and *Cephalotaxus* from various Cretaceous deposits. Their number has doubtless been considerably swelled by doubtful determinations, but of the existence of the family in Lower Cretaceous times there is now no question. Berry (1908 B) established the existence of a Taxaceous leaf in the American Middle Cretaceous, which was so preserved that the details of cuticle and stomate arrangement were recognisable. Summarising the various American species, Berry (1911, p. 375) says: "The family Taxaceæ is abundantly represented in the Lower Cretaceous, and when the individual abundance is considered rather than the specific differentiation, it must be admitted that the family furnishes an important element in the Potomac flora." The certainty which now attaches to the American Lower Cretaceous fossils of the group strengthens the various European determinations of fruits and foliage from several Middle and Upper Cretaceous deposits.

The new wood just described affords the earliest record of true Taxaceæ in Britain.

V. 5459. Type-specimen. Portion of decorticated wood from which sections have been cut. The wood is now 7 cm. long and 2·5 cm. in diameter, the exterior shows the decorticated wood-texture much teredo-bored.

V. 5459 a. Transverse section of the above. The whole of the pith and protoxylems are destroyed. The annual rings are well marked, and here and there the secondary wood is well preserved.

V. 5459 b. Figured, Pl. XIX, fig. 1. Transverse section of the above, in which the secondary tissues can be well seen, as is illustrated in the plate and described in the text.

V. 5459 c. Figured, Pl. XIX, figs. 2 & 3; and text-fig. 59. Radial longitudinal section of the above, showing very clearly the pitting of the medullary-ray cells, in which groups of pits with distinct borders lie on the radial wall.

V. 5459 d. Partly tangential and partly radial section in which the pitting on the ray-cells can also be well seen.

Lower Greensand; Woburn Sands, Bedfordshire.

[*Collected by H. Veasey, Esq.*], *transferred from the Botanical Dept.*, 1898.

Sub-family *PODOCARPACEÆ.*

This sub-family includes the living genera *Podocarpus*, *Dacrydium*, *Phyllocladus*, etc., of which *Podocarpus* is by far the largest genus, containing about 60 species. The whole family is confined to the Southern Hemisphere, except some species of *Podocarpus*, which penetrate to Japan. The plants vary considerably in vegetative habit, some having fine, spirally arranged leaves, and a general contour like some of the tall Taxodineæ and Abietineæ; others have broad and expanded leaves, in this respect being more like the Araucarineæ, though some of these forms do not grow much taller than large shrubs. The female fructification varies in the different genera, and may be said typically to consist of about two inverted ovules associated, but borne singly on specialised scales or stalks, which may become very brilliantly coloured and fleshy as the seeds ripen. Of a possible pair of ovules frequently only one ripens, and may appear externally like a solitary berry.

Genus **PODOCARPOXYLON,** Gothan (emend.).

[= *Podocarpoxylon* + *Phyllocladoxylon*, Gothan.]

[Abhandl. k. Preuss. Geol. Landesanst., vol. 44, 1905, p. 59.]

Diagnosis.—Gymnospermic wood without resin-canals. Bordered pits of tracheids round, generally isolated, and in one row; if in two rows the pits form pairs and are not alternating or hexagonally compressed. Rays uniseriate. Typically "abietinean pitting" of the ray-cells absent. Radial walls of medullary ray-cells pierced by single, very large pits, simple or with borders, sometimes by two or more such. In the autumn wood the "podocarpoid" pitting is commonly present. Wood-parenchyma present in variable amounts, sometimes very plentiful.

The variability in the pitting in the ray-cells (which is the only feature of separation between these fossil woods) is such that the different species of *Podocarpus* and *Phyllocladus* cannot reliably be separated from each other, though the two woods together form a distinctive group. I therefore unite Gothan's two "genera" under the name of the first, which is the better known and the first to be defined. The uncertainty of their separation can be judged from Gothan's own criteria: of these genera he says:—

"Markstrahltüpfel podocarpoïd bis typisch gross-eiporig. Meist nur 1–2 Tüpfel pro Kreuzungsfeld. Harzparenchym ± häufig.

(*a*) Markstrahltüpfel podocarpoïd bis teilweise eiporig...... } *Podocarpoxylon*, Gothan.

(*b*) Markstrahltüpfel typisch eiporig .... } *Phyllocladoxylon*, Gothan."

Podocarpoxylon woburnense, sp. nov.

[Plate XX, figs. 1 & 2; text-figs. 60, 61, 62, 63.]

Diagnosis.—Podocarpoid wood with well-marked growth-rings, but with a narrow zone of autumn wood. Tracheids fair-sized, up to about 35–55 μ in diameter. Bordered pits rather irregularly rounded, or true circles, principally in one row, but sometimes with pairs of pits on the same level; pits vertically isolated or adjacent, Sanio's rims apparent in many places. Resin-containing wood-parenchyma frequent all through the wood, cross-walls horizontal, with very slight constriction of cell-lumen. Medullary rays all uniseriate, 1–6 tracheids distant, the great majority low. Ray-cells apparently uniform as regards size and thickness of wall, though some contain noticeably more resinous contents than others. Ray-cells with thickened smooth walls, abietinean pitting absent, end-walls curved or at an angle in radial view, nearly straight in horizontal section. One large pit (sometimes two) per tracheid-field in radial walls; pit-pore roughly circular or oval, with a narrow border in some cases.

Horizon.—Lower Greensand.

Locality.—Woburn, Bedfordshire.

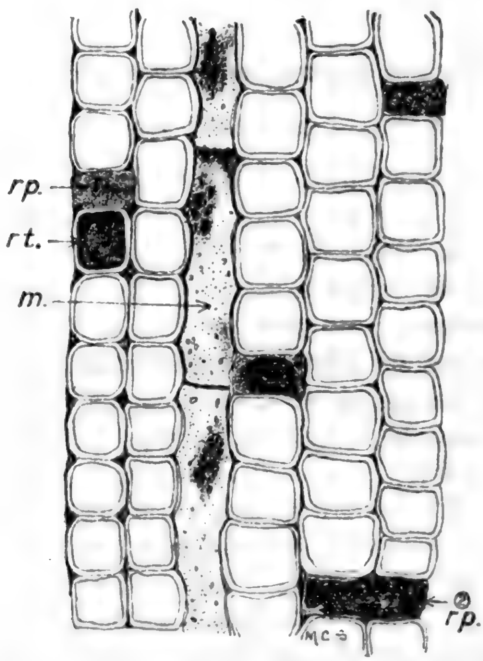
Type.—Block of wood, no. V. 5456, and V. 5456 *a* to V. 5456 *c*, the slides cut from it in 1912; British Museum (Nat. Hist.).

Finder.—H. Veasey, Esq., before 1898.

Co-type.—V. 5451 and slides V. 5451 *a–c* cut from it in 1912.

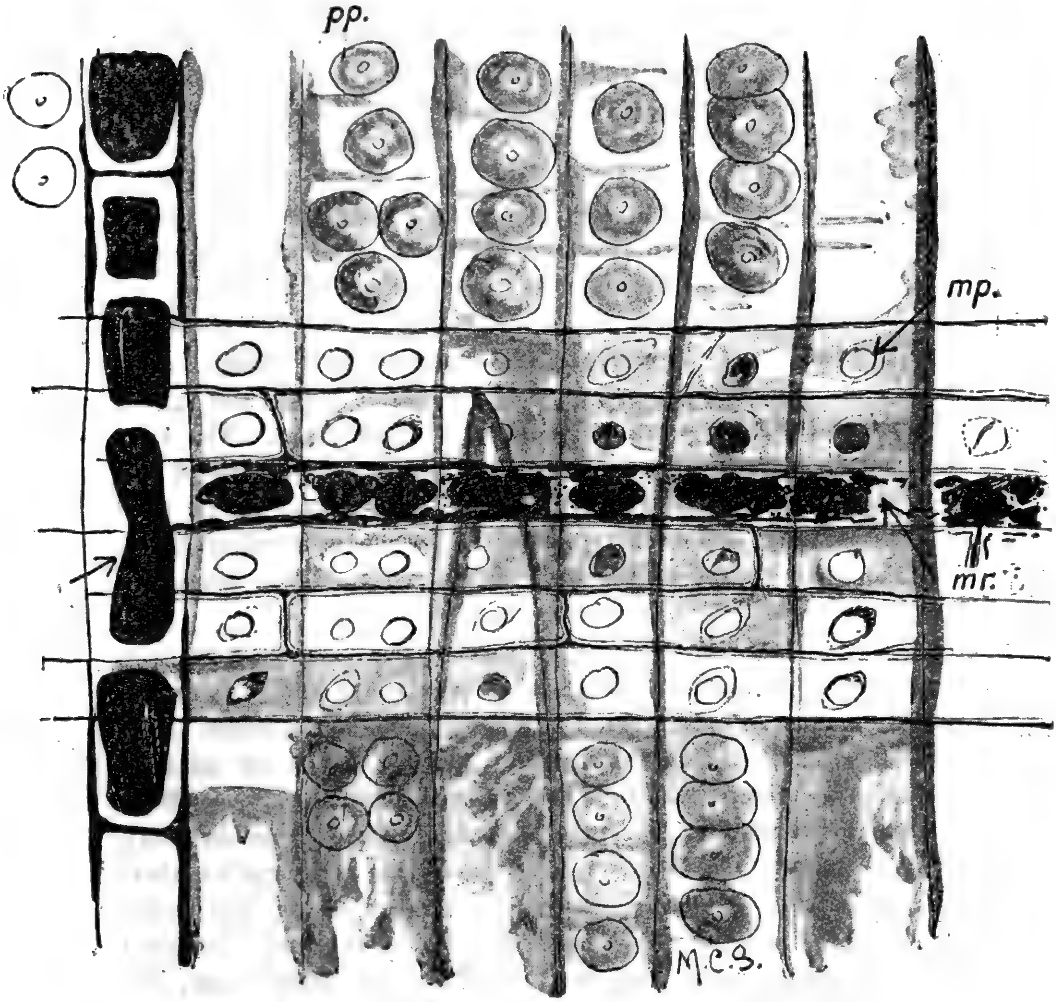
Description.—The type-specimens are two blocks from the same locality, both wedges of secondary wood. One is about

$3 \times 1{\cdot}5 \times 10$ cm. in size, silicified in a dark brown matrix and water-worn at one end, and the other is a wedge $3 \times 2 \times 8$ cm., silicified in a close hard matrix, partly white and partly orange in colour. The two specimens undoubtedly belong to the same species, but slight differences, probably in the time and mode of entry of the petrifying medium have resulted in differing details being best shown in each. In addition to the type-specimens there are several other pieces of trunks and branches collected at various times. An interesting specimen is a largish branch



Text-fig. 60.—*Podocarpoxylon woburnense*, sp. nov. Transverse section of small part of secondary wood, showing: *m.*, medullary ray; *rp.*, resin-parenchyma; *rp.*², resin-parenchyma element stretching across two tracheid-widths; *rt.*, tracheid with resinous contents. No. V. 5451 *a*.

which dates probably from the original Sloane Collection (therefore collected prior to 1750). This branch is free from matrix (text-fig. 63), and shows the woody texture very well. It is about 4·5 cm. in diameter, roughly circular in cross-section, and with the centre of the stem preserved. Another large specimen ($7 \times 5 \times 30$ cm. long) is also apparently part of the original Sloane Collection, and may best be included in this species; for, though the finer details of its structure are not seen, it agrees with the other specimens so far as it is preserved. Other more or less well-preserved portions of wood are also included in the species.



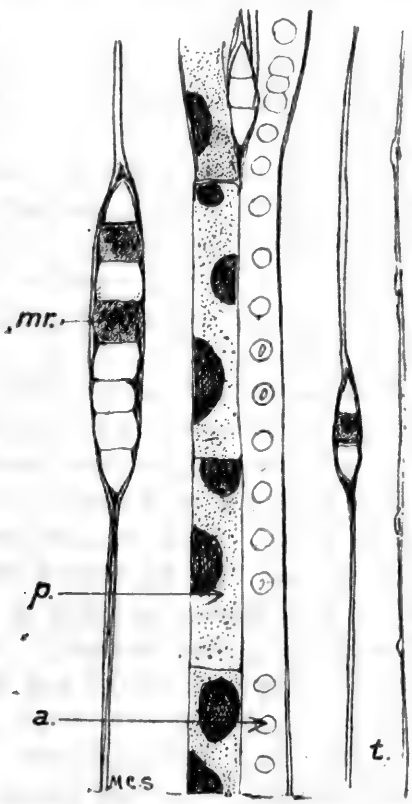
Text-fig. 61.—*Podocarpoxylon woburnense*, sp. nov. Radial section showing medullary ray-cells with single large pits in each tracheid-field, *mp.*; resin-containing element in ray, *mr.*; and resin-parenchyma, *rp.* *pp.*, tracheid with bordered pits in pairs. No. V. 5456 *c.*

Topography of the Stem.—*Secondary wood* alone is present in the type-specimen. In this the growth-rings are sharply differentiated (Pl. XX, fig. 1), and consist of from 12 to 66 radial series of tracheids, the maximum thickness of the rings being about 2·5 mm. In specimens V. 5431 and V. 5460 fragments of a large-celled *pith* are preserved, but are too faulty for description. In both these specimens and in V. 4876 (Pl. XX, fig. 2) the size of the tracheids in the inner wood is rather smaller than in the type, which is probably from an older trunk. The *wood* is regular in texture; many of the elements are somewhat rounded at the corners, the majority of the adjacent elements lying on alternate tangents so as to fit into each other. This is well seen in Pl. XX, fig. 1. Very few of the tracheids contain resinous contents (text-fig. 60, *rt.*). *Wood-parenchyma* cells with resinous contents are very numerous, and are scattered all through the growth-rings of the wood.

No normal resin-canals and no traumatic canals are present.

Uniseriate *medullary rays* are numerous, principally 1 to 6 tracheids distant; in some parts of the wood the great majority of the rays are only one tracheid distant. The rays vary from 1 to about 25 cells high, the great majority of the low rays being 3 cells and of the high ones about 13–15 cells high. Among the ordinary rays, a few show a slightly biseriate character. These do not otherwise differ from the normal rays.

Details of Elements. — *Wood.* The majority of the elements of the growth-rings are of the shape and size of the summer wood (Pl. XX, fig. 1; text-fig. 60), and average about $35–55\ \mu \times 35\ \mu$. In the rather narrow zones of autumn wood, the compressed elements are about $18–20\ \mu \times 30\ \mu$, in which the wall is thicker or the same thickness as the width of the lumen. In transverse section there are large numbers of beautifully preserved, large, bordered pits in the radial walls, and in the autumn wood numerous small bordered pits are seen in the tangential walls. In radial view, the majority of the elements have round bordered pits in single rows (text-fig. 61); these are sometimes almost contiguous, and sometimes at some distance from each other. The outline of the border is often far from a perfect round, and may have irregularity not due to crushing. In some elements the pits lie in pairs (text-fig. 61, *pp.*). In longitudinal tangential section, the pits are small and round and numerous (text-fig. 62, *a.*). "Sanio's rims" are more or less well preserved in a number of the tracheids, the pores of the pits are circular (text-fig. 61). In a few cases the tracheid-lumen is filled with blackish contents which may be resin, but there are no specialised resin-tracheids. *Wood-parenchyma containing resin* is a noticeable feature of the wood (Pl. XX, fig. 1, *r.p.*; text-figs. 60, 61, & 62). The elements are thin-walled, the same size as the tracheids tangentially, but as a rule narrower than the tracheids in a radial direction. In a few cases they



Text-fig. 62.—*Podocarpoxylon woburnense*, sp. nov. Tangential section of the wood showing the medullary rays, with some resin-containing cells, *mr.*; *t.*, tracheids with radial pitting; *a.*, autumn tracheids with small pits on tangential walls; *p.*, xylem-parenchyma with resinous contents. No. 5456 *b.*

are tangentially the size of two tracheids, and are then very conspicuous in longitudinal section. The vertical height of these cells varies greatly; the transverse walls are at right angles to the vertical walls. *Resin-canals* are absent.

The elements comprising the *medullary rays* appear to be all of one kind as regards their walls and pitting. Some of the bands of elements seem to contain a much larger quantity of resin than the others (text-figs. 61 & 62, *mr.*). In radial extension a single ray-cell corresponds to from two to six tracheids; the end-walls are slightly sloping or curved. I have been unable to detect any specialised thickening or "abietinean pitting" on the walls. In the lateral walls adjacent to the tracheids are single, rather large, roundish or slightly oval pits (text-fig. 61, *mp.*). In a few cases there are two such pits in a tracheid-field. In a few of the pits there is a faint suggestion of a border round the pit-pore, in other cases they appear to be simple pits.

Affinities.—The number of fossil woods described as *Podocarpoxylon* is small, and of these there are perhaps only two, *P. aparenchymatosum*, Gothan (1908 A), and *P. Schwendæ*, Kubart (1911), with which direct comparison need be attempted. Of these, Gothan's Antarctic species is, as is indicated in its specific name, devoid of wood-parenchyma, and therefore differs noticeably, though not fundamentally, from our fossil, in which the resin-containing xylem-parenchyma is a marked feature: in the Antarctic fossil also the radial section is not well enough preserved to show the pitting very sharply. Though the two fossils are generically allied, there does not seem any close affinity between the species. On the other hand, between the new English fossil and *P. Schwendæ*, which is well preserved and illustrated, there is a very close similarity. In the tracheid-pitting the two fossils agree completely; and in the pitting of the radial walls of the rays, partly with simple pits and partly with bordered pits, there is a close similarity. In our fossil, however, there seems always to be only one pit or two placed laterally per tracheid-field, while in the Austrian fossil there may be two or three pits vertically above each other. The Austrian fossil resembles ours also in having a considerable quantity of xylem-parenchyma.

I think there is little doubt that, of described fossils, *P. woburnense* comes nearer to *P. Schwendæ* than to any other. The Austrian fossil is, however, of uncertain geological age, being most probably either Tertiary or Flysch; its extreme limit of possible age is probably the Uppermost Cretaceous.

The Austrian fossil has also its pith preserved containing stone-cells, which strengthen the attribution to *Podocarpus*. There is little doubt that these fossils are early members of the Podocarpaceæ.

V. 5456. Type-specimen. A small block of silicified wood, now measuring 6·5 × 2·8 × 2 cm., and a piece cut from it. The specimen consists of a straight splint of secondary wood only, without any matrix, and it shows the wood-texture very clearly in all directions. The petrifying medium is very close and hard, partly white and partly very dark brown, cutting to a rich golden colour in the sections.

V. 5456 a. Transverse section of the above. This shows several well-marked annual rings with the largish tracheids and resin-containing xylem-parenchyma, but the transverse section in the type is not nearly so well preserved as in the co-type, which is the one figured.

V. 5456 b. Figured, text-fig. 62. Tangential longitudinal section of the above, partly very well preserved. It shows the height of the medullary rays, the numerous resin-containing xylem-parenchyma and their cross-walls, and the pitting of the tangential walls of the tracheids in some places.

V. 5456 c. Figured, text-fig. 61. Longitudinal radial section, locally very well preserved and showing the pitting on the tracheids, the resin-containing xylem-parenchyma, and the resin-containing ray-cells. In some places the large pits on the radial walls of the ray-cells can be well seen.

Lower Greensand ; Woburn Sands, Bedfordshire.

Collected by H. Veasey, Esq., transferred from the Botanical Dept., 1898.

V. 5451. Co-type. A wedge-shaped and weathered splint of secondary wood, now 8·5 × 3·5 × 1·5 cm. The end is rounded and evidently waterworn before it was petrified. There is also a small second piece from which the sections have been cut. The whole is free from matrix, and shows something of the woody texture, externally considerably frayed and worn before petrifaction. Locally the preservation of the details is extremely good and, the whole matrix being darkly iron-stained, the cell-walls show up well in section.

V. 5451 a. Figured, Pl. XX, fig. 1; and text-fig. 60. Transverse section showing several annual rings. The tracheids, resin-containing xylem-parenchyma, and medullary rays with their dark and granular contents, are well preserved.

V. 5451 b. Longitudinal tangential section, somewhat oblique. In this direction this specimen is not so well preserved as the type, but all the essential details can be made out.

V. 5451 c. Longitudinal radial section; while apparently very sharp and clear, it does not show the details of the pitting so well as the type, but the pits in the tracheid and medullary ray walls can be made out here and there.

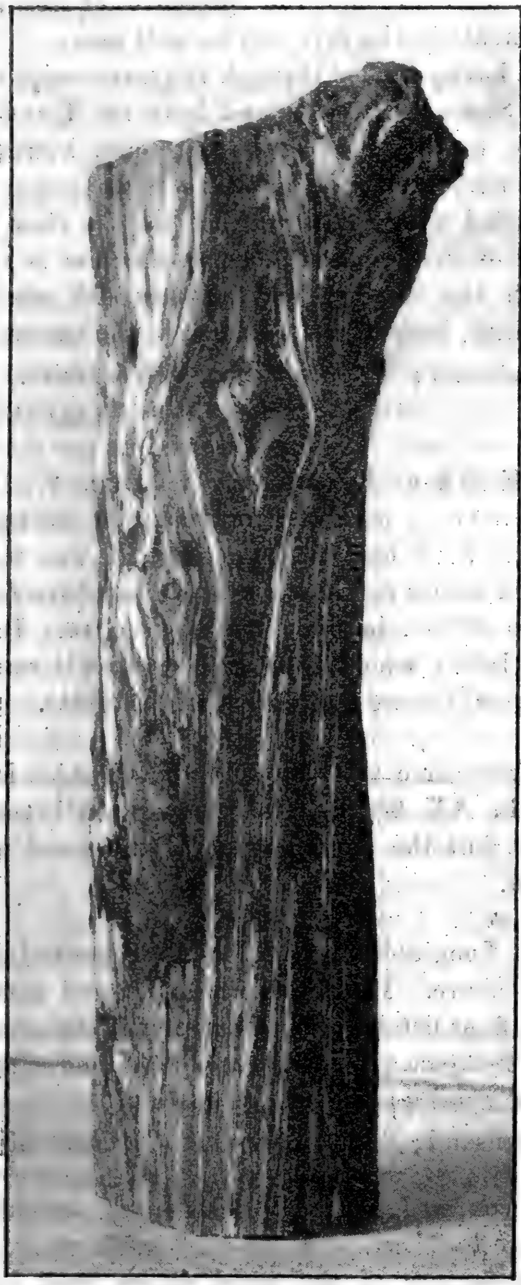
Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept., 1898.

V. 5431, V. 5431 a–d. Figured, text-fig. 63. The external view of this specimen is shown in text-fig. 63. The diameter of the stem is about 4·5 × 4 cm., but though the texture of the specimen is hard and close, there are large gaps in the petrified tissue.

V. 5431 a, b. Transverse sections of the above. The pith-cells are partially represented, as is the primary wood, but both are very poorly preserved. In the rings of secondary wood, parts are well preserved and show the wood-parenchyma very clearly. V. 5431 *b* is a second and poorer transverse section of the same.

V. 5431 c. Radial longitudinal section of above. The pitting of the elements can just be made out in a few places.



Text-fig. 63.—*Podocarpoxylon woburnense*, sp. nov. External view of specimen of woody branch, about $\frac{2}{3}$ natural size. No. V. 5431.

V. 5431 d. Tangential section of the above. In this the height of the rays and the presence of resin-containing elements in the rays can be well seen.

I have searched through the manuscript catalogue of the Sloane Collection and have not found any reference to the specimen; there are, however, several different series of numbers and several specimens labelled 229. The evidence for the view that this is part of the original Sloane Collection is an old label with the number and another old label with the locality, both firmly attached to the specimen.

Lower Greensand; Woburn Sands, Bedfordshire.

(?) *Sloane Coll.*, no. 229.

V. 4876, V. 4876 a–c. Figured, Pl. XX, fig. 2. This large specimen is part of a branch, now 30 cm. long and about 7 × 5 cm. in diameter. It was fully decorticated before petrifaction, and must have been not less than 20 cm. in diameter when alive. It bears two old labels, which seem to prove that it was one of the original Sloane Collection (see V. 5431).

V. 4876 a. Transverse section of the above, which is illustrated in Pl. XX, fig. 2. The preservation is rather imperfect, but the annual rings of the wood can be well seen.

V. 4876 b, c. Longitudinal radial and tangential sections of the above. Preservation is poor and does not show the finer details. The character of the rays and resin-parenchyma can just be made out, and agree with the type-species so far as can be seen.

Lower Greensand; Woburn Sands. (?) *Sloane Coll.*, no. 643.

V. 5446. Two wedge-shaped pieces of secondary wood, 3·5 × 2 × 7 cm. and 2·5 × 1·5 × 5·5 cm. Externally the texture of the wood shows well in the hard silicified medium. The specimens are somewhat iron-stained, as is usual from the Woburn beds.

V. 5446 a. Transverse section of the above. The tissue is very imperfectly petrified. So far as it goes the specimen agrees with the others described for this species, though its identification is a little uncertain, as it was so poorly petrified that it was not thought worth while to have longitudinal sections cut.

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept.

V. 5460. A small knotted branch 15 cms. long and of irregular diameter. At the straight end, from which the sections are cut, the stem is $1{\cdot}8 \times 1{\cdot}5$ cm. in diameter. Externally the decorticated axis shows the woody fibre and several "knots" and the bases of branches. The silicified medium is locally iron-stained in the sections.

V. 5460 a, b. Transverse sections of the above. The pith-cells are very incompletely preserved. The primary wood lies in large shallow bundles, which are not very well preserved and are further obscured by black mineral granules. The rings of secondary wood are locally well preserved, and show definite, though narrow, zones of autumn wood. All through both spring and autumn wood, large resin-containing xylem-parenchyma cells are very conspicuous. The medullary ray-cells are also large and well preserved (*cf.* text-fig. 60).

V. 5460 c. Radial section of the above. Locally this is very well preserved, and large numbers of the ray-cells show the pittings of their radial walls. In the great majority the pits are large roundish pits, one per tracheid-field (*cf.* text-fig. 61), in other cases there are two large pits per tracheid-field, one above the other. The resin-containing xylem-parenchyma is conspicuous, with rectangular transverse walls. In general, the radial section agrees with that figured for the type (text-fig. 61).

V. 5460 d. Oblique tangential section of above. The tangential view of the rays can just be seen, but most of the section shows the radial view of the tissues.

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept.

V. 5450. A small specimen of decorticated branch, 3 × 2·5 cm. in diameter and 6 cm. long. The stem is very similar to the above in preservation.

V. 5450 a. Transverse section of the same. The section is poor and the preservation of the fossil very faulty. So far as observable, it seems entirely to agree with the above specimen.

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept.

V. 5455. A small part of a very small branchlet or twig, too imperfectly preserved for certain determination, but perhaps of this species. The type-specimen is part of a much older axis, so cannot well be compared. This small branch measures 1 cm. in diameter and contains a central pith. After cutting the sections only about half a centimetre of the specimen remains. The wood is decorticated, and externally shows the woody texture. The tissues are poorly preserved in an almost colourless silicified medium, here and there very small streaks of iron-stain make the details show up a little more clearly.

V. 5455 a. Transverse section of the above. The pith is 1·5 mm. in diameter, and a few of the large irregular cells are clearly preserved, the majority are much macerated. Primary wood in several bundles round the pith is preserved in a shadowy vague form. A number of regular rings of secondary wood are faintly preserved, these showing a well-marked differentiation of spring and autumn wood. Resin-containing xylem-parenchyma is scattered through the wood. Passing out through the secondary wood is a large leaf-trace. This is coloured by a streak of iron-stain and shows up better than the rest of the tissues, and in it the spiral and fine scalariform elements can be clearly recognised.

V. 5455 b. Radial longitudinal section of above. Very little of the tissue is well preserved. The resin-parenchyma can be recognised, however, and here and there the round, isolated, bordered pits in the tracheids and the medullary rays. The observable details agree entirely with the radial section seen in text-fig. 61.

V. 5455 c, d. Tangential longitudinal sections of the above In *d* the outgoing leaf-trace can be well seen.

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept.

V. 5447. An irregular wedge of secondary wood, measuring $3 \times 2 \times 6$ cm., doubtfully referable to *P. woburnense.* In longitudinal sections, nothing can be made out except the fact that the tracheid-pits are large, round, and isolated. The transverse section, however, agrees very closely with the type. Externally it shows the woody texture, and is petrified in a whitish silicified medium, locally iron-stained.

V. 5447 a. Transverse section of the above, in general very poorly preserved, but locally, where it is iron-stained, the tissue is clearly seen. The medullary rays are conspicuous, and interspersed among the large tracheids are numerous resin-containing xylem-parenchyma cells (*cf.* text-fig. 60).

V. 5447 b, c. Longitudinal sections, both extremely poorly preserved.

Lower Greensand; Woburn Sands.

Transferred from the Botanical Dept.

Podocarpoxylon bedfordense, sp. nov.

[Plate XXI; text-fig. 64.]

Diagnosis.—Podocarpoid wood with well-marked growth-rings, but with a very narrow zone of autumn wood. Species founded on an axis not less than 8 cm. in diameter, and perhaps more.

Tracheids small, up to about 28 μ in diameter, even the spring elements rather thick-walled and very much rounded off at the corners, leaving considerable intercellular spaces between the tracheids. Bordered pits in one row, nearly circular but slightly flattened where they are adjacent in short chains of three to a dozen disposed in the thicker parts of the tracheids, which appear to be locally wider and more constricted in different regions. Wood-parenchyma is scattered through the wood. Medullary rays all uniseriate, chiefly 2–4, up to 8 tracheids distant, principally low, *i. e.* 2–4 cells high. Ray-cells uniform, walls thickened but smooth, abietinean pitting absent, end-walls at an angle. Single large pits per tracheid-field, with wide-open oval pores placed at an angle, and with nearly round wide borders.

Horizon.—Woburn Sands, Lower Greensand.

Locality.—Woburn, Bedfordshire.

Type.—An axis, which may be the core of a larger trunk, no. V. 13191, and slides V. 13191 *a–d* cut from it in 1912; British Museum (Nat. Hist.).

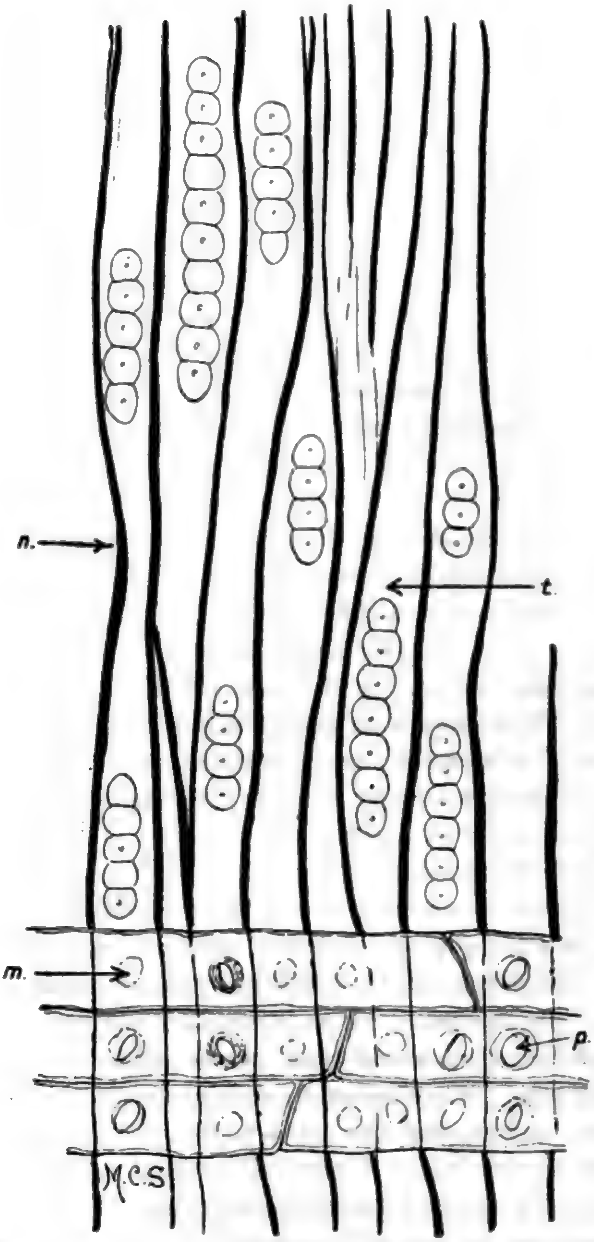
Description.—The specimen at present measures 6 × 3 cm. in diameter and is 13 cm. long. It is irregularly split, and may be the core of a large trunk or may be a smaller branch; in any case, it could not be less than 8 cm. in diameter when alive, as is indicated by the present position of the centre of the stem. Externally the specimen is free of matrix, and shows the partly weathered and partly freshly broken texture of the secondary wood split in various directions. The wood is evidently drift wood and has several teredo-borings. The petrifying medium is close and hard, externally weathered to a whitish cream, and internally a rich brown colour. The preservation is locally very good, though the pith and primary wood are obliterated.

Topography of the Stem.—*Secondary wood* only is preserved, the pith and primary wood at the centre of the axis being entirely decayed. Over 30 growth-rings are preserved, but are not very sharply marked in the texture of the wood, as there are only 3 or 4 rows of autumn elements the walls of which are not greatly thickened, and even the last row of autumn wood does not show any great radial compression. In transverse section the rings show well (Pl. XXI, fig. 1) because of the accumulations of blackened and carbonised granules in the first-formed spring wood. The *wood* is uniformly small-celled, the elements being considerably rounded off and lying on alternate tangents so as to fit into each other. Resin-parenchyma is scattered all through the wood. *Resin-canals* are entirely absent.

The *medullary rays* are numerous, entirely *uniseriate*, about 1–8, chiefly 2–4, tracheids distant. Vertically the rays are low, from 1–10 cells in height, principally 2–4 cells high. The cells of the rays are all of one kind.

Details of Elements.—The great majority of the *tracheids* are of the size and character of the spring elements, and average $15 \times 20\ \mu$ to $20 \times 28\ \mu$ in diameter. Even in the spring wood the walls are rather thick, and are so much rounded off at the corners as often to be true circles, and in the majority of cases, therefore, there are six small intercellular spaces round each tracheid separating it from its neighbours. In transverse section bordered pits are frequently to be seen on the radial walls, and in the autumn wood also in the tangential walls. The bordered pits are in one row in the radial walls, and are nearly circular, but are a little flattened top and bottom where they are adjacent to their neighbours, and lie in close rows (Pl. XXI, fig. 3; text-fig. 64, *t.*). These groups or chains of pits number from 3 to 10 or more, and lie, as a rule, in the thicker parts of the tracheids, which are themselves rather peculiar, alternately increasing and decreasing in thickness (in text-fig. 64 at *n.* is a thin part of a tracheid, and in the thicker part above and below it are chains of pits). In the narrower zones of the tracheid-length the walls appear to be without pits. Isolated pits are very uncommon in this wood, practically all the elements having chains of adjacent pits such as are figured. "Rims of Sanio" are consequently not visible, and the wood would therefore be put in the Araucarineæ by some authors. *Wood-parenchyma* containing resin is scattered through the xylem, and the cross-walls are horizontal, with a very slight constriction of the cell-lumen. *Resin-canals* and specialised resin-tracheids seem to be entirely absent.

In transverse section of the *medullary rays* the tangential diameter of the ray-cells equals or is less than that of the adjacent tracheids. In radial extension the ray equals about 2–6 tracheids. The vertical height of the individual ray-cells may be as great as, or once and a half as great as, the width of the adjacent tracheids (text-fig. 64, *m.*). The pits in the radial



Text-fig. 64.—*Podocarpoxylon bedfordense*, sp. nov. Radial section showing the groups of adjacent pits on the thicker parts of the tracheids, *t.*, which are irregular in bore; the medullary ray pits, *m.*, mostly with rather indefinite outline, and a few, *p.*, with definite podocarpoid border; *n.*, narrow part of tracheid. No. V. 13191 *d.*

walls of the ray-cells are very characteristic, being single, large, oval or nearly circular pits, placed one per tracheid-field, some of which show very distinct circular borders.

AFFINITIES.—The pitting and character of the walls of the medullary rays, coupled with the other features of the wood, are so characteristic of the modern *Podocarpus* that I have no hesitation in placing the species in the genus *Podocarpoxylon*. In the irregular bore and the chains of pitting of its tracheids, however, our fossil is unlike, not only any fossil, but any living Podocarpoid plant with which I am acquainted. Series of pits adjacent or almost adjacent to each other are found in several living and fossil species (among fossils, for example, in *Brachyphyllum macrocarpum*, see Jeffrey, 1906); but in all such cases the adjacent pits do not form definite chains, but merely places where locally the pits, elsewhere isolated, are more closely crowded.

Owing, doubtless, to their arrangement, the rims of Sanio are not seen in this fossil—a point which certain botanists would at one time have taken to be proof of Araucarian affinity (*e.g.* Holden, 1913 B). On other grounds there are reasons to anticipate an ancestral relationship between the Podocarpineæ and Araucarineæ; whether the pitting of the tracheids of this early Podocarpoid form is an indication of it, is open to discussion.

V. 13191. Type-specimen. Decorticated splint of wood from the core of a woody branch or trunk. Present diameter 6 × 3 cm. and 13 cm. length. The position of the centre of the stem indicates that it must have had a minimum diameter of 8 cm. when alive. The wood is free from matrix, and shows the woody texture very well in various directions; there are a few teredo-borings.

V. 13191 a. Figured, Pl. XXI, fig. 1. Transverse section of the above, somewhat broken in cutting. The position of the pith and primary wood is clear, but both are entirely decayed. Growth-rings can be clearly seen, particularly with the low power. The tracheids, medullary ray-cells, and xylem-parenchyma are all well preserved.

V. 13191 b. Tangential longitudinal section of the above, partly oblique to show rays in radial section; both in the rays and the tracheids the radial pitting can be well seen. In this section a small branch and leaf-traces can be seen coming off.

V. 13191 c. Longitudinal section, partly obliquely radial and partly tangential. Where it is truly tangential the rays, and also the horizontal cross-walls of the resin-parenchyma cells, can be well seen.

V. 13191 d. Figured, Pl. XXI, figs. 2 & 3; and text-fig. 64. Radial longitudinal section, showing in various parts the numerous low medullary rays, the pitting in their radial walls and in their tracheid-walls; also the numerous resin-containing xylem-parenchyma cells. The wavy outline of the tracheids and their groups of adjacent pits can be seen in this section and also in V. 13191 *b*.

Lower Greensand; Woburn Sands, Bedfordshire.

Presented by W. G. Smith, Esq.

Podocarpoxylon Gothani, sp. nov.

[Text-figs. 65 & 66.]

Diagnosis.—Species founded on a small decorticated branch, 2·5 cm. in diameter, with pith. Coniferous wood without resin-canals and with a very small amount of resin-containing xylem-parenchyma, of which the principal feature is the pitting in the radial walls of the medullary ray-cells, where very large, oval, obliquely placed pits are placed one per tracheid-field. In secondary wood the growth-rings are well-marked, very irregular, a few partly composite. Tracheids rather variable, up to about 40 μ in diameter; bordered pits round, isolated, in one row, nearly as large in diameter as the tracheid-walls in which they lie. Medullary rays all uniseriate, principally from 6–9 tracheids distant, low, principally 2–4 cells high. Cells all alike, walls smooth, thickened, but without abietinean pitting. Ray-pits large, oval, solitary or in pairs per tracheid-field, without borders. Primary wood all centrifugal, protoxylem-groups large, elements spiral and scalariform. In one pith, large, very thick-walled stone-cells are mingled with the ground-tissue.

Horizon.—Lower Greensand.

Locality.—Luccomb Chine, I. of Wight.

Type.—Small decorticated branch, no. V. 13194 and slides V. 13194 *a–c* cut from it; British Museum (Nat. Hist.), and slides SE *a–c* Stopes Coll.

Finder.—M. C. Stopes, 1912.

Description.—The species is founded on a specimen of a branch, 2·5 cm. in diameter, which is well petrified in a dark brown silicified medium. The specimen is embedded in the coarse granular matrix characteristic of the Luccomb Chine deposit.

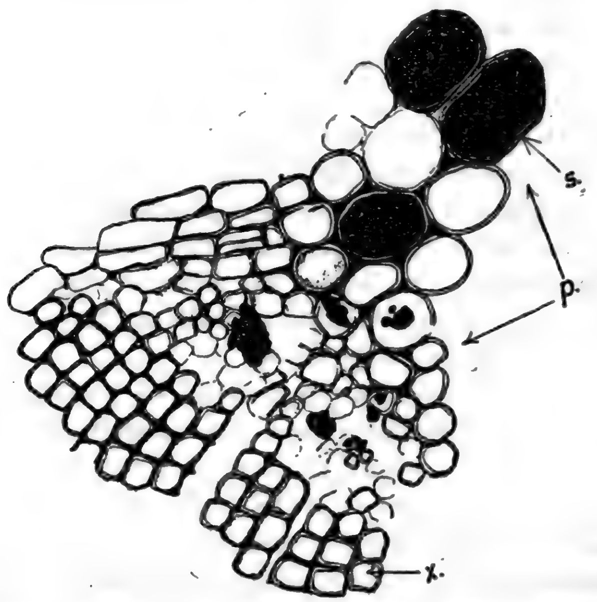
Topography of the Stem.—Growth-rings are well marked and very variable in thickness, a few being composite.

The *pith* is about ·6 mm. in diameter, circular, with five main projections due to the grouping of the bundles of primary wood in five main groups. The cells of the pith are rounded, and all are thick-walled; among the ordinary cells are large, excessively thickened stone-cells (text-fig. 65, *s.*).

The *primary wood* forms small groups, the protoxylems seem endarch, and no centripetal xylem has been recognised. The *secondary wood* forms normal rings of solid wood, in which the *growth-rings* tend to be composite. The wood-elements are small, rounded at the corners, and adjacent elements lie on alternating tangents, so as to fit into each other. *Wood-parenchyma* containing resin does occur, though it is very scanty. In transverse section the large number of dark elements in the wood are due to carbonised granules, scattered irrespective of arrangement, through the tracheids. In radial sections the number of elements showing transverse walls, and thus proving themselves to be parenchyma, is very small, which is characteristic of plants of *Phyllocladus*-affinity, where it may be absent altogether (see Gothan, 1908 A & 1907). *Resin-canals* are absent.

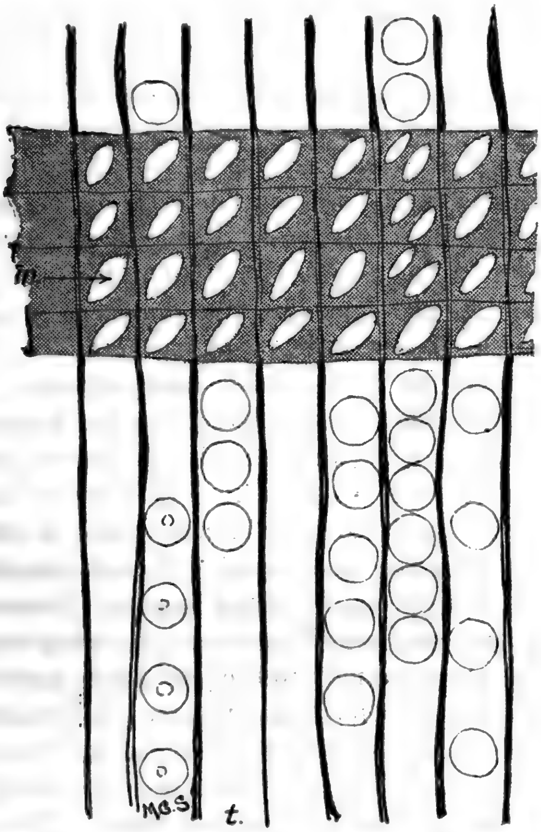
Medullary rays are all *uniseriate*, from 2–16 tracheids distant, the commonest being from 6–9 tracheids distant. They are low, from 1–10 cells high, the greater number being 2–4 cells high. The cells composing the rays are of one kind and have somewhat thickened walls.

Details of Elements.—The *pith* is composed of rounded thick-walled cells, the size of these cells increasing towards the centre, reaching about 100 μ in diameter. In vertical direction they are not much elongated. The cell-walls are all thickened and pitted, and between the rounded elements lie triangular intercellular spaces. Among these are a few short elements of large size with excessively thickened walls (*s.*, text-fig. 65). These stone-cells have no definite arrangement, and lie so that three or four appear in each transverse section. They are not vertically elongated.



Text-fig. 65.—*Podocarpoxylon Gothani*, sp. nov. Transverse section of a small part of the centre of the stem. *p*, pith-cells, among which are *s.*, the stone-cells; *x.*, xylem. No. V. 13194*a*.

The *primary wood* forms small, rather irregular bundles, not very well preserved in transverse section. In longitudinal section a few of the spiral protoxylems are to be seen. No centripetal wood can be recognised. The *secondary wood* consists of tracheids rather variable in size, the average of the larger element being 25–35 $\mu \times 40$ μ in diameter. The narrowest autumn tracheids measure about 10 $\mu \times 22$ μ; they do not have very excessively thickened walls. The pits on the radial walls of the tracheids are almost all in one row, a few only are in irregular pairs. These pits may lie very close together, or separated by as much as 2–3 times the width of their own borders. The diameter of the border of the pit is nearly as great as the tracheid-wall in which it lies (text-fig. 66). *Wood-parenchyma* containing resin is very sparsely scattered through



Text-fig. 66.—*Podocarpoxylon Gothani*, sp. nov. Radial section showing the tracheids, *t.*, with their round-bordered pits, and the medullary ray-cells, *m.*, with single large oval pits per tracheid-field. No. V. 13194 *b*.

the wood. A few elements in the radial sections show the transverse walls, which slightly constrict the lumen.

The tangential diameter of the cells of the *medullary rays* in transverse section may be equal to the adjacent tracheids, but in most cases is rather less. In radial extension a ray-cell seems to correspond to about 5 or 6 tracheids, but not very many of the end-walls are well enough preserved to make this clear. The cells appear all alike, and their vertical height about equals the diameter of the tracheids they cross (text-fig. 66). The pits in the radial walls are very large oval pits, lying obliquely one in each tracheid-field. In a few cases a couple of pits lie together, but the great majority have the single large pit (text-fig. 66, *m.*). The end-walls of the ray-cells are unfortunately not preserved in radial section.

Affinities.—I do not know of any described species of *Podocarpoxylon* with which this can directly be compared. The few species of the genus which have been described do not show their piths and protoxylems (with the exception of *P. Schwendæ*, in which the pith is preserved), nor in their wood-structure are any of them so sharply differentiated as to be conclusively comparable with the present fossil. The antarctic wood described by Gothan (1908 a) as *Phyllocladoxylon antarcticum* has large single pits per tracheid-field rather rounder, but otherwise very similar to the pits in our fossil. Judging from his illustrations alone, the preservation of his fossil does not seem to be very good, and it is possible that the large pits are somewhat eaten out, as their limits are not well defined. In his specimen xylem-parenchyma is said to be absent. Furthermore, his specimen is Tertiary, and these various differences make it unlikely that we are dealing with the same species, though possibly the two fossils may represent closely allied species. Reasons for not using Gothan's generic name *Phyllocladoxylon* are given on p. 210, and apply even more strongly to the use of the generic name of the living *Phyllocladus* for fossil woods. A Pliocene fossil is described and figured by Schenk (1890 a, fig. 424) under the name *Phyllocladus Mulleri*, in which the ray-pitting is almost the same as that in the new English fossil. This specimen, however, is of very recent date, and being from the Southern Hemisphere (New Zealand), in which *Phyllocladus* is still native, his identification may be justifiable.

Gothan (1907) describes a wood from König Karl's Land as *Phyllocladoxylon* sp. The medullary rays and their pitting, however, do not appear to be sharply preserved. It has no xylem-parenchyma. If Gothan's identification is correct, and if his wood is really of Jurassic age, his specimen is possibly in direct ancestral relationship with our Lower Greensand form.

Among the earlier-described woods, that recorded by Cramer (1868) from Banksland as *Cupressinoxylon pulchrum* is rather suggestive of our fossil in its ray-pitting, though the majority of the pits seem to be in pairs per tracheid-field.

In its possession of pith and protoxylem our fossil differs from these described species, and, as our branch is evidently a young one or the core only of an older branch, comparison with the other fossils, which are probably older trunks, is all the more difficult. So far as preserved, the pith, with its large stone-cells, supports the conclusion that the fossil is a member of the Podocarpaceæ, in which family idioblasts and various kinds of stone-cells are prevalent in the pith.

In conclusion, while I place the fossil in the broad "genus" *Podocarpoxylon*, the very characteristic pitting of the ray-cells is highly suggestive of the living *Phyllocladus*, with which it is not impossible that the fossil had true affinity, notwithstanding the fact that the living genus is now confined to the Southern Hemisphere.

I name the species after Dr. Gothan of Berlin, in recognition of the service his researches in fossil wood-structures have done to Palæobotany.

V. 13194. Type-specimen. A small branch, now 2·5 cm. in diameter, showing the centre of the stem and a number of annual rings of wood. The specimen is decorticated and completely embedded in the coarse granular matrix of the Lower Greensand. The portion of the branch now remaining is 6 cm. long, with some pieces from which sections have been cut.

V. 13194 a. Figured, text-fig. 65. Transverse section of the above, showing well-preserved pith with stone-cells, slightly broken protoxylems, and a number of rings of secondary wood. These are extremely variable in thickness, and are partly "composite," the zones of tissue being very well preserved.

V. 13194 b. Figured, text-fig. 66. Longitudinal radial section of the above, showing zones of wood. The pitting of the tracheids, the medullary rays, and the resin-containing xylem-parenchyma can all be well seen. Locally the pitting of the medullary ray-cells is very conspicuous and well preserved (text-fig. 66).

V. 13194 c. Tangential longitudinal section of the above. This shows well the height and frequency of the medullary rays and also cuts across a small outgoing branch.

Lower Greensand; Luccomb Chine, Isle of Wight.

Found and presented by Dr. M. C. Stopes, 1912.

The following species does not come strictly within the diagnosis of *Podocarpoxylon*, but the curious pith suggests a Podocarpoid affinity, which does not conflict with any of the details preserved in the wood :—

[?] **Podocarpoxylon Solmsi,** sp. nov.

[Plate XXII; text-figs. 67, 68, 69, 70.]

Diagnosis.—Coniferous wood of a branch more than 20 years old, and 4 cm. in diameter, without normal resin-canals, and with much resin-containing xylem-parenchyma. The most characteristic feature is the pith. In this are three kinds of cells :—(*a*) Ground-tissue cells with slightly thickened walls, squarish or oblong outline in longitudinal section, and with granular contents; (*b*) much larger, thin-walled, and nearly empty cells; (*c*) extremely thickened stone-cells. The stone-cells and large specialised cells tend to form chains running longitudinally among the ordinary cells, fairly regularly arranged so that one large cell alternates with a couple of stone-cells. Protoxylems in primary bundles, spiral, and scalariform. Secondary tracheids up to $55 \times 45\ \mu$ in diameter, round bordered pits principally in one row, the border about $\frac{1}{2}$ the diameter of the tracheid-wall in which it lies. Growth-rings well marked, narrow zone of autumn wood, a few of the outer rings partly "composite." Wood-parenchyma containing resin scattered all through the wood-rings, cross-walls horizontal with very slight constriction. Medullary rays all uniseriate, rather inconspicuous, principally low. Ray-cells uniform, walls thickened but smooth, abietinean pitting apparently absent, end-walls curved and at an angle. Radial pitting of the rays not preserved.

Horizon.—Lower Greensand.

Locality.—Luccomb Chine, at the foot of the gorge.

Type.—Small branch, not less than 4 cm. in diameter and more than 20 years old, with pith and primary wood, no. V. 2117 and slides V. 2117 *a* to *h* cut from it in 1912; British Museum (Nat. Hist.).

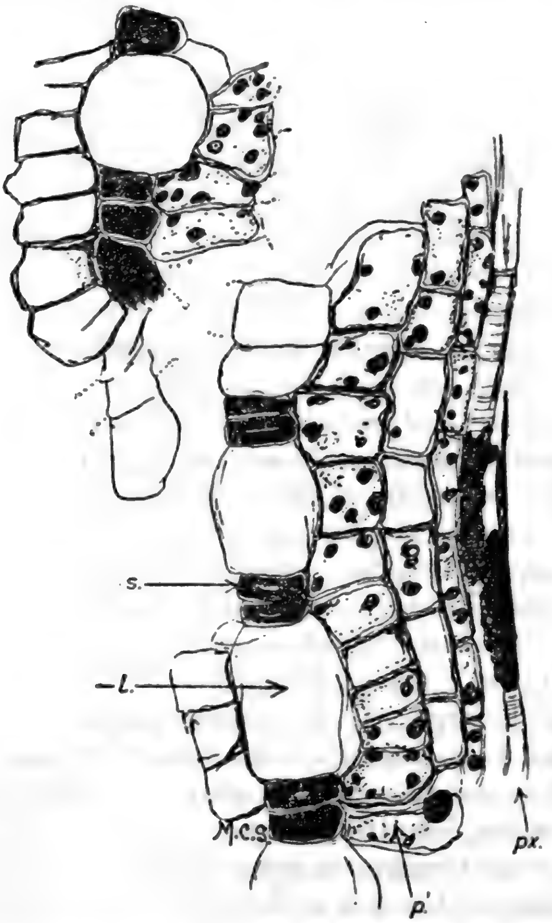
Finder.—Count Solms-Laubach, August 1889.

Description.—The type-specimen is of special interest, as it is one of the pieces of wood mentioned by Count Solms-Laubach (1890) as having been found *in situ* by himself when he visited the locality of the famous *Bennettites Gibsonianus*. He speaks of finding sandy concretions *in situ* and says: "Zerschlägt man diese Concretionen, so findet man gewöhnlich inmitten derselben ein Fragment fossilen Coniferenholzes von guter Erhaltung, mitunter äusserlich nur von dünner Gesteinskruste überzogen."

The particular specimen in the Museum now described is 4 cm. in diameter and embedded in the characteristic granular matrix. Sections were cut from it in 1912, when its beautiful preservation, especially of the pith and primary wood, was apparent. Round the pith and protoxylems are at least 20 annual rings of secondary wood, which are locally very well preserved and show sharply marked seasonal growth.

A second specimen, which appears to belong to the same species, is V. 5427, though in one or two trifles it differs somewhat from the type. It is a rather smaller axis, 3 cm. in diameter and 5 cm. long, which also retains the pith and protoxylems. Its annual rings are more feebly marked and the protoxylems less definitely grouped in bundles, otherwise there seems to be no recognisable difference between the two specimens. Owing to the lack of detail in the radial walls of the medullary rays, however, it is possible that it may really be a different species, though it is not determinable as such.

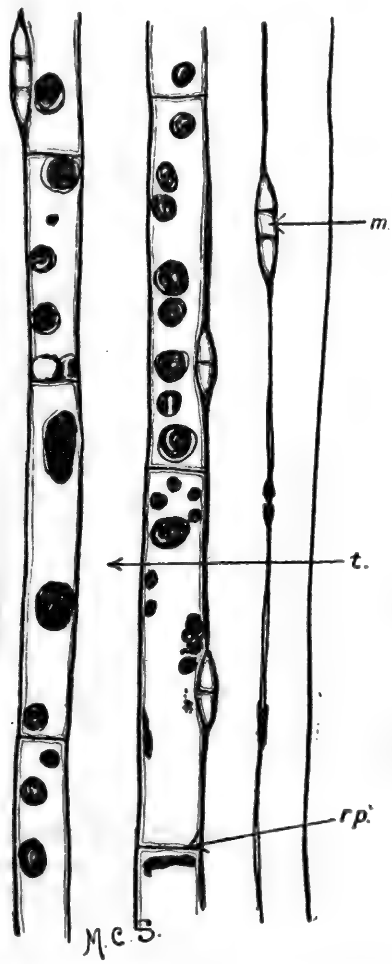
Topography of the Stem.—The *pith* is about 1 mm. in diameter, circular stellate, and surrounded by about 20 principal *primary bundles*. The pith consists of three types of cells, one of them being very much thickened stone-cells (see text-fig. 67). The *protoxylems* are extensive, but no centripetal wood appears to be present. *Growth-rings* in the *secondary wood* are very clearly marked, and have well-defined narrow zones of autumn wood. The number of elements composing each growth-ring varies from about 20 to 70 elements in radial series, the thicker rings measuring about 2 mm. in width. The number of narrow elements of autumn wood is about 3 to 8. In the outer rings of wood a few of the autumn zones are locally doubled, reminding one of the



Text-fig. 67.—*Podocarpoxylon Solmsi*, sp. nov. Longitudinal section of the pith, showing the ordinary cells, *p.*, among which are irregular chains of specialised cells. *l.*, large empty cells, alternating with, *s.*, thickened stone-cells; *px.*, the protoxylems. No. V. 2117 *d.*

"composite" rings so noticeably developed in the contemporaneous *Cupressinoxylon vectense* (see p. 169). The *wood* is uniform, and in the inner zones the individual tracheids are somewhat rounded at the corners to fit into each other, but this is much less the case in the outer rings of the wood, where the elements are rather squarer (Pl. XXII, fig. 1).

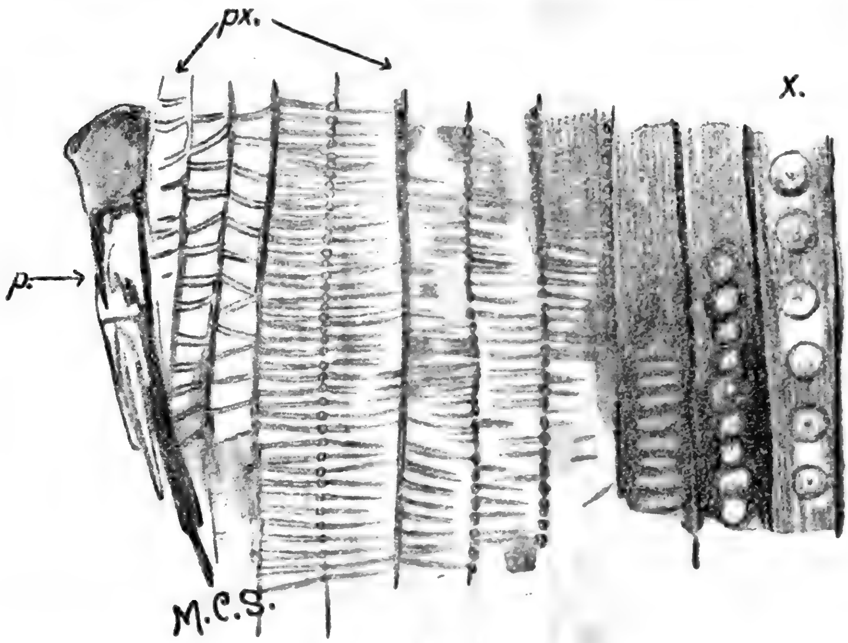
Xylem-parenchyma containing resin is thickly scattered through the whole width of the wood-rings.



Text-fig. 68.—*Podocarpoxylon Solmsi*, sp.nov. Tangential section of the wood, showing the characteristic resin-containing xylem-parenchyma, *rp.*, the tracheids, *t.*, and the low medullary rays, *m.* No. V. 2117 *h.*

Normal resin-canals are entirely absent, and in the type-specimen I have not detected any traumatic canals. In the second specimen, however, toward the outer rings, where there are several signs of wounding, there are series of traumatic canals (Pl. XXII, fig. 2) and also zones of the parenchyma and enlarged medullary ray-cells, which persist for a short distance after the canals have died out.

Medullary rays are all *uniseriate*, rather inconspicuous, and from 2 to 20 tracheids distant. They are low, the great majority being from 2 to 5 cells in height (see text-fig. 68). The cells composing the rays are all alike, with somewhat thickened walls. In the tangential section two or three small leaf-traces can be seen coming out in a medullary ray.



Text-fig. 69.—*Podocarpoxylon Solmsi*, sp. nov. Radial section, showing the primary xylem, with protoxylems, *px.*, against the pith, *p.*, and later-formed, fine, scalariform elements merging into the ordinary tracheids with bordered pits, *x.* No. V. 5427 *d.*

Details of Elements.—The *pith* is composed of three well-marked types of cells. The majority of the ground-tissue cells are circular in transverse section, increasing from small elements round the primary wood to larger central cells. All these have somewhat thickened walls and granular contents. Longitudinally they are squarish, the external cells being a little more, but not greatly, elongated (text-fig. 67, *p.*). In transverse section, scattered through the pith, are larger more irregular cells, up to $100\,\mu$ in diameter, which are generally devoid of contents. There are also roundish stone-cells with excessively thickened walls. In longitudinal section the arrangement of these is peculiar, as is shown in text-fig. 67, *s.* & *l.*; they form longitudinal chains, one of the large empty cells alternating with two or three of the stone-cells. These chains run for long distances vertically through the pith, where they form a noticeable feature in longitudinal sections (see slide V. 2117 *d*).

The *wood* round the pith forms bundles of primary xylem which is apparently all centrifugal. The quantity of the protoxylem-elements is large, and in the second specimen, where it is beautifully preserved, there are 8 or 9 spiral and narrow finely scalariform elements lying on one radius (text-fig. 69, *px.*). In the *secondary wood* the tracheids increase in size as the wood gets older. In the outer rings the average size of the spring wood is $40 \times 30\,\mu$ to $55 \times 45\,\mu$. The narrowest autumn tracheids are about 10 to $12\,\mu \times 30$ or $40\,\mu$, with a wall 4–5 μ thick.

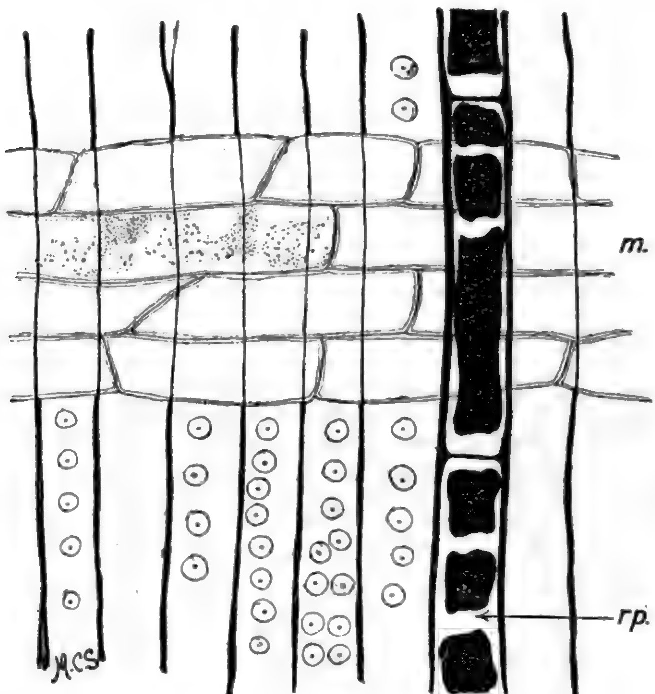
The pits on the radial walls are principally in one row, most of them being isolated from each other by a distance equal to their own border. Most of the pits are small, the diameter of the border being equal to about half that of the tracheid in which it lies. In a few cases a second row of pits lies in the radial wall (text-fig. 70). Pits are present in the tangential walls of the autumn wood.

Wood-parenchyma containing resin is scattered through the wood. The transverse walls of these cell-rows slightly constrict the lumen in the radial section (text-fig. 70, *rp.*). In the tangential section these walls are straight. The walls appear to be somewhat thickened, but I have not detected special pitting in them.

Traumatic *resin-canals* only are present, and they show no special feature; they lie in irregular tangential rows (Pl. XXII, fig. 2). In regions cut apparently above or below the endings of these canals large parenchymatous cells and enlarged cells of the medullary rays are conspicuous. None of these elements show any special pitting.

In transverse section the *medullary rays* are very inconspicuous, the cells having a tangential diameter of only $\frac{1}{2}$ to $\frac{1}{3}$

of the adjacent tracheids. In radial extension a ray-cell corresponds to about 2–6 tracheids. The cells are all alike, and all appear to have rather thickened walls, but, unfortunately, none of them are sufficiently well preserved to show their radial pitting. The cells have end-walls which slope somewhat or are slightly curved (text-fig. 70, *m.*). Though narrow tangentially, the cells are sometimes rather high vertically, as is seen in the radial section.



Text-fig. 70.—*Podocarpoxylon Solmsi*, sp. nov. Radial section of the wood, to show the small distant bordered pits, the resin-containing wood-parenchyma, *rp.*, and the outlines of the medullary ray-cells, *m.* No. V. 2117 *f.*

Affinities.—As the radial pitting of the medullary ray-cells is not petrified, it is impossible to settle conclusively the systematic position of this fossil. There are, however, many details which indicate a Podocarpoid affinity, and none which contradict this conclusion. Though there is little conclusive in a transverse section, the general appearance of the wood with its narrow zones of autumn wood and well-marked growth-rings is quite similar to *P. woburnense* (p. 211), while the pitting of the tracheids with irregularly doubled rows is like the pitting in that species and in *Podocarpus Schwendæ*. The resin-containing xylem-parenchyma and the ray-cells with their smooth walls are also like those of other species of the genus. The presence of the peculiar specialised and stone-cells in the pith, however, is distinctive, and is much more suggestive of the Podocarpaceæ than of any other family. Stone-cells in the pith occur in various species of the genera *Araucaria*, *Cryptomeria*, *Juniperus*, *Torreya*, *Dacrydium*, and *Podocarpus*, and in a few others such as isolated species of *Pinus*. Of these the type of pith in the living *Dacrydium* comes nearer than the others to the fossil, though in its peculiar and specialised chains of cells our new fossil appears to be unique.

V. 2117. Type-specimen. Part of a decorticated branch, now about 4 cm. in diameter, of which over 20 annual rings are preserved. The wood and pith are partly well petrified, though the axis is riddled with teredo-borings, the spaces of which are filled with a finer silt with only a few coarse Greensand grains in them. The stem, as a whole, is embedded entirely in the coarse granular Lower Greensand matrix. The specimen is now 10 cm. long, and there are several smaller portions of it from which sections have been cut.

V. 2117 a. Figured, Pl. XXII, fig. 1. Transverse section of the above, in which the plant-cells are locally very beautifully preserved. The pith with its various kinds of cells and the primary xylem can all be well seen.

V. 2117 b, c. Two transverse sections of the above, partly well preserved, but rather thick and much fractured in the mounting of the sections.

V. 2117 d. Figured, text-fig. 67. Median longitudinal radial section passing through pith, protoxylems, and secondary wood. The wood is much eaten out by teredo-borings, but is locally well preserved. The pith-cells show very beautifully the different specialised cell-types composing chains among the unspecialised cells (text-fig. 67), though locally the pith is broken out.

V. 2117 e. Longitudinal radial section of secondary wood just touching the pith tangentially.

V. 2117 f. Figured, text-fig. 70. Longitudinal radial section of secondary wood showing the annual growths very clearly, and also the resin-containing xylem-parenchyma, the tracheid-pits, and the outline of the medullary ray-cells.

V. 2117 g. Tangential longitudinal section, partly obliquely radial. It is not well preserved, but the resin-containing xylem-parenchyma cells show up very clearly in it.

V. 2117 h. Figured, text-fig. 68. Longitudinal section partly radial and partly tangential. It is locally very well preserved, and shows in some places small leaf-traces cut across in their exit.

Lower Greensand; Luccomb Chine, I. of Wight.

Found and presented by Count Solms-Laubach, 1889.

V. 5427. A small piece of branch 2·5 cm. in diameter, in two fragments, from one of which sections have been cut; the other is 5 cm. long with a scrap of matrix adhering. The centre of the stem is preserved with a number of rings of woody growth, but none of the outer tissues. The texture of the decorticated wood is partly visible, but the petrifying medium is neither hard nor clear, and the wood has rather the consistency of "lignite."

V. 5427 a. Transverse section of the above. Part of the pith and the primary xylem are very well preserved. In the secondary xylem the tracheids and medullary rays are well preserved, and the feebleness of the differentiation of the growth-rings is noticeable.

V. 5427 b, c. Tangential sections of the above, showing the height and frequency of the ray-cells.

V. 5427 d. Figured, text-fig. 69. Median longitudinal radial section passing through the pith, primary xylems, and secondary wood. The narrow protoxylems are very well preserved indeed, and form an unusually broad zone next the pith.

Lower Greensand; Shanklin, I. of Wight.

Presented by Prof. T. Rupert Jones, transferred from the Botanical Dept., 1898.

INCERTÆ SEDIS.

Coniferous Wood (?).

1766, 1768. Remains of a fragment of decorticated secondary wood, 10 × 5 × 4 cm. The woody tissue only remains as a structureless film on the enclosed sandstone matrix. Also a smaller specimen similar to the above. Kentish Rag; Iguanodon Quarry, Maidstone.

Presented by W. H. Bensted, Esq., 1839.

V. 8315. A small wedge of secondary wood, 4 × 2·5 × 1·5 cm. It is completely decorticated and very imperfectly petrified, so that it is friable and is tending to disintegrate. Kentish Rag; Maidstone. *Caleb Evans Coll.*

41336, 41336 A. A flat irregular fragment of decorticated, partly petrified wood, 9 × 6 × 2 cm. The texture of the wood is very "knotty," and there are a number of small bore-holes through it. Also a very small fragment of extremely badly preserved secondary wood. "Lower Greensand; Isle of Wight." *Dixon Coll.*

41338. Fragments of splintering secondary wood, simulating small twigs about 3–6 cm. long, and very imperfectly preserved. Flat mineral bands split the wood into honeycomb-like segments. Isle of Wight.

Dixon Coll.

V. 5432. The forking base of a branch, showing externally the knotted irregular woody tissue of the decorticated axis. The specimen measures 9 cm. in length, and the axis is about 3 cm. in diameter, giving off a branch equally big. The petrifying medium is locally firm, and probably part of the tissue would show well in microscopic sections. Woburn Sands.

Transferred from the Botanical Dept.

V. 5438, V. 5438 a–d. A small twig 1·5 cm. in diameter, 5·5 cm. long. The decorticated axis shows the woody texture. Sections *a–d* in transverse, radial, and tangential directions are all so badly preserved that specific identification is impossible. A few cells in the transverse section prove its coniferous nature. Among the innumerable granules scattered through all the sections, some are strongly suggestive of fungal spores. Lower Greensand; Woburn.

Transferred from the Botanical Dept.

V. 5448. Irregular wedge (10 × 5 × 3 cm.) of secondary wood, entirely decorticated and showing the woody texture. The piece is knotty and irregular in structure, probably part of a good-sized trunk. It is somewhat iron-stained, and would probably show its tissue fairly well if sections were cut from it.

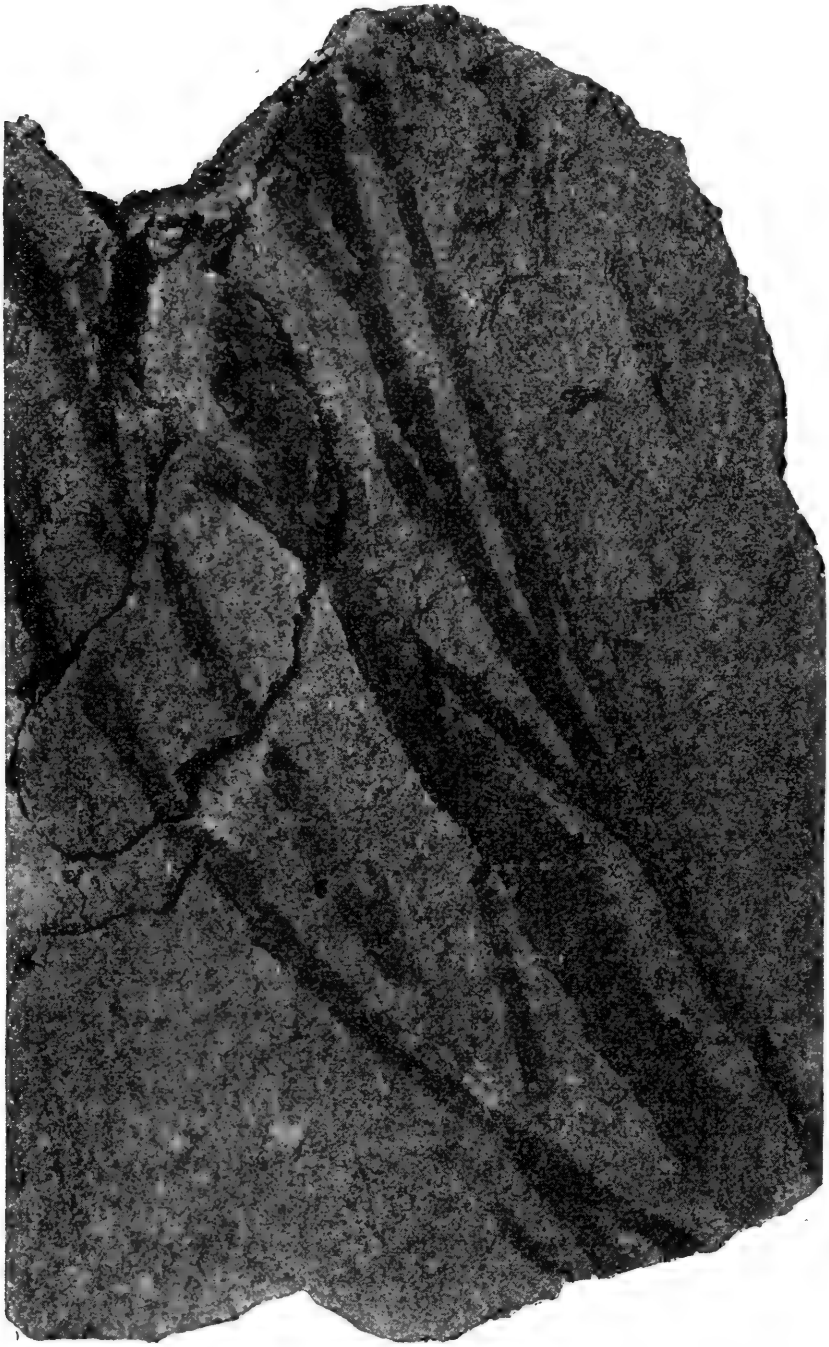
Transferred from the Botanical Dept.

V. 5458. A curved splint of teredo-bored secondary wood, 14 × 5 × 2 cm. The wood is completely decorticated, and shows the woody tissue externally. The material is somewhat iron-stained, and would probably show its tissue fairly well if sections were cut from it. Lower Greensand; Woburn.

Transferred from the Botanical Dept.

V. 5480, V. 5489. Two parts of the same specimen. Secondary wood riddled by a mass of teredo-borings, so that no woody tissue is preserved, the wood remaining only as a brown film in the sandy matrix. Kentish Rag; Iguanodon Quarry, Maidstone.

Transferred from the Botanical Dept.



Text-fig. 71.—Casts of Coniferous roots in Kentish Rag, Maidstone Museum. Photo. by Mr. H. Elgar, 1912. $\frac{7}{9}$ nat. size.

V. 6450. Small fragment, 3·5 cm. long, of secondary wood imperfectly petrified and partly embedded in the coarse sandy matrix. Kentish Rag; Maidstone.

Transferred from the Botanical Dept.

V. 8314. A small fragment, 4 × 3·5 cm., of secondary teredo-bored wood, forming a structureless film on the coarse sandy matrix. Lower Greensand (?); Folkestone.

Caleb Evans Coll.

Coniferous Roots (?).

Among the fossils which it is impossible to place with certainty, and yet which must be mentioned, are specimens like that shown in text-fig. 71.

Poorly preserved in the coarse sandy matrix of the Kentish Rag, little or no plant-tissue remains in them. All that is to be seen, as a rule, is a cast or groove deeply iron-stained by the decomposed plant-débris. Sometimes a few fragmentary tracheids can be detected in a microscopic preparation of the brown powdery surface.

The specimens are of considerable size, slabs 15 cm. or more across expose a number of laterals varying from 3 mm. to 10 mm. in diameter, which branch irregularly and interlace like the roots of an existing Coniferous tree.

INCERTÆ SEDIS.

Genus **VECTIA**, nov.

The specimen about to be described cannot be included in any known genus of fossils. The specimen consists of one kind of tissue only, so that true generic diagnosis cannot be attempted. It was found in the Isle of Wight, and consequently the name *Vectia* appears suitable as the pseudo-generic name requisite till further portions of the plant are discovered and reveal its structure sufficiently for true diagnosis.

Vectia luccombensis, sp. nov.

[Plates XXIII–XXV; text-figs. 72–75.]

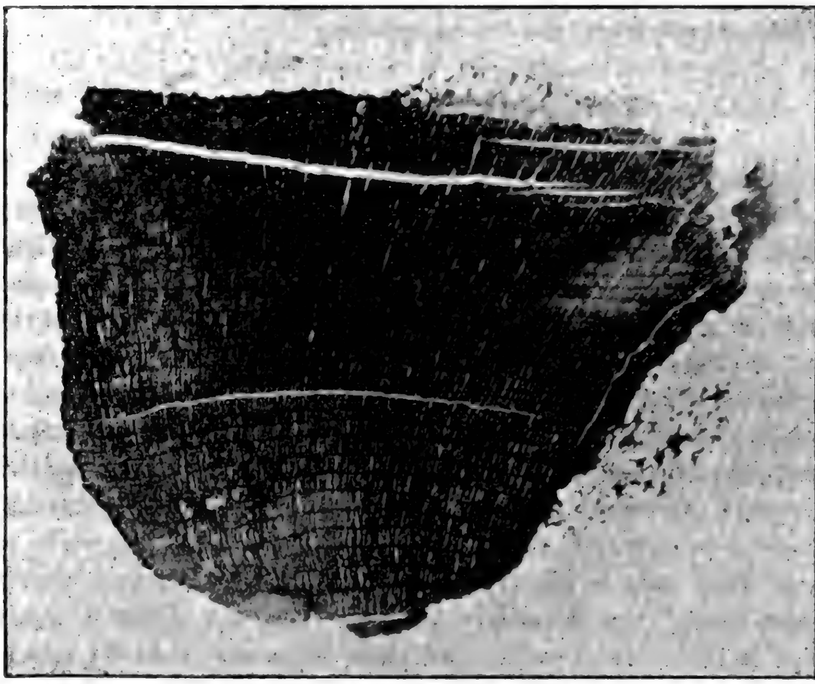
Diagnosis.—Species founded on a massive secondary tissue which appears to be phloem. The tissues are extensive, uniform, and part of a large trunk. The deceptive appearance of annual rings is obvious to the naked eye, and is really formed by narrow, regular, cork bands which do not break up the tissue; a thickness of 26 mm. and probably more, holding together uniformly and showing no limiting layer. The tissue is entirely composed of regularly alternating thick and thinner walled elements, arranged in tangential bands. The fibres average 40–50 μ in diameter, are squarish in shape, and have walls so thick that only a minute lumen is left. The thinner vessels (sieve-tubes?) are in radial pairs, with large round pits in single rows in their radial walls. Adjacent elements generally appear contiguous, but in the angle between four of the latter elements small parenchyma-cells, somewhat elongated and with straight end-walls, may occur, and in some places these are tangentially united by narrow crushed elements, which may be collapsed portions of one of the cells. Medullary rays are entirely uniseriate, the individual cells of the ray large, with nearly rectangular end-walls.

HORIZON.—Plant-band, Lower Greensand.

LOCALITY.—Luccomb Chine, Isle of Wight.

TYPE.—V. 13230 and slides V. 13230 *a, b, c* cut from it in the British Museum (Nat. Hist.), and slides SB. *a, b, c* in the Stopes Coll.; also block and slide SBG. Stopes Coll.

General Description.—I found the specimen *in situ* in the plant-bed at the bottom of Luccomb Chine, and it was evidently part of a trunk of large size. The mass of tissue was enclosed in the dark, coarsely granular matrix forming a pseudo-nodule in the way characteristic of this deposit. The tissue consisted of an oblong mass, forming a flat wedge, which, when broken across, seemed entirely like uniform secondary wood. It was large and heavy, and I broke it up into several pieces, bringing away two small wedges, which are the specimens from which

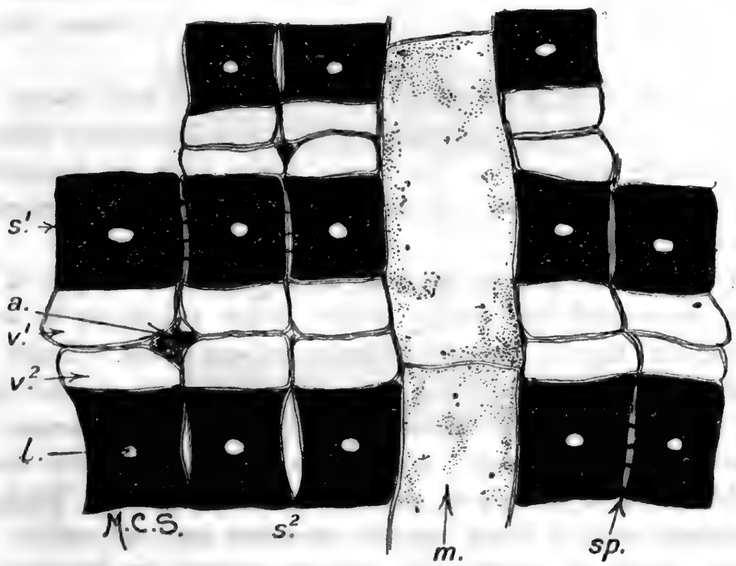


Text-fig. 72.—*Vectia luccombensis*, sp. nov. Transverse section showing the mass of tissue with the false appearance of annual rings and generally wood-like texture. × 2. Stopes Coll., SBG.

the sections have been cut. It is important to record that the mass, which looked to the naked eye like angiospermic wood, showed no signs of other tissue, such as cortex, pith, etc., but seemed to be throughout a uniform portion of secondary wood. There was no rapid curving of the apparent growth-rings, as there must have been in a small branch, but for about 15 cm. at least in a transverse direction the tissues were arranged on a very flat curve, as could only have been the case were the specimen part of a large axis. The outer zones of the tissue were frayed and broken up before petrifaction, but there was no limiting layer to either face.

In the specimen now in the Museum, from which the sections were cut, the transverse diameter is about 20×35 mm. In the second specimen in my collection, it is as much as 26×37 mm., and both show regularly running and nearly straight zones which have every appearance to the naked eye of being ordinary and rather uniform annual rings (text-fig. 72).

The frayed edge of the specimen in the British Museum is penetrated by the granular matrix and glauconite grains, and



Text-fig. 73.—*Vectia luccombensis*, sp. nov. Transverse section of a small area showing the regular alternation of the fibres, $s.^1$, $s.^2$ with the radial pairs of pitted elements, $v.^1$ and $v.^2$; *m.*, medullary ray-cells, with straight end-walls; *a.*, small parenchyma-cell in the angle between four thin-walled elements; *sp.*, pits between adjacent fibres; *l.*, much reduced lumen of fibre.

also by minute fragments of disintegrated plant-débris, among which is a seed, unfortunately too much broken for determination, and also the little twig of *Sequoia giganteoides*, sp. nov. (see p. 70).

Topography of the Tissues.—No *pith* or *cortex* is present. The tissues consist entirely of very definitely alternating zones of elongated pitted elements and excessively thickened elements, with a small quantity of parenchyma. The sequence of the various elements is remarkably uniform: one thick-walled element alternates with *two* thinner-walled elements on the same radius (text-fig. 73, and Pls. XXIV & XXV). At the corner between four adjacent thin-walled elements the small space is sometimes filled by small parenchyma-cells, which sometimes stretch tangentially between the pairs of pitted elements. No other parenchyma seems to be normally present, though near the cork-bands the cells are sometimes irregular.

The regular alternation of thick- and thin-walled elements results in a definite tangential zoning of the structure, which can be seen in Pl. XXV, fig. 1.

The *medullary rays*, which penetrate the whole tissue, are wide and conspicuous, principally 2–4, up to 7 elements distant, and *entirely uniseriate*. They are fairly high in tangential section, running from about 4 up to 30 cells in vertical sequence.

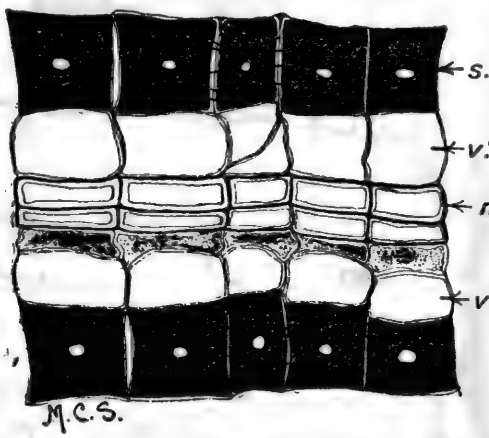
In transverse section, as well as in the cut surface of the block, the naked eye readily detects what appear to be well-marked and regular *annual rings* or *growth-zones*. These are roughly equidistant, and run nearly straight and parallel with the longer diameter of the section. Under the microscope the apparent "growth-rings" are less conspicuous, but are recognisable as bands of two or three very narrow cells. While in transverse section these narrow elements are not unlike the narrow elements common in autumn tissues, in longitudinal section they are short and have every characteristic of cork-cells (Pl. XXIV, fig. 1, *n*.).

There appears to be no indication of true growth-rings in the tissues.

While the bands of narrow cork-elements are arranged so that to the naked eye they appear very regular, their course is less so under the microscope, where irregular loops etc. can be seen, locally giving rise to small groups of irregular cells.

Details of Elements.—The tissue consists of three kinds of elements:—(*a*) excessively thickened, elongated elements; (*b*) thinner-walled elements (sieve-tubes?) with large pits; (*c*) small parenchyma-cells.

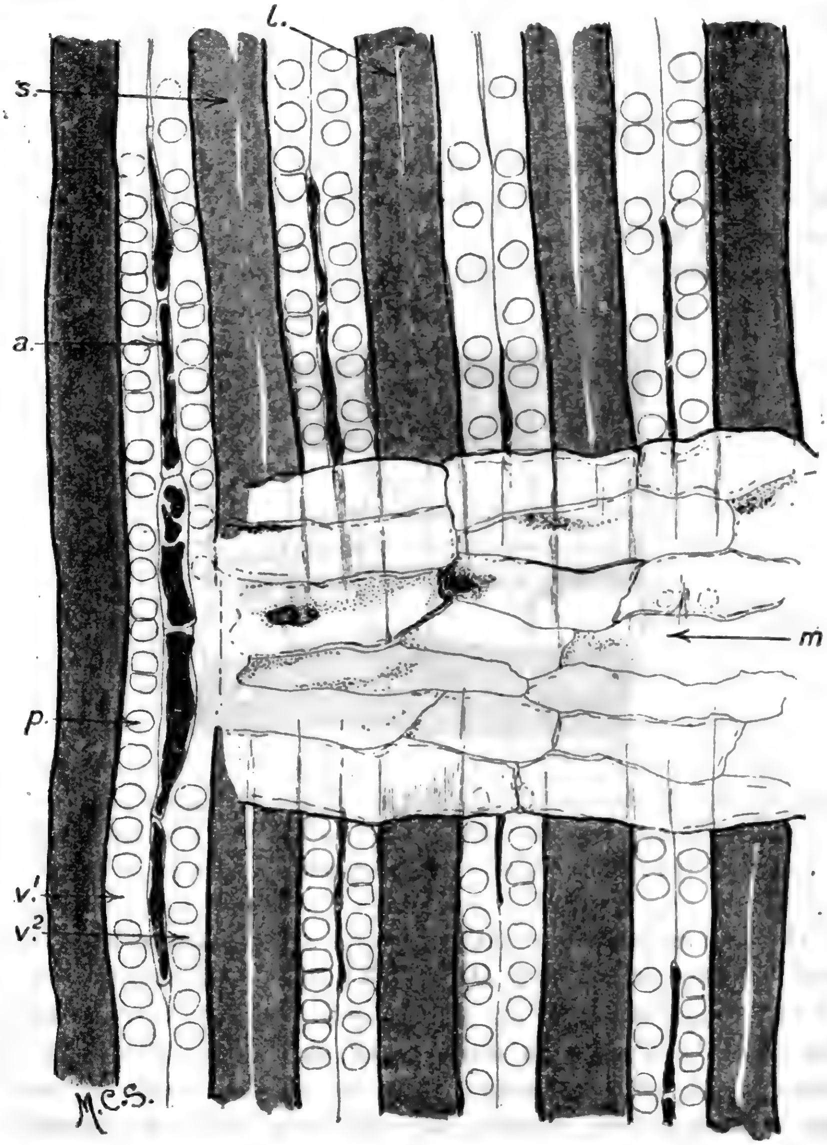
(*a*) The *excessively thickened elements* are the most conspicuous feature in the transverse section (Pls. XXIII, XXV, fig. 1, *s.*), and stand out as black squares owing to the nature of their walls. They are generally squarish or oblong (Pl. XXIII, fig. 2, *s.*) and average about 40–50 μ in diameter, though in some cases they are radially extended up to a size of 70 μ. In radial direction one of these cells always alternates with a pair of the thinner-walled and pitted elements; and these series are arranged so that the fibres are always laterally adjacent to each other, so that they form straight tangential bands which run for long distances, with no interruption save the medullary ray-cells which separate adjacent elements but do not interfere



Text-fig. 74.—*Vectia luccombensis*, sp. nov. Transverse section of a small area showing the narrow band of cork-cells, *n.*, lying between the pair of thin-walled elements, *v.*[1] and *v.*[2]; *s.*, fibres.

with their radial or tangential sequence. This can be seen very well in the central part of Pl. XXV, fig. 1. The radial walls of two adjacent fibres are generally in complete contact (text-fig. 73, *s.*[1]), though in some cases these split apart, as in text-fig. 73, *s.*[2]. In many places the middle lamella between the cells is clearly shown, and on either side a somewhat thickened white zone of the wall through which the pits can be remarkably well seen (text-fig. 73, *sp.*) in transverse section, and also in some places in longitudinal section.

The secondary thickening of the wall is dark brown or black, and therefore conceals the pits in most cases, though locally, where the petrifaction has a clear golden colour, the pits can be seen through the wall leading to the minute central lumen. The lumina of the cells vary somewhat in size, but are always extremely reduced (text-fig. 73, *l.*, and Pl. XXIII). In longi-



Text-fig. 75.—*Vectia luccombensis*, sp. nov. Radial section showing the regular alternation of pairs of thin-walled pitted elements, *v.*[1] and *v.*[2], with the fibres, *s.* *l.*, lumen of fibres; *m.*, medullary ray-cells; *a.*, compressed parenchyma-cells intermittently found between *v.*[1] and *v.*[2]; *p.*, large circular pits which lie in a single row in the radial walls of *v.*[1] and *v.*[2]. No. V. 13230 *b*.

tudinal section these elements are also conspicuous (Pl. XXIV, *s.*, and text-fig. 75) and very long. In tangential section their narrow, sloping, pointed ends can be seen from time to time, as well as their pitting. In a few cases in the sections, the walls of these elements are so cut through that a surface-view of the roundish or oval pits liberally scattered all over them can be seen.

(*b*) The *thinner-walled elongated elements* (sieve-tubes?) lie always in radial pairs, alternating on the radius with single thick-walled elements (text-fig. 73). They have the same tangential diameter as the thick-walled elements (40–50 μ), but are radially narrower, the pair of them together being very little wider than the single thick-walled elements. While their walls appear thin in comparison with their excessively thickened neighbours, they are actually considerably thickened and their radial walls are conspicuously pitted (text-fig. 75, and Pl. XXIV). In the radial section the two elements, lying between the dark walls of the fibres, can be very clearly seen. In each element is a single row of large pits, generally isolated and nearly circular, in some cases lying in vertical pairs. The diameter of the pit is nearly as great as the radial diameter of the cell, so that the pit fills the wall. I have not been able to detect any border to these pits. On the other hand, the appearance, rather suggestive of a "sieve-area" seen in the photograph, is due to minute granules in the matrix, to be seen elsewhere all through the fossil. It is probable that these large simple pits represent sieve-areas of which the finer pitting has been eaten out, though their appearance is very like that of pits in wood-elements.

(*c*) The *parenchyma-cells* lie only in the angle between four of the last-described elements, but are either not present in every case or are frequently collapsed, for the larger elements often meet so as to leave only a small lacuna between them. In a few cases these parenchyma-cells, much flattened, stretch tangentially between a pair of sieve-tubes. When present, the parenchyma-cells usually appear as squarish blackened blots in transverse section (text-fig. 73, *a.*, and Pl. XXIII, fig. 2), but they are much more conspicuous in the radial longitudinal section, where they may lie in a vertical row between the pitted elements (see *a.* between $v.^1$ and $v.^2$, Pl. XXIV, fig. 1, and text-fig. 75). They are somewhat elongated and have approximately horizontal cross-walls, their outline is very variable, and they are sometimes stout, and at others squeezed and attenuated out of existence, as can be seen in the radial section, text-fig. 75. They are almost universally filled with very blackened contents.

The *medullary rays* consist of only one kind of cell. In transverse section the ray-cell is conspicuous, and may be as wide or even wider than the adjacent elements (Pl. XXV, fig. 1, *m.*, and text-fig. 73, *m.*), and averaging about 40–60 μ in tangential diameter. The cells are not greatly elongated radially, and equal from two to four of the adjacent elements, averaging about 70–100 μ in radial extension. The rays are entirely uniseriate, and the end-walls are approximately straight or slightly curved (Pl. XXIII, fig. 1, *m.*). In *radial* section the rays have very wavy walls, and the cells are arranged with considerable irregularity, their waving outlines, however, fit into each other (text-fig. 75, and Pl. XXIV). The cells appear all alike and rather thin-walled, and I have not been able to detect any pitting in them. In a number of places where a ray crosses the cork-like zones, the ray-cells are locally greatly thickened and are often much narrower and more regular, as though the regularity and thickness of wall of the cork-like layer had been contagious and spread for a short distance along the ray.

In *tangential* section the rays are also very conspicuous (Pl. XXV). The cells which compose them round themselves off, leaving very definite and large spaces at the corners. The cells composing the different rays vary greatly in size, as can be well seen in Pl. XXV, fig. 2, where the contrast between ray *x* and ray *y* is very noticeable. The upper and lower limiting cells of the ray appear quite like the others, though there is often a long narrow space above and below the ray before the adjacent thick-walled elements come into contact.

The *cork-bands* are narrow, composed of two, three, or four rows of narrow flattened cells (text-fig. 74, *n.*). These generally lie between the thinner-walled elements, but may be adjacent to or pass obliquely through a band of the much-thickened elements. Bands of these cells can be seen at *n.*, Pl. XXIV, fig. 1. They have the peculiarity of cork, and appear identical in longitudinal and transverse sections.

Affinities.—So far as I can ascertain, no fossil in the least like the above has yet been described. Were the tissues proved to be wood, they would represent a striking new type of organisation, which would tempt one to look upon it as a "Pro-Angiosperm," intermediate between a higher Gymnosperm and an Angiosperm. Its external appearance is entirely wood-like, while the microscope reveals the uniform presence of entirely *uniseriate* medullary rays, a feature unparalleled in any tissue of the thickness of the present fossil, except wood, so far as my experience goes. Further, the strongly marked, circular pits of the pitted elements are very tracheid-like superficially, though this is probably due to the nature of the petrifaction.

Nevertheless, were the tissues present in but a small quantity, there is no doubt that the regular alternation of fibres and thinner-walled elements would lead to its identification as phloem. A good account of the phloems of many Gymnosperms and Angiosperms is to be found in Moeller (1882), to which reference should be made. I am indebted to Mr. A. J. Wilmott and Mr. W. N. Edwards, of the Museum, for drawing my attention to this very useful book.

As is well known, in *Cryptomeria*, *Phyllocladus*, *Thuja*, and other Gymnosperms, the phloems show a regular alternation between fibres and soft cells, differing in the numerical proportions of the cells, but otherwise very similar to the fossil. In general, the true phloem has a maximum thickness of 3–4 mm., and even in the giant *Sequoia* a trunk in the Museum with a girth of over 40 ft. has a narrow zone of phloem averaging only about 4 mm. thick; outside this the corky tissues are quite broken up and irregular. Mr. Boodle, however, tells me that he has cut a *Taxodium* phloem 12 mm. thick.

The fossil, therefore, must have been a giant phloem—if it is a phloem, as appears to me to be the case. Assuming that this is its nature, it has two peculiar features worthy of remark. First, its immense size: this must have resulted from the holding together instead of the exfoliation of the successive zones cut off by the unusually regular series of narrow corks. Were the thickness of the phloem less, the presence of uniseriate rays would not be remarkable, because such are found in the narrow phloems of several Gymnosperms. Second, the position and character of the parenchyma-cells. In the living *Thuja*, *Sequoia*, and other genera which the fossil to some extent resembles, the radial sequence of cells consists of *three* soft cells between each fibre zone, and of these the central cell is parenchymatous and is as large in transverse section as the sieve-tubes on either side of it (see Moeller, 1882, p. 15, fig. 2; p. 32, fig. 15, etc.). In the fossil, however, these cells appear to be represented by the small cells which are not regularly but only intermittently distinguishable at the corners of the sieve-tubes (text-fig. 73). Their peculiar position, their narrow and elongated shape, and the blackened contents are all highly suggestive of *companion cells*. They suggest, indeed, an interesting possibility: is our present fossil one which has taken a step toward angiospermic structures in this respect, while remaining otherwise gymnospermic?

It may, however, only be due to age and the consequent collapse of the parenchyma-cells, for, as Mr. L. A. Boodle kindly showed me in *Taxodium distichum*, where normally there are three cells between each narrow fibre and the next on the same radius, the old state of the bark shows the crushing and sometimes the complete collapse of the parenchyma between the sieve-tubes.

Without unduly expanding the present preliminary account, detailed comparison with the various species cannot be attempted, and it may suffice to say that the new fossil is in the main similar to the phloems of some Cupressinean, Taxinean, and Taxodinean genera; but the behaviour of its corks, and the consequent giant size it attained, seem to be a peculiarity not matched among recent plants.

V. 13230. Type-specimen. The remains of the block, now in three pieces, from which the sections have been cut. Externally the dark, coarse, granular matrix conceals the plant-tissue. On the cut faces, particularly in the longitudinal face, the "woody" texture is very apparent.

V. 13230 a. Figured, Pl. XXIII, figs. 1 & 2; and text-figs. 73 & 74. [Also, for *Sequoia giganteoides*, sp. nov., Pl. II; text-fig. 16.] Transverse section showing the tissues as described; the granular matrix encloses the tissue on one side, and the fragments of other débris, together with the mineral granules, penetrate between the partly disintegrated zones, among which lies the twig of *Sequoia giganteoides* described on p. 70. The false "growth-rings" can be seen very well with the naked eye, and locally the tissues are very beautifully petrified, as is indicated in the illustrations.

V. 13230 b. Figured, Pl. XXIV, fig. 1; text-fig. 75. Radial longitudinal section in which the pitting can be very well seen, also the parenchyma-cells locally present between the pitted elements, and the medullary rays in radial view.

V. 13230 c. Figured, Pl. XXV, fig. 2. Tangential longitudinal section, in which the uniseriate rays are conspicuous. The narrow ends of the fibres and their pitted walls can also be seen at various places.

Further sections from the same block are in the Stopes Coll.

Plant-band, Lower Greensand; Luccomb Chine, Isle of Wight.
Found and presented by Dr. M. C. Stopes, 1912.

Class ANGIOSPERMÆ.

The largest and most important class of plants, which have their reproductive organs enclosed and surrounded by very specialised scales, the whole forming a *flower*, which may be uni-sexual or bi-sexual, simple or complex, small and inconspicuous, or large and highly coloured, but in which the seeds are always enclosed by the carpels. The vegetative structure shows every range of variation from woody trees to minute and simplified herbs.

Sub-class MONOCOTYLEDONS.

The embryo has only one cotyledon, often peculiarly modified and specialised; and the leaves have generally parallel veins. Normal cambium and, consequently, woody trunks are almost universally absent.

The only specimen in the Lower Greensand deposits which even doubtfully may be regarded as a Monocotyledon is an imperfect cast, presumably of a leaf, in the Maidstone Museum. The specimen measures about 24×18 cm. across, and looks like the segments of a palmate leaf penetrating the coarse sandstone matrix. Its nature, however, is very doubtful.

The other specimens which have been described as Monocotyledons have all been disposed of in other sections of the plant kingdom by later and more critical work. The principal of these is the famous "Dragon-Tree," for so long placed in *Dracæna*, a curious genus of living Monocotyledons. Its gymnospermic nature has already been demonstrated (see p. 163).

Sub-class DICOTYLEDONS.

The embryo has two cotyledons, and the foliage leaves have generally reticulate veins. Primary bundles are in one ring, normal cambium is often present, giving rise to woody trunks.

Dicotyledons largely preponderate in the existing flora, and in the lists of Tertiary and Upper Cretaceous floras, and very many fossil species (principally leaf-impressions) have been described. While it seems certain that in some part of the globe, Angiosperms must have existed in Jurassic times, if not earlier, no reliable determinations of Angiosperms appear to have been made (with the possible exception of a few French impressions) before the Cretaceous.

A useful critical account of the earlier reputed Angiosperms is given by Berry (1911), to which reference should be made. He says (p. 149): "There is fairly satisfactory evidence of Angiosperms in beds which are classed as Aptian, and by the close of the Albian dicotyledons became a considerable element in the floras." Regarding the so-called earlier Angiosperms, the *Ficophyllum*, etc., of the American Potomac, of which so much has been made by some authors, even since the publication of my paper (Stopes, 1912), Berry "is convinced that these forms are not Angiosperms . . . . and it would do no violence to the known facts if some of them were referred to the Filicales." The discovery of Angiosperms of Aptian age in England (see Stopes, 1912) extended the range of the early forms, and called in question the assumption that the Angiosperms originated on the American borders of the North Atlantic and had not spread to Northern Europe by that time (see Chamberlin & Salisbury, 1906).

The problem of the origin of the Angiosperms has attracted much interest and hypothetical dissertation. Facts, however, are needed, and unfortunately hitherto the few available early fossils have been leaf-impressions, which are difficult and unsatisfactory evidence.

In the present volume further new species of dicotyledonous *woods* are described. They bring into prominence the lack of real knowledge concerning the systematic anatomy of woods. At present it is impossible to obtain, regarding the living forms, the information necessary for palæontological work. Until the Dicotyledonous woods have been given the careful attention which has been expended on the woods of Conifers, no satisfactory progress in the palæontology of the earliest Angiosperms can be made. It is my opinion that, as in the case of the Conifers, the details of the medullary ray-cells will prove of considerable diagnostic value. I am not aware, however, of any publication which attempts to illustrate even the

s 2

leading types of the principal families. Similarly, in the relatively few important papers dealing with fossil Dicotyledons, essential details generally remain undescribed—for instance, neither Felix (1883) nor Schenk (1883) illustrates the thickening or pitting of the medullary ray-cells in the woods discussed.

As a consequence, I have not attempted any exact determination of the still earlier Dicotyledons here described, but have endeavoured to illustrate adequately the details of their structure by photographs and line-drawings. When similar illustrations are available of the living plants, palæontological determinations may be attempted.

The fact of prime importance, however, viz. that Dicotyledons existed in this country in Aptian times, is demonstrated by these specimens; while it is also clear that they appear to have been highly specialised types, and to show little evidence of any "primitive" features. Though it has not been possible to place them in any given family, one by one their details may be matched in the woods of living forms.

Hence, though these specimens have a peculiar interest, as they are the earliest Dicotyledons of which the anatomy is known, from any part of the world, they are not in any sense "pro-angiospermic," and the really primitive forms are still awaited.

Genus **CANTIA**, nov.

As only one specimen of this type has as yet come to light, the diagnosis of the genus and species will be given together.

Cantia arborescens, sp. nov.

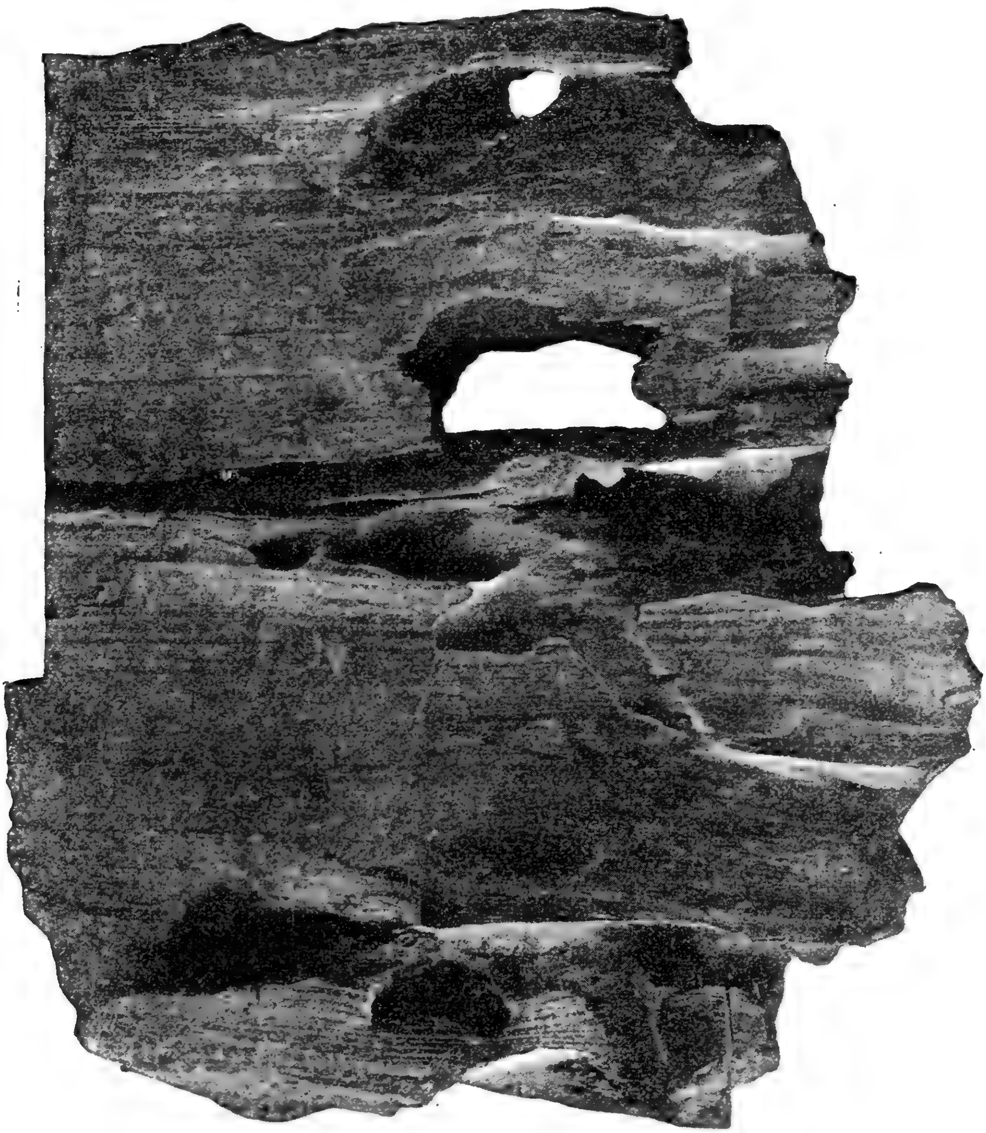
[Plates XXVI-XXVIII; text-figs. 76-78.]

Diagnosis.—The species is founded on the decorticated secondary wood. A large woody trunk, forming timber 30 cm. and more in diameter, with normal growth-rings. Wood consisting of small quantities of fibre-tracheids and parenchyma, with large numbers of isolated circular vessels uniformly distributed, averaging 30–50 μ in diameter. Medullary rays numerous, all uniseriate, all the ray-cells with thickened and pitted walls, numerous circular or oval pits, sometimes bordered in the radial walls. Vessels pitted variously, with round, oval, and scalariform pits. Wood-fibres with large, round, bordered pits.

HORIZON.—Folkestone Beds, Lower Greensand.

LOCALITY.—Near Ightham, Kent.

TYPE.—V. 13231 and slides V. 13231 *a*, *b*, *c*, *d*, *e*, *f*, cut from it, in the British Museum (Nat. Hist.).



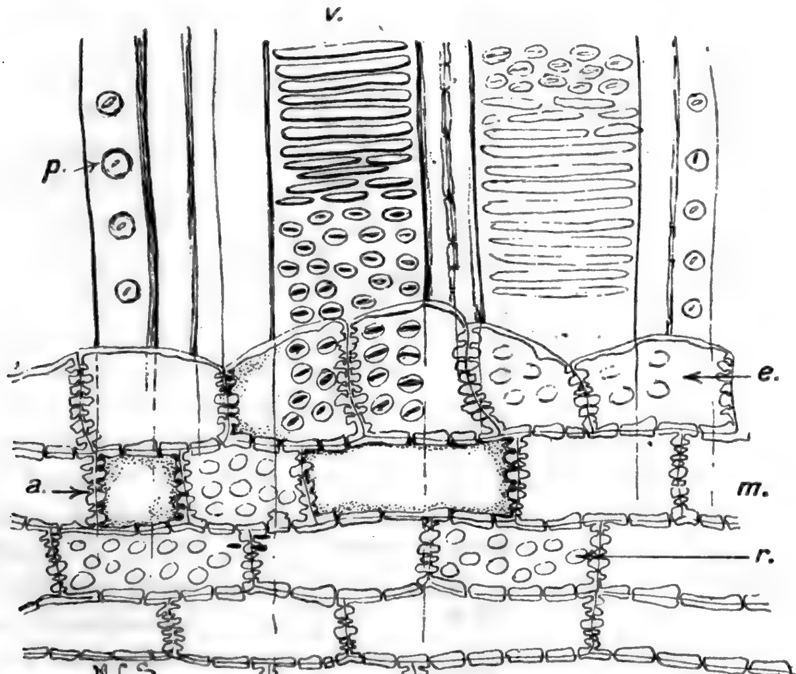
Text-fig. 76.—*Cantia arborescens*, sp. nov. External view of the wood showing the bore-holes, woody texture, etc. Slightly less than ½ nat. size. No. V. 13231.

General Description.—The large specimen, now measuring $25 \times 5 \times 23$ cm., is evidently part of a still larger woody trunk, which, judging from the curve and direction of the growth-rings, could not have been less than 30 cm. in diameter when alive. The wood is evidently a drifted log, waterworn and teredo-bored before petrifaction. It is petrified in a close hard medium, very slightly iron-stained, and the surface is clean from matrix and shows the woody texture exceedingly well, particularly in the radial splints (text-fig. 76). Secondary wood alone is preserved, without any sign of phloem or bark, and the wood is that of the outer wood-zones, probably formed when the plant was many years old, as there is no sign of the more abrupt curves of the limits of the central rings of growth.

Topography of the Wood.—The proportion of vessels to wood-fibres and parenchyma is large, as can be seen in Pl. XXVI, figs. 1 & 2. The vessels are scattered singly, very close to each other, often with only one fibre-tracheid or wood-parenchyma cell between them, or with very small groups of these elements. In several cases series of vessels may be adjacent. Wood-parenchyma is small in quantity, and is scattered among the small groups of fibres, and may or may not be adjacent to the vessels. *Growth-rings* are clearly to be seen (Pl. XXVI, fig. 1), but the autumn zones are very narrow, and have little or no effect on the distribution of the vessels. The whole zone measures from about ·5 up to 2·5 mm., and is therefore narrow for the size of the whole trunk.

Medullary rays are very numerous and *uniseriate*. I have not detected any broader multiseriate rays, even in sections of large area, so it is probable that they are entirely absent. The rays consist of cells all very much alike, averaging from about 10–24 cells in vertical sequence.

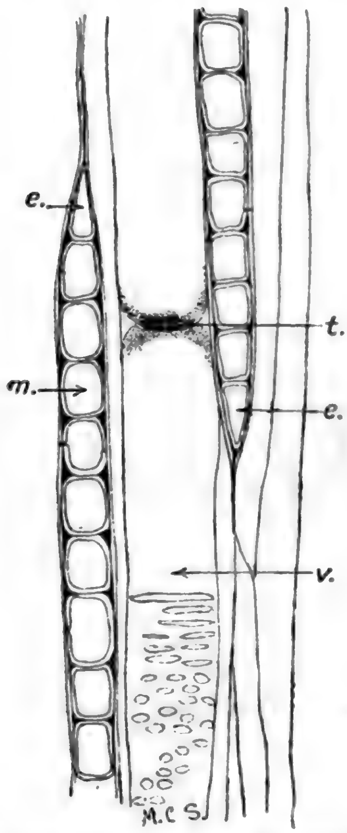
Details of the Elements.—The *wood-vessels* are now rather crumpled in most cases, but were normally roughly circular or squarish in transverse section. They average about 30–50 μ in diameter, and are therefore small. The walls appear to have been but slightly lignified. In longitudinal sections, however, the pittings show up with remarkable frequency and beauty of preservation. The main lengths of the vessels are perforated by innumerable, small, oval, bordered pits (Pl. XXVII, fig. 1), lying between the vessels and the adjacent ray-cells (*cf.* Pl. XXVIII, fig. 2). Between these, and also towards the ends of many of the vessels, the bordered pits are intermingled with and give place to broad, regular, scalariform perforations (Pl. XXVII, fig. 2). The minute dots in the smaller pits, which can be just made out in the photograph (Pl. XXVII, fig. 1 *b*), appear to be due to mineral granules caught on the pit borders, so that their appearance of being "sieve-like areas," such as are described in the vessels of a number of the higher Dicotyledons by Jönsson, 1892, is deceptive.



Text-fig. 77.—*Cantia arborescens*, sp. nov. Radial longitudinal section showing the vessels, *v.*, and their pitting; the fibre-tracheids, *p.*; and the medullary rays, *m.*, in which the end-walls, *a.*, are much thickened and pitted, and the radial walls have groups of large round pits, *r.* The terminal cells, *e.*, of the ray are slightly larger and squarer than the others. × 400. No. V. 13231 *c.*

Nearly all the vessels show the end-walls of numerous *tyloses* (Pl. XXVIII, fig. 1, *t.*).

The *wood-fibres* or *fibre-tracheids* are inconspicuous in transverse section. They are roughly oblong or hexagonal in transverse section, according to the space in which they have to fit. They average about 10–20 μ in diameter. Their walls are thick, but not excessively so, apparently about $\frac{1}{4}$ the diameter of the whole wall. Their pits are round and bordered, as can clearly be seen in Pl. XXVII, fig. 2, *p*. *Wood-parenchyma* appears to be present in rather small quantities, and in the transverse section shows thinner walls than the fibres and has dark contents. Medullary rays are so numerous in the



Text-fig. 78.—*Cantia arborescens*, sp. nov. Tangential view of part of two rays, a vessel and fibres: *m.*, ordinary cells of medullary ray; *e.*, end-cells of ray; *v.*, wood-vessel, across the lumen of which can be seen the end-walls of tyloses, *t*. × nearly 400. No. V. 13231 *f*.

longitudinal sections that I have not been able to determine the nature of the cross-walls of the parenchyma. *Medullary ray-cells* are all alike, save for minor differences in shape (text-figs. 77, 78, and Pl. XXVIII, fig. 2). Their walls are all considerably thickened and pitted. The pits in the radial walls are numerous, and bordered in contact with the vessels; those in the end-walls between adjacent ray-cells being like those described as "abietinean" among the Conifers. The terminal cells of the rays are slightly higher and more irregular than the others (text-fig. 77, *e.*), but the difference between them and the adjacent cells is so trifling that the rays may be said to be entirely uniform, and are a great contrast to those in *Aptiana* (text-fig. 92, p. 291).

Affinities.—The most noticeable feature of this wood is the simple uniform rays, which are *entirely uniseriate.* Several families and a number of isolated genera of Angiosperms have uniseriate rays, which are by some writers (see Eames 1910, Thompson 1911, etc.) considered to be a primitive feature in Dicotyledons.

Among the species with uniseriate rays, those which in other respects also appear to come nearest to the fossil, are species of *Franklinia*, *Euonymus*, *Alnus*, and *Salix*. *Franklinia altamabra* is in all its details noticeably like the fossil, save that a few of its medullary ray-cells show long scalariform pits. While I have not detected these in *Cantia*, it is not impossible that they may have been present, though, as the ray-pitting is so exceptionally well preserved, it seems likely that they would be present in the sections if they had been a feature of the plant. Some species of *Euonymus* also come very near the fossil and have, like it, large pits in the fibre-tracheids, in which particular they come nearer the fossil than does *Alnus* with its smaller-pitted fibre-tracheids. Both the genera *Alnus* and *Salix* contain species which seem very close to the fossil, though they both contain also a large proportion of species in which the vessels are generally in series instead of isolated as is the case in the fossil.

Regarding the affinities of *Cantia*, Mr. L. A. Boodle, of Kew, who has kindly looked at the sections, writes to me as follows:—"Affinity with Betulaceæ might be suggested as possible, while holding oneself ready to discard this suggestion should a more significant agreement with some other wood be observed. Considering the age of the specimen, it is perhaps to be suspected that its structure might incline towards a primitive character in some of its details as compared with its nearest relatives among living plants. The large size of the pits on the fibres may be a case in point. Again, the broad false rays of some species of *Alnus* may be a comparatively late acquisition" (see Bailey, 1911). "In Magnoliaceæ there are simple pits between the vessels and the medullary rays, and I have not seen any example with exclusively uniseriate rays. Otherwise some members of this family rather resemble your plant."

Viburnum lantana appears to be another species with which legitimate comparison may be suggested; but, as in the case of four out of five of the other fossil Angiosperms here described, no exact determination of its affinity can be made in the present state of our knowledge of Angiosperm anatomy.

V. 13231. Type-specimen. Figured, text-fig. 76. A large block, measuring $25 \times 5 \times 23$ cm., externally water-worn. The wood was evidently much broken away and teredo-bored before petrifaction. It is now petrified in a very fine hard medium, in which the wood-cells are locally exquisitely preserved. The specimen is free from matrix and shows the woody texture very clearly; slightly weathered-out growth-rings can be recognised by the naked eye.

V. 13231 a. Figured, Pl. XXVI, figs. 1 & 2. Transverse section of part of the above block. The narrow limiting zone of the growth-rings can be well seen in places. Locally the numerous wood-vessels and ground-tissue, as well as the uniseriate rays, are well petrified, though, on the whole, the petrifaction in transverse section is not very good.

V. 13231 b. A smaller transverse section similar to the above. Toward the middle of the section the wood-fibres are well enough preserved to show their thickened walls.

V. 13231 c. Figured, Pl. XXVIII, fig. 1; and text-fig. 77. Radial longitudinal section showing a very large number of medullary rays crossing the wood-elements. The ray-cells are all thick-walled and are petrified with remarkable beauty, showing their thickening, pit-canals, etc., in many cases, as illustrated.

V. 13231 d. Figured, Pl. XXVII, figs. 1 & 2; Pl. XXVIII, fig. 1. Radial section similar to the above, showing the pits in the walls of the rays in all directions and the pitted areas in the radial walls. Numerous tyloses can be seen blocking the vessels. In many places the scalariform bars and the oval bordered pits of the vessels can be seen, also the isolated round bordered pits of the wood-fibres.

V. 13231 e. Longitudinal section, partly tangential and partly radial oblique, in which many individual cells are well preserved.

V. 13231 f. Figured, text-fig. 78. Tangential longitudinal section, partly rather oblique. Where it is truly tangential the uniseriate nature of the medullary rays and their thickened walls can be seen.

Folkestone Beds, Lower Greensand; near Ightham, Kent.

Presented by the Committee of the Corporation Museum, Maidstone, 1915.

Family DIPTEROCARPACEÆ (?).

Genus **WOBURNIA,** Stopes.

[Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, p. 91 *et seq.*, 1912.]

As one species only of this genus is known the species and genus are not separately diagnosed (see p. 283).

Woburnia porosa, Stopes.

[Text-figs. 79–81.]

1912. *Woburnia porosa,* Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, pp. 91–93, pl. vii, fig. 7; pl. viii, fig. 8; text-fig. 6.

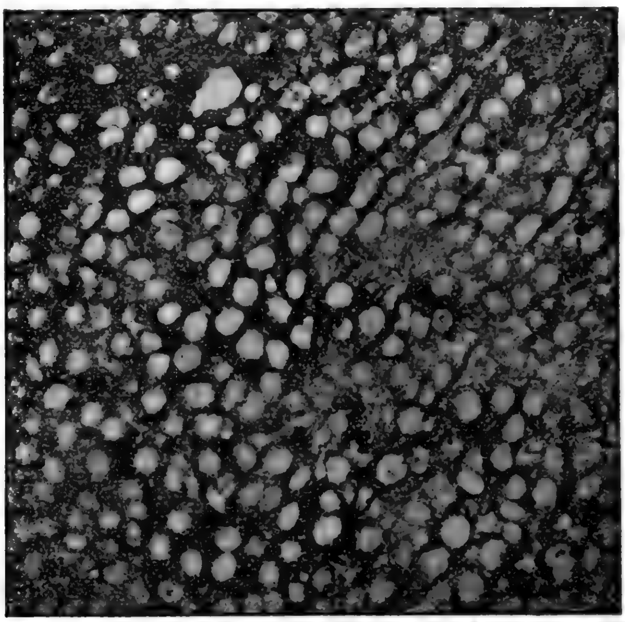
Diagnosis.—The species is founded on a wedge of decorticated secondary wood, from a branch or trunk of unknown size. Secondary wood with exceedingly numerous and very large vessels. Vessels approximately round, placed singly, averaging about 350 μ in diameter. Rays mostly multiseriate, averaging

4–8 cells broad, and about 40–60 cell-rows high; numerous narrower rays, about two cells broad, interspersed between the broad ones. Much wood-parenchyma round the vessels and in groups among the fibres, which are relatively few, thin-walled, and with roundish bordered pits. Growth-rings, if present, more than 2·5 cm. wide, which is the width of the specimen, in which none are present.

Horizon.—Lower Greensand.

Locality.—Woburn Sands, Bedfordshire.

Type.—Block V. 5452, and slides V. 5452 *a*, *b*, *c*, *d*, and *e* cut from it in 1911; British Museum (Nat. Hist.).



Text-fig. 79.—*Woburnia porosa*, Stopes. Part of a transverse section, to show the numerous large vessels and the broad wavy medullary rays. × 10. After Stopes.

General Description.—The species is founded on a single specimen, composed only of secondary wood. A wedge-shaped piece, roughly 2·5 × 1·8 cm. in diameter, shows no signs of growth-zones, but is quite uniform throughout. Externally the woody texture is weathered out and recognisable to some extent, and at one end the medullary rays and the vessels can be detected in the weathered surface. On the cut surface the rays and the vessels can be clearly seen with the naked eye. As can be seen in text-figs. 79, 80, the huge vessels and the medullary rays are obvious, but the finer details of the elements are not properly preserved.

Text-fig. 80.—*Woburnia porosa*, Stopes. Transverse section of small part of the wood showing the large vessels, *c.*; the broad medullary rays, *d.*; *a.*, wood-fibre; *b.*, wood-parenchyma. After Stopes.

Note that this is magnified 100 diameters, and is exactly the same magnification as text-fig. 89, with which it should be contrasted.

Topography of the Stem.—*Pith* and *primary wood* are not preserved. *Secondary wood* is very " light " and porous in structure, with a large proportion of wood-parenchyma both adjacent to the vessels and scattered, relatively thin-walled wood-fibres, and very numerous large vessels close to each other. The isolated vessels are evenly distributed throughout the whole mass of the wood.

Growth-rings are not present, but the greatest radial diameter of the specimen is only 2·5 cm., and though that is much wider than the average growth-zones in timber, such a loosely-textured, probably quick-growing, wood as this may have had very exceptionally wide growth-zones, and the specimen may come within either limit of a single zone. On the other hand, growth-zones are often absent in tropical or subtropical woods.

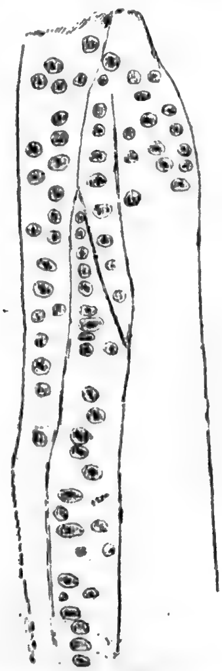
Medullary rays are principally multiseriate, about 4–8 cells wide; smaller interspersed rays, two cells wide, are numerous. The rays are high, many being 40–60 cell-rows in vertical series. The ray-cells are poorly preserved, but seem all alike, and without special differentiation.

Details of the Elements.—The *wood-vessels* are roughly circular, nearly all isolated and very large, measuring on an average from 280–370 μ in diameter (text-fig. 80). In longitudinal view the outlines of the adjacent elements mark areas on the walls of the vessels, which are irregularly covered with small, bordered, irregularly oval pits (text-fig. 81). *Wood-fibres* are slightly hexagonal or circular, and are in groups isolated or in alternating rows among the parenchyma (text-fig. 80, *a.* & *b.*). Their walls are thickened, but not excessively so, as can be seen in the figure. They have pointed ends, and, adjacent to the vessels, appear to have bordered pits (text-fig. 81). *Wood-parenchyma* is much developed, but the details of the cell-walls are not well enough preserved for description.

The individual cells composing the *medullary rays* appear to be all alike, to have a squarish or rectangular shape in radial section, with oval pits in their radial walls, but they are too poorly preserved to be described in detail.

Affinities.—The striking contrast in texture between this wood and that of *Aptiana* (see p. 284) is very remarkable. If, as in many respects one might have pre-supposed, the small size of the vessels and their regular sequence in the radial series of wood-fibres in *Aptiana* indicated a comparatively primitive wood-structure which tallied with its early geological age, the immense size of the vessels and general character of the wood in the present species show that some forms had already evolved far from that type by Aptian times.

While this fossil is not well enough preserved to be identified with certainty, its features are in complete agreement, so far as they go, with some of the Dipterocarpaceæ. The genus *Shorea*



Text-fig. 81.—*Woburnia porosa*, Stopes. Longitudinal view of wood-vessel, with outline of wood-fibres adjacent, showing bordered (?) pits irregularly scattered. After Stopes. No. V. 5452 *b*.

in this family is said by Gamble (1902) not to show annual rings except in the fresh wood. *Hopea odorata* and other Hopeæ also resemble the fossil very closely.

V. 5452. Wedge of secondary wood, 2·5 × 1·8 × 2·5 cm., from which sections have been cut. The external weathered surface shows something of the wood-texture; the cut surface shows the medullary rays and vessels to the naked eye. The specimen is dark reddish brown and irregularly iron-stained.

V. 5452 a. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, pl. vii, fig. 7; pl. viii, fig. 8; text-figs. 79, 80, *ante.* Transverse section showing all the features described. The large vessels are very noticeable to the naked eye. The wood-fibres and parenchyma, which are not very well preserved, are best seen where there are locally dark-stained patches.

V. 5452 c, V. 5452 e. Transverse sections, similar to the above; a dark patch on the left side of slide **e** shows the tissues unusually well.

V. 5452 b. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, text-fig. 6, p. 92; and text-fig. 81, *ante.* Radial, but partly obliquely tangential, section. The large vessels and high medullary rays can be recognised. Tyloses can be seen in several of the vessels and also very pretty septate fungal hyphæ. On some of the vessel-walls the outline of the adjacent elements and the pits between them can be seen.

V. 5452 d. Obliquely tangential section of the above, rather more poorly preserved.

Lower Greensand; Woburn, Bedfordshire.

Transferred from the Botanical Dept., 1898.

Family —— (*uncertain*).

Genus **SABULIA,** Stopes.

[Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, p. 93 *et seq.*, 1912.]

As one species only is known, the species and genus are not separately diagnosed (see p. 283).

Sabulia Scottii, Stopes.

[Text-figs. 82–84.]

1912. *Sabulia Scottii*, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, pp. 93-94, pl. vi, fig. 2; pl. viii, fig. 9.

Diagnosis.— The species is founded on a decorticated stem showing pith and growth-rings of secondary wood; not less, and probably more, than 2·5 cm. in diameter when alive. A branching woody stem with primary wood in a ring without well-marked primary bundles. The wood uniform and compact in structure, with vessels uniformly scattered, singly or in pairs, through the ground-mass of thick-walled fibres. Vessels averaging about 25–70 μ in diameter, with thick walls. Medullary rays inconspicuous, all either uniseriate or only two or three cells wide. Cells of rays rectangular, nearly square, thickened, and pitted.

HORIZON.—Lower Greensand.

LOCALITY.—Woburn Sands, Bedfordshire.

Text-fig. 82.—*Sabulia Scottii*, Stopes. Transverse section of the stem showing the growth-rings, the uniform distribution of the vessels, and the two piths due to branching. *w.*, a healed-over wound; *k.*, a "knot" due to another branch. × nearly 3 diameters. After Stopes. No. V. 5654 *a*.

TYPE.—Block V. 5654, and slides V. 5654 *a*, *b*, *c*, *d*, *e* cut from it in 1911; British Museum (Nat. Hist.).

GENERAL DESCRIPTION.—The species is founded on a single specimen, a short length of a decorticated branch now 2·5 × 2 cm. in diameter. Externally the woody texture shows very clearly, and is free from matrix. At one end the branch is broken across at an angle and weathered, so that the growth-rings of the wood stand out in relief. The cut end of the specimen shows the woody texture very well, and the pith, growth-rings, and vessels can be recognised with the naked eye. The details of the wood-elements are fairly, but not very well preserved in a close, dark, iron-stained medium.

Text-fig. 83.—*Sabulia Scottii*, Stopes. Transverse section of the wood showing the uniform distribution of the wood-vessels, several of which are in radial pairs. *a.*, *a.*, limits of growth (annual ?) rings. ×100. After Stopes. No. V. 5654 *b*.

Topography of the Stem.—The *pith* is preserved in the centre of the stem, measuring nearly 2 mm. in diameter. It is irregular and roughly pentagonal in shape, and is just dividing in the transverse sections available (see text-fig. 82). *Primary wood* is poorly preserved, arranged in an irregular ring, and not in well-marked bundles. *Secondary wood* consists of a solid mass of thick-walled fibres with little or no wood-parenchyma, and with the vessels lying evenly distributed in pairs, sometimes in radial triplets, or isolated. The arrangement and size of the vessels are very little affected by the growth-rings. *Tyloses* occur in many of them. *Growth-rings* are much more conspicuous to the naked eye than under the microscope. Their limits are marked by a narrowing of two or three rows of fibre-elements, rather than by the distribution or size of the vessels (text-fig. 83).

Medullary rays are principally uniseriate, a few are biseriate or three cells wide. The cells appear to be uniform in character save for slight variations in their radial elongation. The rays range in height from about 6 to 40 cells, some of the biseriate rays being a little higher.

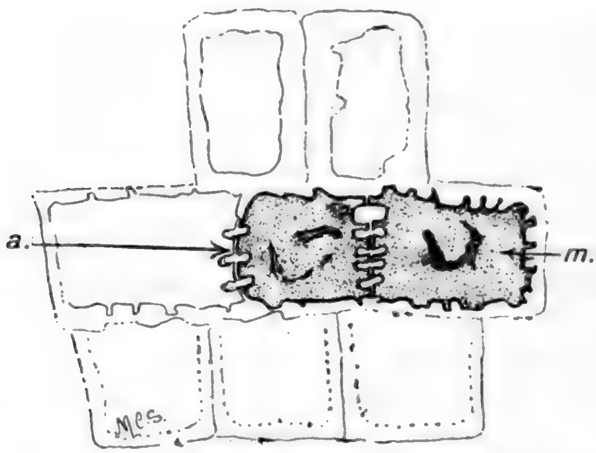
Branching appears to have been frequent, several "knots" are externally visible in the wood, and the remains of two branches at least are seen in the transverse section (see text-fig. 82).

Phloem, *cortex*, and *bark* are unpreserved.

Details of the Elements.—So far as can be judged from the poor state of preservation, the majority of the elements of the *pith* were thick-walled and pitted, roundish in outline, and with small intercellular spaces. Among these are some stone-cells with excessively thickened walls. The *primary wood-elements* are small and too poorly preserved to describe in detail. The *secondary wood-vessels* are roughly circular; when two are adjacent the walls of contact are nearly straight. They average 25–70 μ in diameter, some being a little larger. The walls appear to be very thick, but this may be petrifact. The pits in the walls are just discernible, the details are not ascertainable owing to the poor preservation. *Wood-fibres* are roughly hexagonal, averaging 12–20 μ in diameter. Their walls are exceedingly thick and the lumen very small in most cases; they are pitted, but the nature of the pits is not clear. *Wood-parenchyma* may be present in small quantities. I have not been able to detect cells well enough preserved to be described.

A few of the elements immediately adjacent to the vessels appear to be parenchymatous and show contents.

Slight differences in shape, such as are illustrated in text-fig. 84, seem to be the only variations in the cells of the *medullary rays.* In transverse section their radial extension is generally small, only half as much again as their tangential diameter; in many cases this is less, and the cells are practically square. Their end-walls are nearly straight or at a slight angle, and even in the transverse section the heavy thickening and pitting of all the walls can be made out. Typical cells are illustrated at *m.*, text-fig. 84, where the end-walls are to be seen with well-marked thickenings and pittings of the type described



Text-fig. 84.—*Sabulia Scottii*, Stopes. Radial section showing the shape of a few of the ray-cells, with details of their pitting, *m.* Thickening and pitting of end-walls, *a.*, similar in type to the "abietinean pitting" of Conifers. No. V. 5654 *e.*

as "abietinean" when found in Gymnosperms. In a few of the cells there are indications of oval or round pittings of a larger size on the radial walls.

Affinities.—As was the case when I first described this specimen (Stopes, 1912), I do not feel in a position to draw any useful comparison between it and the woods of any definite living genus. Every detail of its structure is characteristic of the higher groups of woody Dicotyledons. The lack of "primitive" features in so early a plant is the chief interest of the specimen.

V. 5654. Small piece of petrified decorticated wood, now measuring only 2·5 × 2 × 3 cm., and the pieces from which the sections have been cut. In the largest piece the central pith, growth-rings, vessels, etc., can all be clearly seen with the naked eye.

V. 5654 a. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, pl. vi, fig. 2; and text-fig. 82, *ante*. Complete transverse section of above stem, showing all the features described. In the centre two distinct piths are to be seen, as a result of branching.

V. 5654 b. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, pl. viii, fig. 9; and text-fig. 83, *ante*. Transverse section similar to the above, but showing the pith still undivided. Locally this is rather better preserved than the other sections, and the details of vessels, wood-fibres, and medullary rays can all be made out. On the right-hand side of the section are the remains of another branch.

V. 5654 c. Transverse section very similar to the above, showing the pith of the smaller branch nearer to the axis than in section **a.**

V. 5654 d. Rather oblique tangential section of the above. The details are poorly preserved, but the height of the medullary rays can be made out. A small outgoing branch is well preserved in transverse section.

V. 5654 e. Figured, text-fig. 84. Radial longitudinal section passing through the pith. Locally the medullary ray-cells are fairly well preserved in radial section, and show their much thickened walls and pitting.

Lower Greensand, Woburn; Bedfordshire.

Transferred from the Botanical Dept., 1898.

Genus **HYTHIA**, nov.

As one species only of this type has been found, the species and genus are not separately diagnosed.

Hythia Elgari, sp. nov.

[Plates XXIX, XXX ; text-figs. 85, 86.]

Diagnosis.—Species founded on tho secondary wood, 14×8·9×22·4 cm. of which is petrified, probably part of a much larger trunk. A woody trunk forming timber of unknown girth, but evidently considerably more than 14 cm. in diameter. Growth-rings may or may not have been present. Wood consisting of fibre-tracheids, parenchyma, and isolated circular vessels uniformly distributed and averaging 50–70 μ in diameter. Medullary rays numerous, multiseriate, some of the rays very broad and conspicuous; ray-cells of at least two kinds, the majority of the cells being very much compressed and radially elongated and thin-walled. The shorter bordering cells of the ray with thickened and pitted walls, with groups of round to almost scalariform pits in the radial walls. Vessels irregularly pitted with round pits merging into scalariform pits.

Horizon.—Hythe Beds, Lower Greensand.

Locality.—Near Maidstone, Kent.

Type.—In the Maidstone Museum; a part of the type block and sections cut from it in the British Museum (Nat. Hist.), V. 13232 and V. 13232 *a, b, c, d, e, f, g*.

General Description.—The specimen consists of a good-sized block of secondary wood, measuring 14×8·9 cm. by 22·4 cm. long. It appears to be but a portion of a still larger woody trunk, and there is nothing to indicate the limits of the size it may have reached. The woody texture is now petrified in a fine and hard medium, but the woody fibre was evidently a good deal macerated, fungus-eaten, and softened before petrifaction, as can be seen by the extraordinary contortions of the medullary rays (text-fig. 85, and Pl. XXIX, fig. 1). These contortions obliterated any traces there may have been of growth-zones, so that I am unable to determine whether or not they were present. The angiospermic nature of the wood can be at once detected by the naked eye from the appearance of the weathered surface, where the broad rays are very conspicuous. Secondary wood alone appears to be present.

Topography of the Wood.—The salient characters of the wood are its numerous broad medullary rays and the slightness of the lignification of the vessels, fibres, etc. The wood must

Text-fig. 85.—*Hythia Elgari*, sp. nov. Cut surface of the end of the block showing the woody texture and the broad medullary rays, which are extremely crumpled owing to crushing before petrifaction. Block in the Maidstone Museum, part of it presented to the British Museum (Nat. Hist.), No. V. 13232. Nearly natural size.

have been very soft in texture. The vessels are fairly large, and are numerous, scattered chiefly singly but often in lateral pairs. Between them are small groups of thin-walled elements, apparently parenchyma, and a small number of wood-fibres with but slightly thickened walls. Owing to the presence of numerous fungal hyphæ, and to a rather curious type of petrifaction, there is reason to believe that the apparent delicacy of all the walls may be to some extent petrifact.

Growth-rings, if they were present, must have been rather wide, but they are obliterated by the excessive crushing of all the tissues prior to petrifaction.

Medullary rays are very numerous, apparently nearly all *multiseriate* with a large number of cells composing them, a dozen cells or more composing an average ray. The cells appear to be of at least two kinds, the majority being very much elongated radially and extremely narrow; the rays are bordered in many cases by oval shorter cells. So far as I can judge, all the narrow cells appear to be thin-walled, but evidence on this point is obscure. The rays are very high, rays up to 150 cells in vertical series and more being frequent.

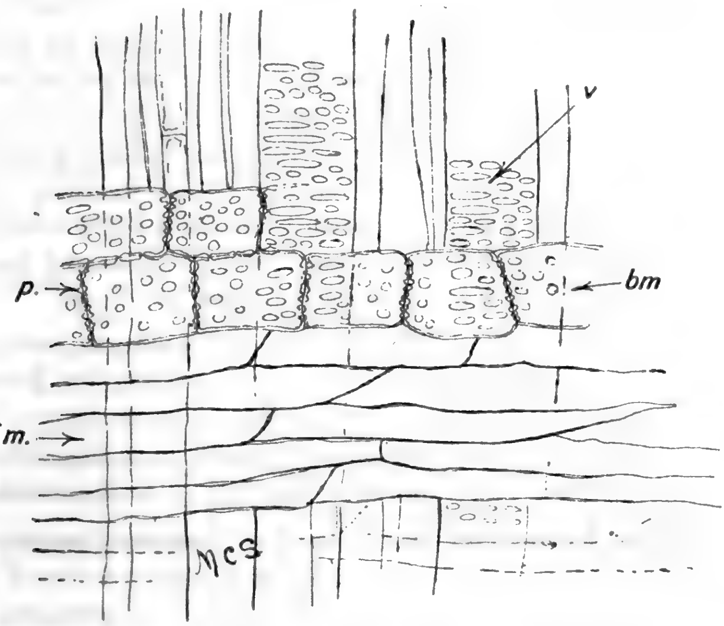
Details of the Elements.—The *wood-vessels* are now rather crumpled in most cases, but appear to have been roughly circular when alive. They average about 50–70 μ in diameter. The walls are now extremely slender, with barely any sign of lignification in transverse sections. In longitudinal section the pittings can be seen in many places (Pl. XXX, fig. 3). The pits are round, oval, or much elongated, so that they merge into a scalariform type here and there anywhere along the length of the vessel. These scalariform pittings are quite distinct from those well-marked scalariform end-walls found in so many species. *Tyloses* are to be seen in nearly all cases, filling the vessels.

The *wood-fibres* are inconspicuous, and have but slightly thickened walls. They are oval, hexagonal, or variously shaped, according to space demands, and have small intercellular spaces at their corners. They vary considerably, averaging roughly 8–20 μ in diameter. I am uncertain as to the nature of their pitting; a few seem to have roundish, slightly bordered pits.

Wood-parenchyma appears to be scattered in considerable quantities in the transverse sections, sometimes adjacent to the vessels.

Medullary ray-cells appear to be of at least two kinds:—(*a*) The majority of the cells are greatly elongated radially, very narrow, and with pointed ends in transverse section (Pl. XXX, fig. 2). These appear to be entirely thin-walled. (*b*) Bordering some of the rays, and forming the uniseriate termination to multiseriate rays, is a relatively small number of wider, short, oval cells. These have somewhat thickened and definitely pitted walls (text-fig. 86, *bm.*).

Affinities.—The general arrangement of the tissue, the broad and numerous narrower medullary rays composed of



Text-fig. 86.—*Hythia Elgari*, sp. nov. Radial section showing the cells of the medullary ray; *m.*, narrow elongated cells forming the bulk of the ray; *bm.*, broad, shorter, cells bordering the ray in some places with thickened and pitted walls, *p.*; *v.*, vessels showing the scalariform pits. No. V. 13232*f*.

pointed narrow cells, the scalariform pitting of the vessels and other details, are very suggestive of *Fagus*. On the other hand, in the species of *Fagus* which I have been able to examine, the ray-cells all have walls thickened to some slight degree at any rate, in which pits are visible; while in the fossil the majority of the ray-cells appear to be quite thin-walled, and thus to be in marked contrast to the shorter rounder cells which sometimes border the rays and have definitely pitted walls.

The tissues are not particularly well preserved in this fossil, thus adding to the difficulty of making a determination which carries conviction. While suggesting some possible affinity with *Fagus*, I feel that the affinities of this plant are an open question.

V. 13232. Two pieces from which sections have been cut, part of the original type block in the Maidstone Museum. The larger of the two pieces is 7 × 6 cm. in transverse section and about 3 cm. thick. It is the greater part of the lower third of text-fig. 85. One end is weathered and shows the rays weathered out so as to be visible to the naked eye; the other end shows the cut surface as illustrated in the figure. The woody texture is entirely free from matrix, and is petrified in a clean, very hard medium which weathers cream-coloured, and is grey with brownish streaks internally. The second, smaller, piece is quite similar and has had longitudinal sections also cut from two faces.

V. 13232 a. Figured, Pl. XXIX, fig. 1. Transverse section of the whole area of the larger block in the Museum, showing the much contorted wide medullary rays. At the bottom right-hand corner it is better preserved, and the vessels can be clearly seen with the naked eye.

V. 13232 b. Figured, Pl. XXX, fig. 1. Transverse section of a smaller portion of the same block. A small area towards the centre of the slide is iron-stained and shows the details more clearly than is usual in these slides. The broad rays are very conspicuous, and the numerous vessels, thickly scattered among the small-celled wood-fibres and parenchyma, can be well seen.

V. 13232 c. Figured, Pl. XXX, fig. 2. Another, rather similar, transverse section. In this the delicacy of the walls of the vessels and of the ground-tissue is very apparent. The long, very narrow medullary ray-cells can be well seen in transverse view, and here and there the shorter oval cells bordering the wide rays are also well preserved.

V. 13232 d. Figured, Pl. XXIX, fig. 2. Transverse section of a larger piece of the same block, very similar to the above. Locally the broad rays and the wood-elements can be well seen.

V. 13232 e. Figured, Pl. XXX, fig. 3. Oblique tangential section, in which the rays are cut in various directions and are rather obscure; in very many places, however, short lengths of the wood-vessels, and also of the rays in contact with them, show their pittings very clearly.

V. 13232 f. Figured, text-fig. 86. Rather oblique radial longitudinal section in which very numerous rays are to be seen, with the pitting frequently well-preserved. Numerous pitted vessels are also to be seen, and these are blocked in most cases by tyloses, the end-walls of which are noticeable in a low-power view of the wood.

V. 13232 g. Tangential longitudinal section of the wood showing clearly the great height of the multiseriate broad rays.

Permeating all the above sections, and in particular the cells of the medullary rays, are immense numbers of beautifully petrified fungal hyphæ. There are also structures suggestive of fungal fructifications, particularly in the tangential view of the medullary rays of the wood.

Hythe Beds (Lower Greensand); near Maidstone, Kent.

Presented by the Committee of the Corporation Museum, Maidstone, 1915.

Genus **APTIANA,** Stopes.

[Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, p. 84, 1912.]

As only one species of this genus was known when it was originally described, and as botanists are not yet in a position to determine which features in angiospermic wood-anatomy are of generic and which of specific importance, the species and genus were not separately diagnosed.

Aptiana radiata, Stopes.

[Text-figs. 87–92.]

1912. *Aptiana radiata,* Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, pp. 84–91, pl. vi, figs. 1, 3, 4, 5; pl. vii, fig. 6; pl. viii, figs. 10, 11; text-figs. 1–5.

1912. *Aptiana radiata,* Janssonius & Moll, Proc. Sect. Sci. K. Akad. Wetenschap. Amsterdam, pp. 623–626, text-fig. 1.

Diagnosis.—The species is founded on a stem, or branch, 3·5 cm. in diameter. Primary wood without marked bundles; secondary wood with growth-rings, and consisting entirely of fibre-tracheids with bordered pits, and of singly placed vessels which are so arranged as barely to disturb the radial rows of the fibre-tracheids and average 20–40 μ in diameter. Wood-parenchyma, if present, scanty, and arranged beside the vessels tangentially spanning the space between the rays. Medullary rays numerous, multiseriate and uniseriate, the uniseriate rays principally only two wood-fibres distant. Multiseriate rays principally 3–4 cells wide, never running through a complete radius of the stem, but dwindling to uniseriate rays or dying out entirely; those reaching the phloem expand to funnel-shaped ends. Cells composing the rays of various types, end-cells often much drawn out vertically. The phloem composed of sclerised elements and of soft cells in irregular alternating patches.

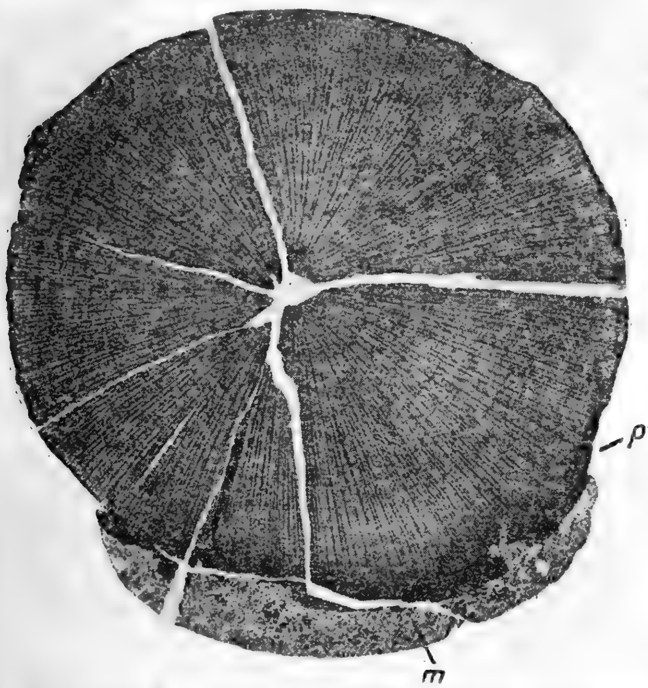
Horizon.—Lower Greensand.

Locality.—Probably Luccomb Chine, I. of Wight.

Type.—V. 11517, and sections V. 11517 *a, b, c, d, e, f, g, h,* cut from it in the British Museum (Nat. Hist.).

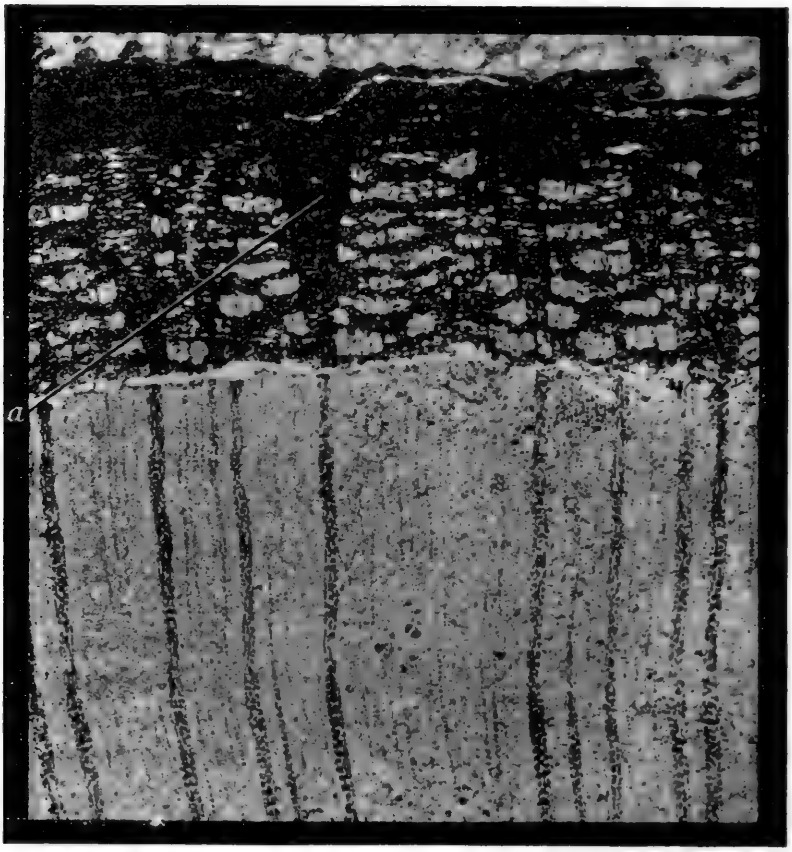
General Description.—A short length (about 3 cm.) of the stem is petrified in a dark medium in the coarse, glauconitic sandy matrix characteristic of the Luccomb Chine and Shanklin plant-beds in the Lower Greensand. The side of the specimen, which is still embedded in the matrix, has the phloem and part of the cortex preserved outside the wood (text-figs. 87, 88); the centre of the stem is also present, so that the specimen is unusually complete and its true diameter is known (4 × 3·5 cm.). Petrified woods with their phloem and bark preserved are among the rarest of fossils. The details of the elements are also exceptionally well petrified, as can be surmised from text-fig. 90, though no illustration can do justice to the beauty of the actual sections. One end of the block is weathered out, and the wood-texture with the broad medullary rays can be seen with the naked eye: in the cut surface the broad rays and the phloem zone can be seen clearly, but the growth-rings and the vessels are too fine to be detected with the naked eye.

Topography of the Stem.—The *pith* was central and apparently nearly circular. The stem was broken through the middle before cutting (text-fig. 87), so that fragments only of the pith remain. The *primary wood* does not form very pronounced bundles round it. The *secondary wood* is very small-celled and



Text-fig. 87.—*Aptiana radiata*, Stopes. Transverse section of the stem, × 1¾ diameters, showing the rays. The black zone at *p.* is phloem; *m.*, the granular matrix. After Stopes.

remarkably uniform in structure. *Growth-rings* are clearly recognisable, but, as they do not strikingly disturb the arrangement of the elements, the limits of some of the outer rings are a little uncertain. There appear to be 28–30 growth-zones in the wood, averaging about ·6 mm. thick. The *vessels* are small, and generally arranged so as not to disturb the regular radial sequence of the wood-fibres. The vessels are nearly all isolated, a few being in pairs. Vessels are uniformly distributed, rather larger toward the inner zones of the growth-rings. The regular texture of the wood and small size of the vessels can be seen in text-figs. 89, 90. Text-fig. 89 should be compared with text-fig. 80, which is on exactly the same scale of magnification, to show the more usual relation between vessels and fibres. The *wood-fibres* (fibre-tracheids) are arranged with remarkable

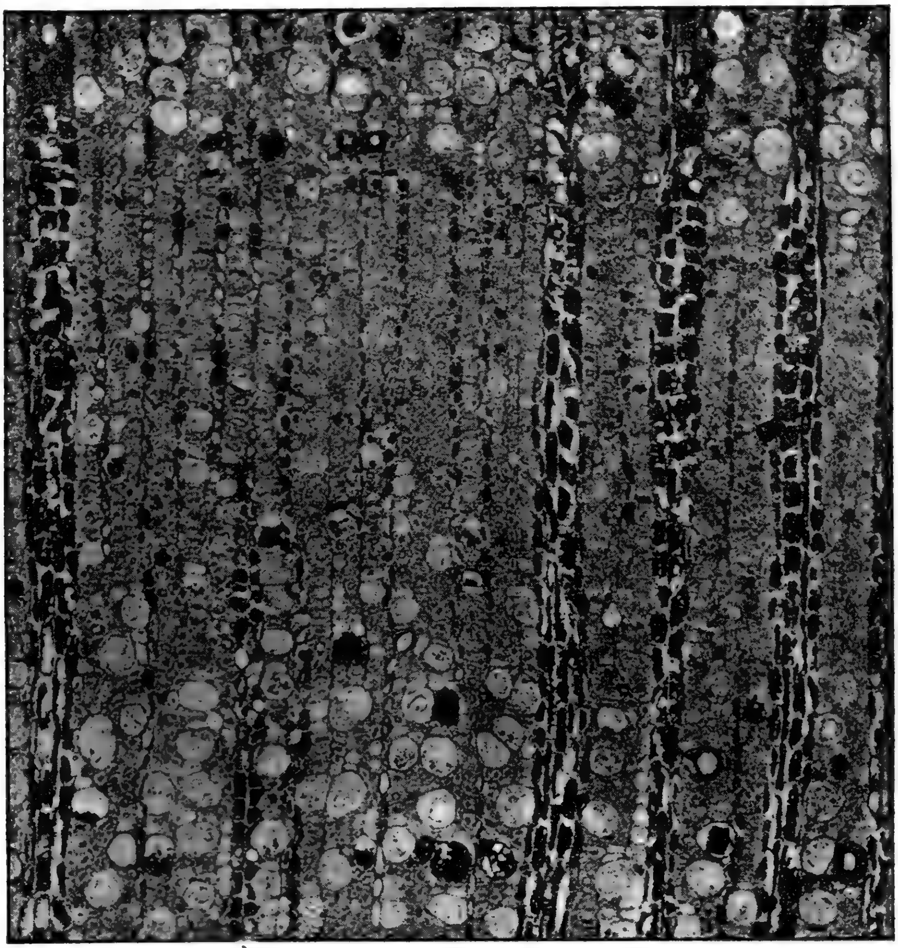


Text-fig. 88.—*Aptiana radiata*, Stopes. Transverse section of outer part of the stem, showing the wood with the multiseriate rays extending into the phloem, where they end in funnel-shaped expansions, *a*. After Stopes.

regularity in radial rows (text-figs. 89, 90), and are principally squarish or rectangular in shape.

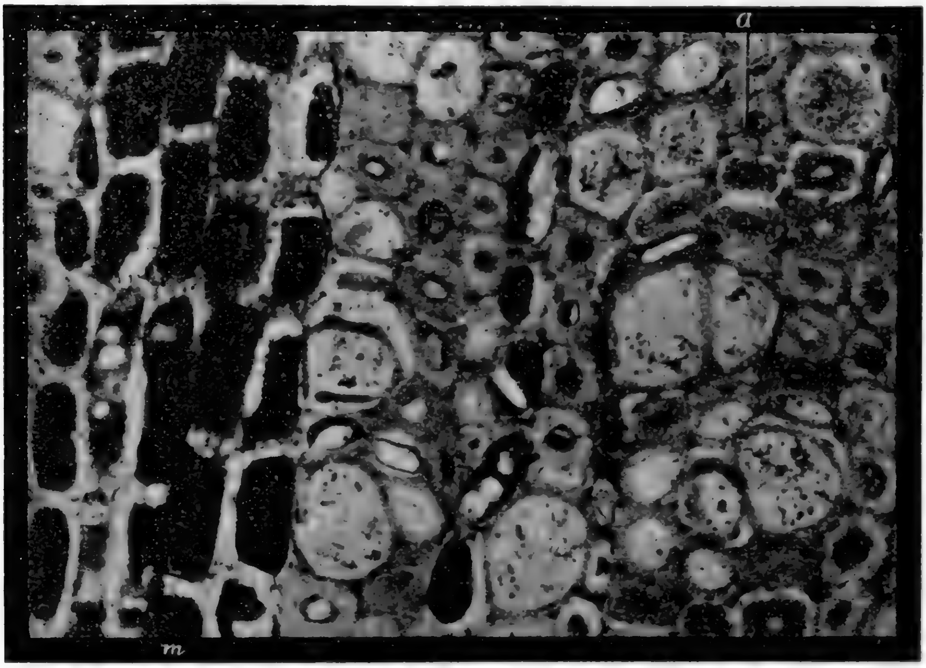
Wood-parenchyma is almost, if not entirely, absent—the nature of the petrifaction makes it impossible to determine this point absolutely. Some elements lying adjacent to the vessels and linking two medullary rays may be parenchyma (see Stopes, 1912, text-fig. 1).

Medullary rays are very numerous and conspicuous. The *multiseriate* rays are principally about 4 cells wide and a dozen or more cells high. None of these rays run for any great radial extent in the wood, but become uniseriate or die out altogether (text-fig. 89, *md.*). Those which reach the phloem expand



Text-fig. 89.—*Aptiana radiata*, Stopes. Transverse section of the stem showing the texture of the wood, with its small vessels, and fibre-tracheids in regular rows. The broad medullary rays, *m.*, are conspicuous, the ray *md.* is seen to be dying out to a uniseriate ray. [Note that this and fig. 80 are magnified exactly the same amount, showing the great contrast between the two woods.]

there to broad funnel-shaped ends (text-fig. 88, *a.*). *Uniseriate rays* are innumerable, lying generally only two, or even one, wood-fibre series distant. The cells composing the rays are all rather thick-walled and pitted, their shape and character being very various, and the end-cells of the multiseriate rays sometimes being extremely elongated vertically. *Cambium* is preserved in places, and is quite normal. *Phloem*, 1·5 mm. thick, is preserved and is composed of irregularly alternating masses of stone and soft cells (text-fig. 88). A little very much crushed *cortex* is preserved, in which no true cork is identifiable, though there is a suggestion of its presence.

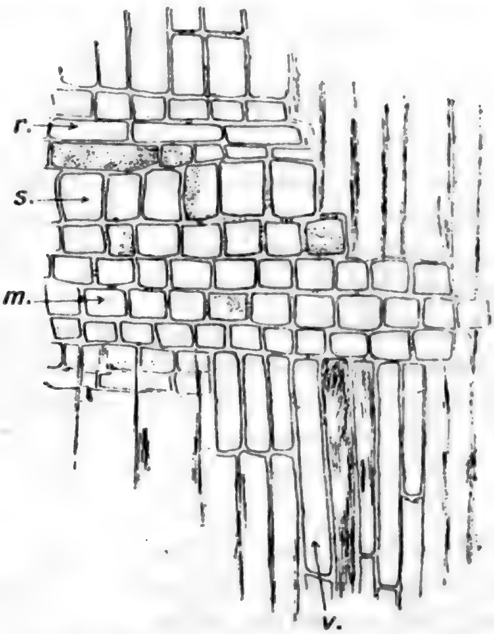


Text-fig. 90.—*Aptiana radiata*, Stopes. Transverse section of a small part of the wood enlarged, showing the small vessels little larger than the wood-fibres. At *a.*, a fibre-tracheid shows the pit-canal of a bordered pit in each of its walls. *m.*, the thickened and pitted cells of the medullary ray. × nearly 500.

Details of Elements.—The pith-cells appear to have been uniform, roughly circular, averaging about 30–40 μ, with some larger cells toward the centre. The smaller peripheral elements merge imperceptibly into the bundle-sheaths of primary wood. The *primary wood-elements* in transverse section consist of small cells with thickened walls, in which true vessels are not recognisable. As the radial sections do not pass through the primary wood, the nature of the protoxylem-walls cannot be determined. In the *secondary wood* the *vessels* are often but little larger than the wood-fibres of the radial series in which they lie (text-fig. 90). They are generally roughly circular, with slightly flattened sides. The larger vessels are a little more irregular, but also roughly circular, and average about 20–40 μ, principally about 30 μ in diameter. The walls are thickened, but not remarkably so, the lignified walls thinner than those of the adjacent wood-fibres. The majority of the walls have *scalariform* perforations; locally these may merge into scalariform-like oval pits, and here or there, finally, into roundish and more irregularly placed pits. The assumption of Janssonius and Moll (1912, p. 625), that the scalariform pitting is only on the end-walls, is incorrect, as also is their statement that the end-walls are "very obliquely placed." Where they can be seen in the actual fossil, the end-walls seem to be placed at a rather unusually high angle, thus giving the vessels blunt instead of very elongated ends.

The *wood-fibres* (fibre-tracheids) vary considerably, but on the whole tend to be squarish or rectangular, averaging $15 \times 10\ \mu$ in diameter, a few nearly 20 μ. The radial is generally less than, sometimes only half, the tangential diameter. Walls greatly thickened, so that the lumen is only one-third or less of the whole diameter (text-fig. 90). The walls are perforated by numerous round *bordered pits*, in both the tangential and radial walls. These are seen remarkably well in transverse section (text-fig. 90, *a.*), where a single section of a cell may show as many as four pits, one in each of its walls. Vertically, the pits lie in a single row or in two rows here and there, and each pit in the radial walls is separated from its neighbours roughly by its own diameter.

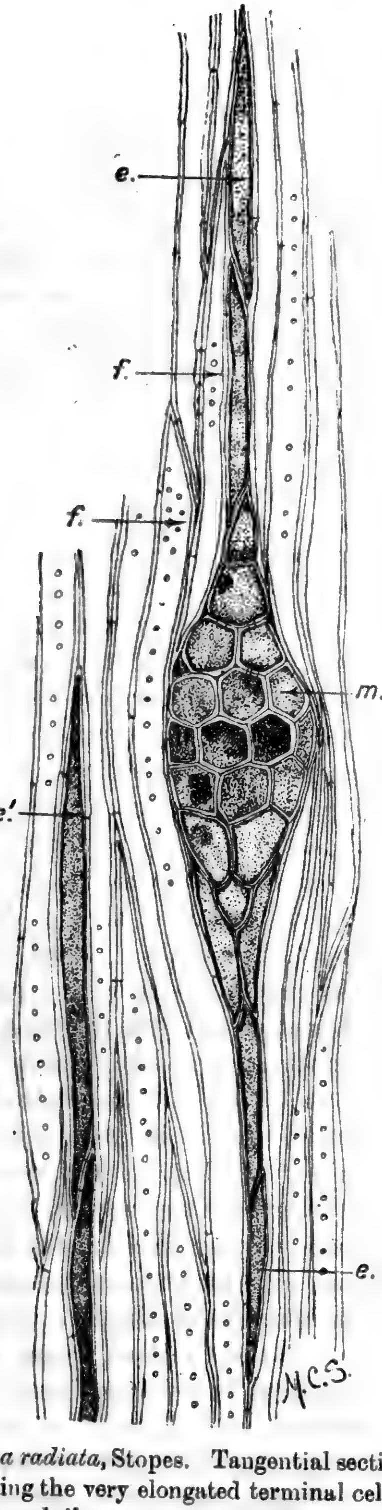
The *medullary rays* consist of elements all of which have thickened walls with numerous simple pits. The cells are all closely adjacent, entirely without intercellular spaces. The various cells differ considerably in shape and size (text-figs. 91, 92). Some being nearly square in radial, and hexagonal in tangential section (*m.*), others being rectangular and elongated either vertically or horizontally (*r.* and *s.*), while the end-cells are extremely elongated vertically (*v.*, *e.*), and show very striking lens-shaped cells in the vertical section (text-fig. 92, *e.*). These cells may be even more elongated than is shown in the figure; in the actual sections some are three times as long as the limiting cells illustrated. The appearance of these cells in the tangential section is very striking. They frequently measure 250 μ and more in vertical extension. The *phloem* elements of the *soft bast* are so much crushed that their details cannot be described. The soft cells are in groups of numerous cells, apparently tangentially extended. The *hard bast* forms clusters of two or three up to twelve elements, most of which are



Text-fig. 91.—*Aptiana radiata*, Stopes. Radial longitudinal section of part of a medullary ray showing: *m.*, ordinary ray-cells, with thickened pitted walls, without intercellular spaces; *s.*, larger square cells; *r.*, radially elongated cells; *v.*, vertically elongated cells—all with thickened pitted walls. No. V. 11517 *b*.

irregularly hexagonal in shape with walls so much thickened that the lumen is almost obliterated.

Affinities.—The original account of the affinities of this fossil (Stopes, 1912, pp. 90–91) premised that it was impossible conclusively to identify it with any living genus, and consequently a non-committal name was given to the specimen.



Text-fig. 92.—*Aptiana radiata*, Stopes. Tangential section of a small multiseriate ray, showing the very elongated terminal cells. *f.*, wood-fibres; *m.*, main cells of medullary ray; *e.*, end-cells of the ray, spindle-shaped and very much elongated; *e.*[1], end-cell of a neighbouring ray, the main extension of which is out of the figure. × nearly 500. No. V. 11517 *g.*

From this conclusion Professors Janssonius & Moll (1912) dissented, and stated that, had I used their system of "Linnean description" for the new fossil, it would have been apparent that it belongs to the living family Ternstrœmiaceæ, if not actually to the species *Eurya acuminata*. From their account of the *wood only*, it is true that there is evidently a considerable likeness between this genus and *Aptiana*; but, when *all* the details are taken into consideration, the likeness does not seem to be greater than I already noted to some species of *Lonicera*, *Viburnum*, *Magnolia*, or *Liriodendron*.

While I have benefited greatly by the example of their careful and detailed descriptions, I cannot accept the confident conclusions of Janssonius and Moll regarding *Aptiana*. Detailed comparison of sections of *Eurya acuminata* and other species of the genus with the fossil shows that, particularly in the longitudinal sections (where the horizontal cross-walls of numerous parenchyma and medullary ray-cells are conspicuously unlike the fossil), the general appearance of the two plants is very different. A more important difference is the character of the end-cells of the medullary rays. The excessively long end-cells of the ray in *Aptiana* (250 μ and more) are not present in such material of *Eurya acuminata* as I have been able to cut myself, nor are they described in Moll & Janssonius' (1906, p. 302) own account of the species. I am much indebted to Prof. Moll for kindly providing me with a piece of material of *Eurya* larger than I was myself able to obtain.

So far as my experience goes, these excessively elongated end-cells of the rays are rather an unusual feature in angiospermic woods. In the several hundreds of woods which I have examined, I have observed them in less than a dozen species. In this respect, of the woods known to me, *Cliftonia ligustrina*, *Viburnum rufotomentosum*, and *Ilex decidua* approach the fossil most nearly. Indeed, save for the larger size of its vessels, the wood of *Cliftonia* is remarkably similar. *Cliftonia* is a small, rather isolated genus of the Cyrilleæ, living in the swamps of Florida, so that, without convincing proof, one would not identify the fossil with it.

In consequence of the above and many other considerations, it appears premature to locate *Aptiana* in any one living family.

V. 11517. The original block, now in five pieces, from which sections have been cut. The specimen is dark in colour, and partly embedded in the coarse granular matrix. One end is weathered and shows the broad rays and wood-texture. The diameter of the wood alone is about 3·5–3·8 cm.; in addition there are 1·5 mm. of phloem and cortex on the side which is embedded in the matrix. In the cut face, the broad medullary rays form a striking feature obvious to the naked eye.

V. 11517 a. Transverse section of the above, from which the phloem has been ground off in the cutting. All the described features of the wood can be observed in the well-preserved tissues.

V. 11517 c. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, pl. vi, figs. 3 & 4; pl. vii, fig. 6; pl. viii, fig. 10: also text-figs. 87, 89, 90, *ante.* Transverse section similar to the above, but showing the phloem preserved in the granular matrix. The section has unfortunately begun to split and float about within the balsam, but large areas of it still show the exquisitely petrified details of the elements. The bordered pits of the fibre-tracheids and the medullary rays are particularly fine. On the upper end of the section the cambium-layer between the xylem and phloem is preserved unbroken.

V. 11517 d. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, pl. vi, fig. 1: also text-fig. 88, *ante.* Transverse section very similar to the above. The funnel-shaped expansions of the medullary rays and stone-cell groups in the phloem are shown, particularly clearly at the right-hand bottom corner of the slide.

V. 11517 b. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, pl. viii, fig. 11, text-fig. 3: also text-fig. 91, *ante.* Radial longitudinal section showing very well the details of the broad rays, with their various types of cells. Locally, the pits of the wood-fibres and the vessels can be seen, but they are not very well preserved. The section passes through the phloem.

V. 11517 h. Radial longitudinal section similar to the above, but less well preserved locally. The scalariform pitting of the vessels can clearly be seen in several places.

V. 11517 f. Figured, Stopes, Phil. Trans. Roy. Soc. Lond., ser. B, vol. 203, 1912, pl. vi, fig. 5. Tangential longitudinal section, showing very clearly the broad multiseriate rays and the fusion of these rays.

V. 11517 g. Figured, text-fig. 92. Tangential longitudinal section similar to the above, showing extraordinarily well the elongated lens-shaped cells which terminate the broad rays.

V. 11517 e. Tangential longitudinal section similar to the above, but less well preserved.

Lower Greensand ; ? Luccomb Chine.

Transferred from the Botanical Dept.

APPENDIX.

The following species are not included in the body of the descriptive text because their age is rather doubtful. Though they were found in the "Potton Sands," which are of Lower Greensand age, it is generally held that Potton fossils of the colour and texture of these (a rich red-brown limonite) are derived from the Wealden.

They are included in the present volume not only to complete the account of the fossils found in the Lower Greensand, but also because they afford new evidence regarding the hitherto neglected anatomy of *Cycadeoidea* as distinct from *Bennettites* (see p. 23).

Genus **CYCADEOIDEA**, Buckland.

[Proc. Geol. Soc., vol. 1, no. 8, 1828, pp. 80, 81; and Trans. Geol. Soc., ser. 2, vol. 2, 1828, pp. 395-401.]

Diagnosis.—Genus founded on vegetative trunks, which are of uncertain height, some conical or ovoid, some cylindrical, covered by closely arranged leaf-bases, generally rhombic in shape, which may or may not be transversely elongated. In its internal anatomy the trunk shows two or more (up to eight are recorded) zones of secondary wood, the zones composed of distinct series of tracheids each more or less regularly arranged in radial sequence. Pith very large, with gum-canals, but no vascular strands.

In the above diagnosis, which is provisional until more is known of the fossils, the clear distinction between *Cycadeoidea* and *Bennettites* is presented for the first time.

Much confusion has existed on the subject of the nomenclature of the Cycad-like fossil trunks since 1828, when Buckland founded the genus *Cycadeoidea*, followed almost at once by Brongniart's genus *Mantellia*. Many other so-called genera have since been founded, e. g. *Yatesia*, Carr., *Clathraria*, Schimp., etc., but these are generally recognized as being based more on differences in the preservation than in the actual structure of the trunks, of which the anatomy is almost unknown. As the nomenclature has been frequently considered at length (see Berry 1911, Wieland 1908, 1906, Seward 1895, Solms-Laubach in Capellini & Solms 1892, Carruthers 1870, etc.), there is no need to recapitulate the discussions. At present it suffices to say that of all the proposed names only two remain important, namely *Bennettites* and *Cycadeoidea*. The latter name was proposed by Buckland, and in his description of the two fossils which are the types of the genus, he was dealing with *vegetative structures* only. In his account, as in his figures, there is no indication of the fructifications of these "cycad-like" plants.

In 1870, Carruthers demonstrated the unique and peculiar fructifications of certain fossils of a different geological age, but of rather similar external appearance. The differences between these fructifications and those of any previously known fossil were ordinal; and Carruthers named his new fossils *Bennettites*, placing them in a tribe named the Bennettiteæ. Since that date, British botanists have called the fossils with this peculiar type of fructification *Bennettites* (Scott 1909), but the Americans have assumed the identity of this type with the original *Cycadeoidea* of Buckland (Ward 1894 B, Wieland 1906, 1908, Berry 1911, etc.)—an assumption which the present work demonstrates is unwarranted, as Buckland's type has anatomical features which are not found in *Bennettites*. That being the case, the two names, *Cycadeoidea* and *Bennettites*, may both be used, but they stand for different things.

It is unfortunate that both the type-specimens of the two species on which Buckland founded his genus *Cycadeoidea* are lost. It is said that they formed part of the original Sowerby collection. Most of this collection was purchased by the Museum, but neither of these types is among the specimens. Buckland's descriptions (1828 A), also, are not sufficiently precise regarding points about which information is most desirable; nevertheless, both in his plate 49, figs. 1 & 2, and in his description, he makes it clear that his *C. microphylla* had two distinct secondary woods, and not a single wood-ring as in *Bennettites*.

He says (p. 398): "The trunk is longer in proportion to its width, whilst its transverse section exhibits at the centre the same indistinctly cellular appearance as the species last described; but near the circumference instead of one *it has two laminated circles, and exterior to each of these a narrow band devoid of laminæ, analogous to the two bands of cellular substance that are placed in similar relation to the two laminated circles in a recent* Cycas." It is curious that this important and interesting feature in the anatomy of the type of *Cycadeoidea* has been overlooked by writers who discuss the nomenclature of the Cycadophyta as though *Bennettites* and *Cycadeoidea* were identical. In Buckland's figure of the external features of *Cycadeoidea microphylla* there is no sign of cones among the leaf-bases, and there is nothing to show that its fructification resembled that of *Bennettites* in any particular.

Nevertheless, many of the "Cycad" stumps from Portland, which later writers have identified as belonging to Buckland's genus, have undoubtedly embedded cones of the *Bennettites*-type. These trunks are rightly included in the same genus as Carruthers's *Bennettites Gibsonianus*, whether it be called *Bennettites* or *Cycadeoidea*. The weak point in the argument of those who call these specimens *Cycadeoidea* is their assumption that such fruiting specimens are really identical with the original trunks described by Buckland, who quite clearly described and illustrated vegetative features in *C. microphylla* which differ from those of the *Bennettites*-type. Under the circumstances it seems to me invalid to identify any fruiting specimen as *Cycadeoidea*, Buckl. It is clear that the great majority of the Portland (as of the American) trunks are species of *Bennettites*.

Owing to the loss of Buckland's type-specimens, and the consequent uncertainty regarding their characters, an arguable case might be made out for dropping the generic name *Cycadeoidea* altogether, though the two specimens about to be described strengthen the arguments for its retention.

The two species of *Cycadeoidea* now described both show two or more rings of wood, thus agreeing with Buckland's type and differing from *Bennettites*. The numerous magnificently preserved American species of *Bennettites* (named by Wieland 1906, etc., *Cycadeoidea*) show the remarkable uniformity of character in the numerous species of the genus, and the similarity in both vascular anatomy and fructification between the American and the European species. An exception to the general rule of a single slender woody cylinder in *Bennettites* is Wieland's *Cycadeoidea Jenneyana* (Wieland 1906, p. 78), in which there is a strong woody cylinder "as extensive and compact as that of *Cordaites*." Unfortunately the illustration given is only a small-scale (reduced by ½) macroscopic photograph of the polished trunk-surface, and no microscopic sections appear to be described. So far as can be judged by an examination of Wieland's plate with a lens, I think his alternative suggestion is the correct one, and that "there has actually been a persistence of the primary cambium with seasonal augmentation of the secondary xylem." But without microscopic sections nothing definite can be deduced from this most interesting form. As the fructifications of *C. Jenneyana* also show some rather important differences from the usual *Bennettites* type, it is probable that it should form the basis of a new genus. Its wood, "extensive and compact as that of *Cordaites*," differs notably both from the single slender cylinder of *Bennettites* and the series of cylinders in *Cycadeoidea*.

Wieland, in a footnote to his p. 78, recognises that anatomical features of this magnitude "are of generic value," and he allows that if the stem-anatomy of Buckland's original *Cycadeoidea* were shown to differ from that of *Bennettites*, "then the genus *Bennettites* is perfectly valid, although for other reasons than those that have hitherto been assigned." A demonstration of essential anatomical differences between *Bennettites* and *Cycadeoidea* being now made, it becomes clear that the name *Bennettites* must be applied to the numerous American specimens of which the well-petrified stems and fructifications are identical with *Bennettites* in all important respects.

Regarding the fructifications of the true Cycadeoideas nothing is known. One of the species now described in detail, and originally recorded by Carruthers (1867) as *Cycadeoidea Yatesii*, was later (1870) put by him in his new genus *Yatesia* (under the name *Yatesia Morrisii*), and the genus *Yatesia* was credited with having "a cone, each carpophyll of which bears two reflexed ovules." The evidence Carruthers gives for this (p. 688) appears to me to rest on so many assumptions that it is valueless, his two principal reasons being: 1st, the structure of the stem appears to *require* deciduous axillary appendages for the organs of reproduction ; 2nd, one of these cones " (*Cycadeostrobus Walkeri*, Carr.) has been found in the same stratum in which the stem of *Yatesia Morrisii* is found." It is now realised how weak is the evidence based on chance association of rare specimens, and in the actual specimens of *C. Yatesii* there is no sign of any fructification, nor are there any features in the stem or leaf-bases which could serve as a justifiable basis for theoretical re-constructions of its fruits.

Cycadeoidea Yatesii, Carruthers.

[Text-figs. 93–97.]

1867. *Cycadeoidea Yatesii*, Carruthers, Geol. Mag., vol. 4, pp. 199–201, pl. ix, figs. 1 & 2.
1870. *Yatesia Morrisii*, Carruthers, Trans. Linn. Soc. Lond., vol. 26, p. 688, pl. lv, figs. 3–6 ; pl. lx, fig. 13.
1874. *Yatesia Morrisii*, Schimper, Trait. Paléont. Vég., vol. 3, p. 555.
1895. *Yatesia Morrisii*, Seward, Cat. Mesoz. Plants, Wealden Flora, vol. 2, pp. 166–7.

Diagnosis.—Species is founded on vegetative trunks showing pith, wood, and leaf-bases ; the inner tissues petrified to show imperfectly preserved anatomical details. Trunk cylindrical, relatively slender for its height, measuring not less than 25 cm. long and 12 cm. in diameter, the axis in this length being quite straight, without any sign of termination or reduction, and having every appearance of having been much longer. Petiole-bases closely arranged in compact regular spirals completely covering the stem. Petiole-bases mostly very regular and uniform in size, measuring 1·8–2 cm. in transverse and 1·6–2 cm. in vertical direction ; some few are less and others more than this. Where it is not worn down, the petiole-base terminates in a rounded tumid boss, directed upwards. Between the petiole-bases the ramental (?) zones are narrow. The pith is very large, as much as 8 cm. in diameter in a stem only 12 cm. in diameter including the outermost leaf-bases. Surface-cast of pith shows deep grooves and ridges, with lenticular ridges due to the broad rays between vascular strands. Two slender wood-cylinders surround the pith, each about 5–8 mm. thick, and composed of radiating zones of secondary wood and between them a zone about 2·5 mm. thick of different tissues (phloem ?). Tracheids in close regular series, averaging up to 30–40 μ in diameter, sometimes as many as 4–5 tracheid-rows adjacent. Round bordered pits in radial walls of the tracheids are chiefly in one, sometimes two alternating rows. [Carruthers describes the tracheids as having 2 or 3 rows of "disks"

Text-fig. 93.—*Cycadeoidea Yatesii*, Carr. Drawing of external view of part of the trunk: type-specimen. *a.*, the persistent leaf-bases; *b.*, the outer face of the second wood-zone, showing lenticular scars due to leaf-traces; *c.*, the corrugated surface of the cortical zone. × about $\frac{2}{3}$. After Carruthers. No. V. 13238.

(bordered pits). I have not been able to confirm this.] Cortex narrow, and leaf-bases not massive in radial thickness.

Horizon.—"Potton Sands," Lower Greensand; probably derived from Wealden.

Locality.—Sand-pit, just outside Leighton Buzzard.

Type (V. 13238).—Specimen transferred to British Museum (Natural History), by Royal Agricultural College, Cirencester, 1915.

General Description.—There are twelve more specimens of this species, all found in the same deposit and all identical in colour and texture, being petrified in a dark limonite, very close and heavy and quite opaque in most cases where sections have been attempted. Three at least of these specimens resemble each other so much that it is certain that they represent parts of the same individual, which must have been much longer than the type-specimen, and consequently much exceeding the length given in the diagnosis.

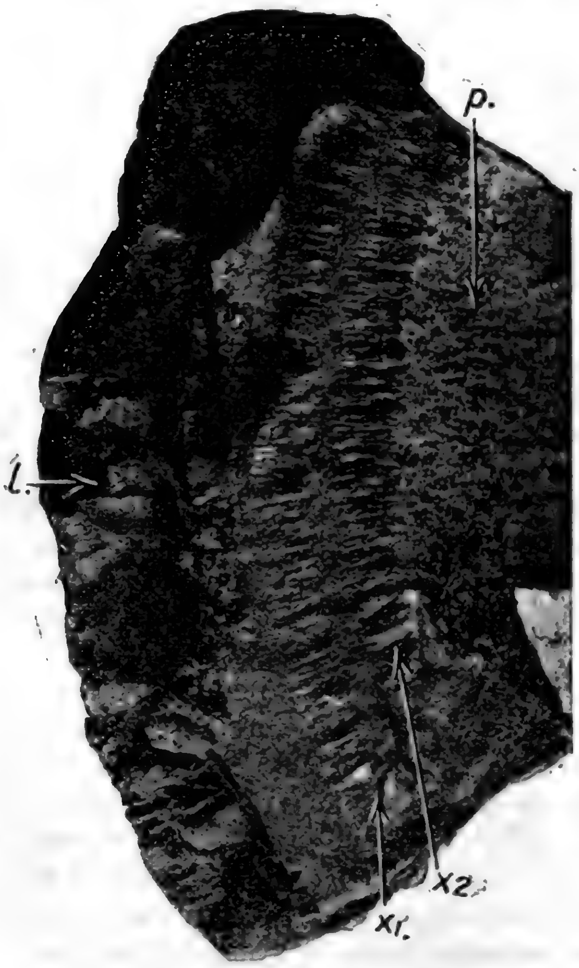
There is every indication that the trunks were straight and relatively slender, and not like the rounded massive trunks of many *Bennettites*. The pith is very large for the diameter of the trunk, but shows no sign of vascular strands within it, the statement of Carruthers that it was "permeated with vascular bundles" being probably due to the deceptive appearance of the pseudo-concretionary matrix toward the centre, which to the naked eye has an effect very similar to the central strands of a *Medullosa*.

The pith measures up to 8 cm. in diameter, and is a straight unconstricted mass. Externally, as is seen in specimen 47049 (text-fig. 94), the primary bundles and broad medullary rays give rise to the lenticular ridges and groovings which are so characteristic of pith-casts in this family. The tissue composing the pith (see section V. 5219 *a*), which is poorly preserved and is generally wanting, appears to have been a uniform mass of unspecialised parenchyma, in which circular cavities suggest the remains of gum-canals.

The *wood* is in two distinct rings, each from 5–8 mm. in radial thickness and apparently formed from distinct cambiums (text-figs. 94 & 95). They can be clearly recognised in the broken ends of most of the specimens, even with the naked eye. Owing to the opaque nature of the matrix but little can be seen in microscopic section in most cases, but in the slides of V. 5219 patches show the regular radial rows of tracheids;

sometimes single rows separated by medullary rays, sometimes as many as 4 or 5 tracheid-rows adjacent (text-fig. 96).

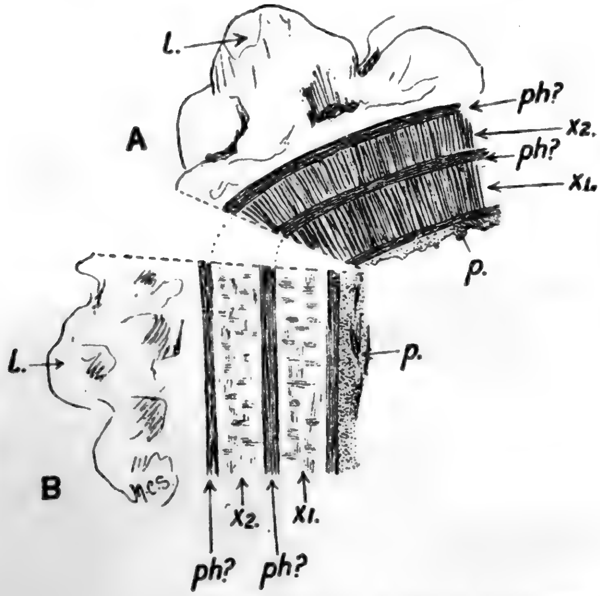
The *tracheids* are squarish or oblong, measuring up to about 30–40 μ in diameter (text-fig. 96). In longitudinal direction they are still more opaque, but in a few cases bordered pits



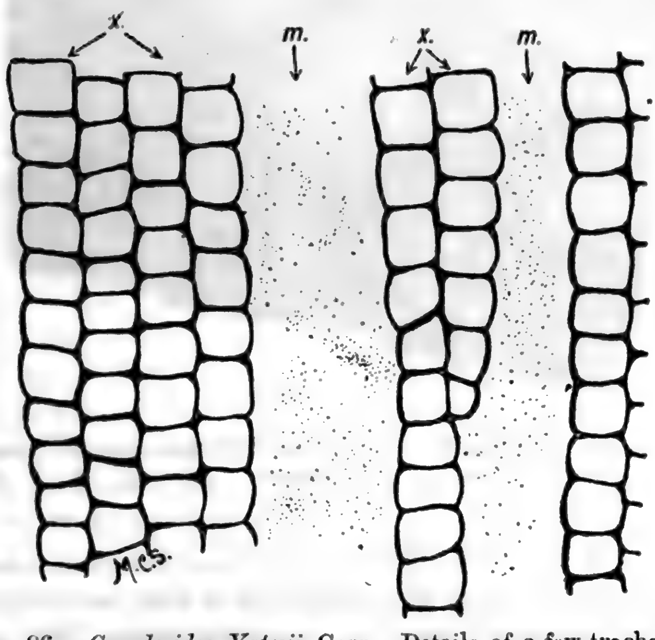
Text-fig. 94.—*Cycadeoidea Yatesii*, Carr. End of a specimen broken across showing the two rings of wood, x_1, x_2, and the wide pith-cast with ridged inner surface, *p.*; *l.*, leaf-bases. Nat. size. No. 47049.

(circular) can be seen. The two rows of bordered pits described by Carruthers are sometimes present.

Between the wood-rings and outside the second wood-ring are zones of different tissue about 2–2·5 mm. in thickness. This



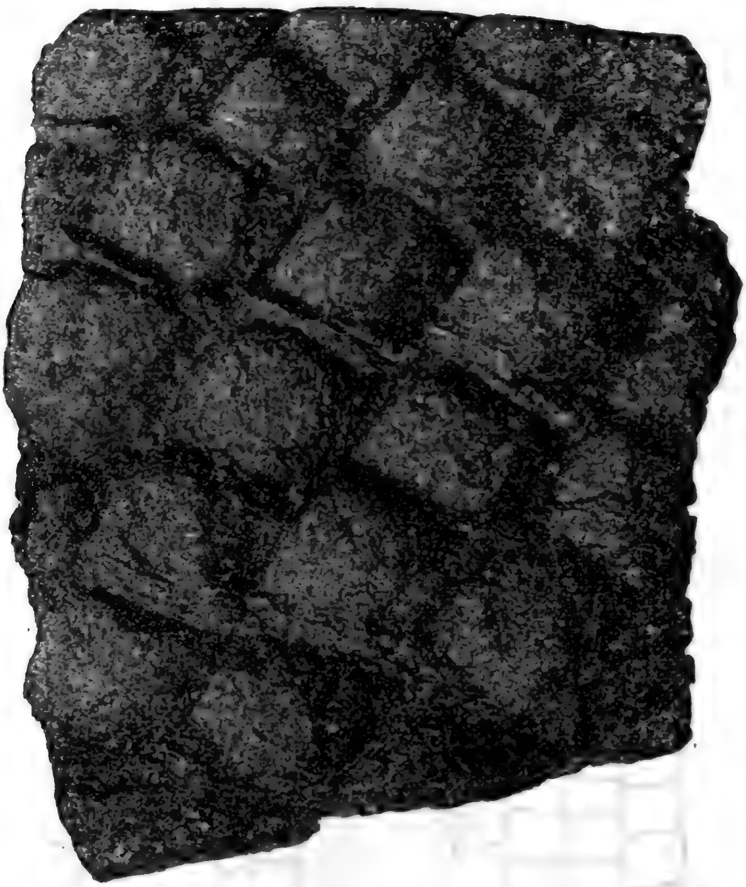
Text-fig. 95.—*Cycadeoidea Yatesii*, Carr. Drawing of a small portion of the broken end of the stem, A in transverse, B in radial longitudinal direction. *l.*, leaf-bases; *ph.*, phloem ?; x_1 and x_2, separate concentric rings composed of radial series of secondary tracheids; *p.*, pith.



Text-fig. 96.—*Cycadeoidea Yatesii*, Carr. Details of a few tracheids from one of the wood-rings. *m.*, medullary rays, of which no cells remain; *x.*, rows of secondary tracheids. No. V. 5219 *a*.

is presumably phloem; when weathered or very slowly eaten out with acid, the difference in texture between this zone and the wood is apparent (text-fig. 95, *ph.?*).

The *cortex* is a very narrow zone; where the leaf-bases are broken away, it is deeply corrugated with lenticular grooves (text-fig. 93, area *c*).



Text-fig. 97.—*Cycadeoidea Yatesii*, Carr. Surface-view of a specimen showing the regular squarish leaf-bases. Nat. size. No. V. 9383.

The *leaf-bases* are not massive, in a radial direction measuring only about 2 cm. They vary somewhat in size, but are typically almost square in surface-view, measuring about 1·8–2 × 1·6–2 cm. in horizontal and vertical diameters. This shape and appearance is largely due to the covering zones of ramentæ (?)

between adjacent leaf-bases; where they are broken away, the narrow lateral extension of the leaf-base can be seen.

Affinities.—In his description of this specimen Carruthers (1867 a) merely said "it must be referred to Buckland's genus *Cycadeoidea* = *Mantellia* Brongn." Carruthers notes that "the woody cylinder surrounding the pith consists of two rings, everywhere pierced by medullary rays, which are often so large as to separate the rings into numerous series of woody wedges, as in recent Cycadeæ." Regarding the rather unusual form of the leaf-bases he notes: "Our species may be distinguished from the others [of the *Cycadeoidea*] by the regular arrangement and symmetrical form of the bases of the petioles. They are rhomboids, the horizontal diameter of which is but little more than the perpendicular, and differing in this respect not only from all the other described recent [*sic*, fossil?] species, but also from all the living Cycads with which I am acquainted."

This accurate description, and the recognition that the plant had affinities with Buckland's *Cycadeoidea*, was confused by Carruthers himself (1870) when he founded the genus *Yatesia* in which he placed this fossil, re-naming it *Yatesia Morrisii*. The genus *Yatesia* was diagnosed as follows:—"*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."

There is no evidence that the present specimen had any of these characters, beyond the cylindrical trunk and persistent leaf-bases. The deductions regarding its fructifications are assumptions; while it is not impossible that they may prove correct, as there is no actual evidence to support them, they cannot be used as the foundations of a genus. Whether or not the genus *Yatesia* may hold for other species cannot be discussed here: it is certain, that as diagnosed, the plant now under consideration cannot be included in the genus *Yatesia*.

V. 13238. Type-specimen. Figured, Carruthers, Geol. Mag., vol. 4, 1867, pl. ix, figs. 1 & 2. Carruthers, Trans. Linn. Soc., vol. 26, 1870, pl. lv, figs. 3–6; pl. lx, fig. 13. Text-figs. 93, 95. This type-specimen is

25 cm. long by 12 cm. in diameter. As is shown in the figures, the upper part is covered by the closely arranged leaf-bases, which are broken off the lower half so as to show the rough surface of the cortex. On the right side of the specimen this again splits off, exposing the outer surface of the outer wood-ring, in which the elongated scars of the leaf-traces are visible. On the other side of the specimen the large pith, 8 cm. in diameter, is represented by roughly granular matrix. On either side of this the axis is split in nearly median radial section, and shows the two wood-rings and the tissue between them very clearly (text-fig. 95, B). The broken end of the section also shows these wood-rings well weathered out (text-fig. 95, A). The leaf-bases at this end show clearly their upturned tumid bosses. This specimen, like all the others, is preserved in dark heavy limonite. "Potton Sands," Lower Greensand; near Leighton Buzzard. *By exchange, Royal Agricultural College, Cirencester*, 1915.

V. 5217, V. 5219, V. 9384. Figured, text-fig. 100. Are all probably part of a single specimen.

V. 5217. A block very similar to the upper end of the type-specimen, measuring 14 cm. long by 9 cm. across, this width not being the complete diameter of the stem. Pith-casts, wood-zones, and leaf-bases can all be well seen. One end of the specimen is cut across, and the smooth surface shows very clearly to the naked eye the pseudo-concretionary nature of the mineral matrix, which gives a false appearance of medullary vascular strands, probably the cause of Carruthers's statement that there are vascular bundles in the pith.

V. 5217 a. Transverse section from the cut surface described above. The tissues are almost entirely obliterated by the opacity of the mineralising medium, and are much broken. Some rows of tracheids in the woody zone can be detected.

V. 5217 b, c. Smaller sections similar to the above, but still more imperfect.

"Potton Sands," Lower Greensand; near Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

V. 5219. A short length, 8 cm. long, and a second small slice from which a section has been cut, of the pith and wood only. The inorganic pattern made by the concretionary nature of the mineral is so similar to that in V. 5217 that there is little doubt that they are from the same trunk.

V. 5219 a. Figured, text-fig. 96. Transverse section of the above, which though rather broken and opaque shows the tracheids in the wood-rings quite clearly in places (as figured in text-fig. 96). The soft cells of the pith are practically obliterated, but round patches among them seem to indicate the presence of gum-canals.

V. 5219 b, c. Radial longitudinal sections of the above, in which the pitting of the tracheid-walls can just be made out here and there, and shows that they apparently have round bordered pits in one or two rows (slide *b*).

V. 5219 d, e, f. Tangential longitudinal sections of the above passing through the wood-zones with their broad medullary rays. The cells are poorly preserved for the most part, but their nature can be made out.

"Potton Sands," Lower Greensand; near Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

V. 9384. A wedge, 12 cm. long, of part of the pith and wood-zones, evidently of the same trunk as the above. The cut surface of one end shows just the same pattern in the matrix of the pith. On one side of the specimen a cast of the surface of the pith shows the lenticular ridges very characteristically. "Potton Sands," Lower Greensand; Leighton Buzzard.

Transferred from the Botanical Dept., 1903.

V. 9383. Figured, text-fig. 97. A specimen showing the external appearance of the leaf-bases very well, as is illustrated in the photograph (text-fig. 97).

A similar piece, still in the Botanical Dept., appears to belong to the same trunk.

"Potton Sands," Lower Greensand; near Leighton Buzzard.

Transferred from the Botanical Dept., 1903.

V. 6602. A block, 20 cm. long and 8 cm. in diameter, consisting principally of pith-cast, but with a portion of two wood-rings and a few fragments of leaf-bases on one side of it. It shows no features not better preserved in other examples of the species.

V. 5266. A small fragment showing three or four leaf-bases, and part of the two wood-rings.

"Potton Sands," Lower Greensand; near Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

V. 221. Two fragments (9×4 cm. and 7×4 cm.) showing some rather irregular leaf-bases and portions of the two wood-rings clearly weathered out. "Potton Sands," Lower Greensand; near Leighton Buzzard.

Morris Coll., 1883.

V. 5267. Probably to be included in the species *Cycadeoidea Yatesii* is a small fragment with much smaller leaf-bases than in the rest of the specimens. Save for the smaller-sized leaf-bases, there seems to be no other difference between this specimen and the others described above; two wood-rings can be clearly seen and the pith-cast is similar to the others. "Potton Sands," Lower Greensand; near Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

47049. Figured, text-fig. 94. The surface-view shows rather irregular leaf-bases, within which the two rings of wood are clearly seen weathered out at one end of the broken surface. Within this is the large hollow of the pith, the surface cast of which (equivalent to the inner face of the inner wood-ring) shows clearly the characteristic lenticular ridges and hollows due to the wide medullary rays and xylem-strands. "Potton Sands," Lower Greensand; Leighton Buzzard.

Morris Coll., 1863.

Cycadeoidea buzzardensis, sp. nov.

[Text-figs. 98–100.]

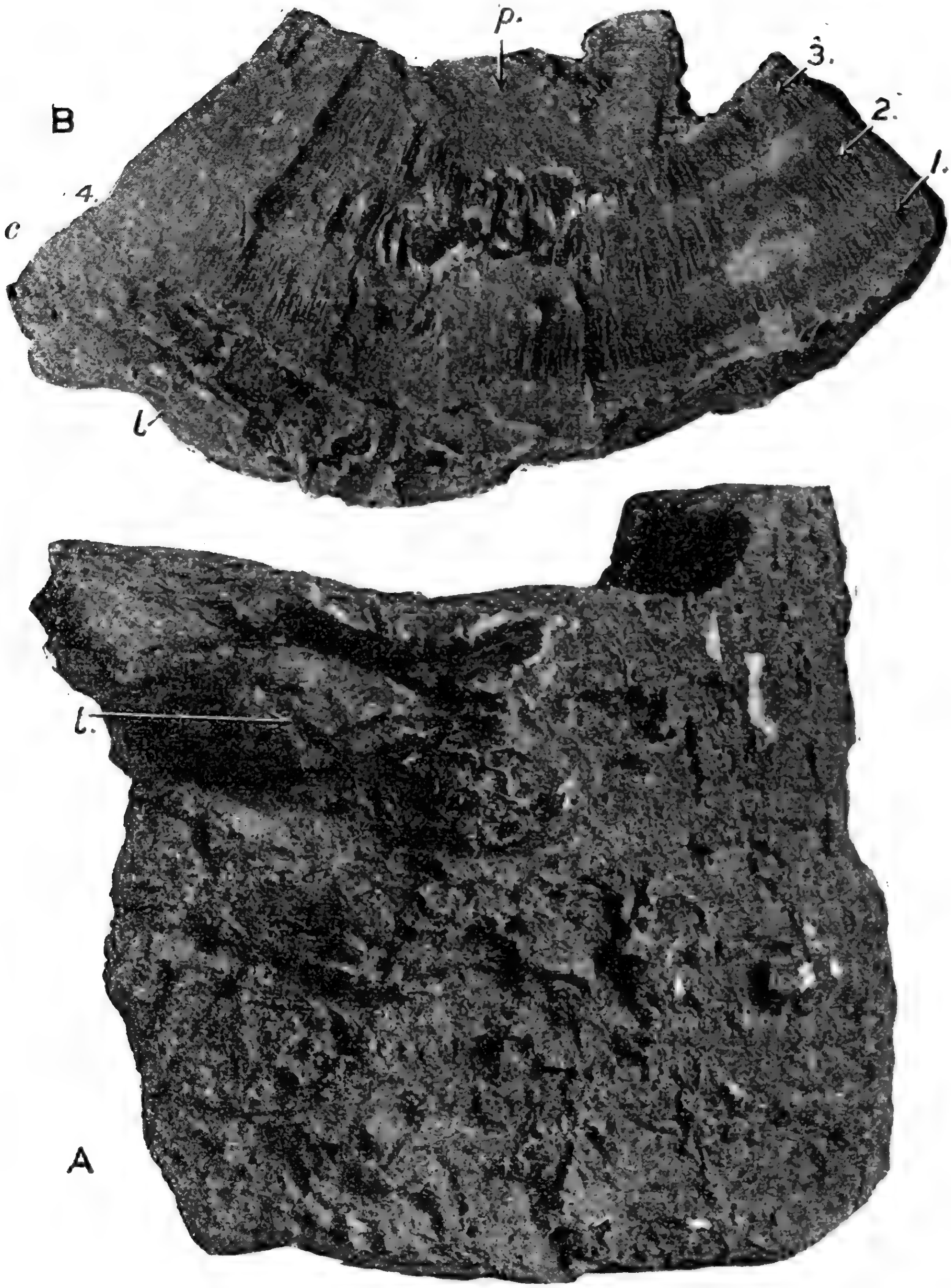
Diagnosis.—Species founded on vegetative trunks, showing pith, wood, and leaf-bases; the inner tissues petrified to show imperfectly preserved anatomical details. Trunk probably cylindrical, probably capable of reaching more than 24 cm. in diameter. Petiole-bases apparently covering the stem, arranged spirally, measuring 3·5 cm. horizontally and 1·5–1·8 cm. vertically, much drawn out laterally. From three to eight or more distinct cylinders of secondary wood surround the large pith. The woody cylinders each having a maximum thickness of about 1 cm., composed of radiating zones of secondary wood. Between the wood-cylinders are zones 2–4 mm. thick of different tissue (phloem ?). Tracheids in regular radial series, averaging 20–35 μ in diameter; [nature of pitting not recognisable]. Cortex very narrow, leaf-bases not massive, cortex and leaf-bases together measuring less than 2 cm. in radial thickness.

Horizon.—"Potton Sands," Lower Greensand; probably derived from Wealden.

Locality.—Sand-pit just outside Leighton Buzzard.

Type.—Co-types, V. 6598 and V. 5895, British Museum (Nat. Hist.).

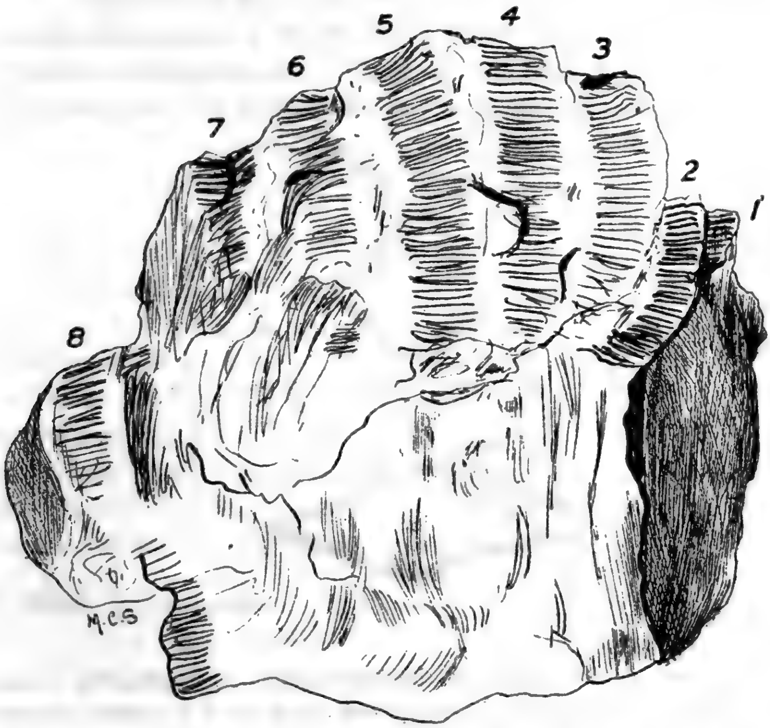
General Description.—The species is described from two specimens in the Museum, probably of different ages, and there are two other pieces of different individuals. The specimens, like *C. Yatesii*, are all alike in colour and texture, being preserved in a dark limonite, very close and heavy, and opaque in section. They are too incomplete to give an accurate indication of their diameter. One of the type-specimens shows both pith and cortex, and must have been at least 14 cm. in diameter; the other consists only of wood-rings, concentrically arranged and therefore all from one side of the specimen, and is without either pith or cortex. An estimated diameter of 24 cm. is the



Text-fig. 98.—*Cycadeoidea buzzardensis,* sp. nov. **A, showing the external features; at *l.* the large, laterally extended leaf-base. B, surface-view of the broken transverse section, showing *l.*, leaf-bases; within the cortex, *c.*, are three distinct** wood-zones, 1, 2, & 3, and part of a fourth, 4; *p.*, pith. $\times \frac{9}{10}$. No. V. 6598.

minimum possible for this specimen, and it may have been much larger. The chief differences between this form and *C. Yatesii* are: the shape and size of the leaf-bases (see text-figs. 98 and 100), and the indefinite number of thick wood-rings in the stem.

The *pith* measured not less than 6 cm. in diameter, but its actual size is uncertain. The cast of its surface shows the rough lenticular ridges and groups characteristic of this genus.



Text-fig. 99.—*Cycadeoidea buzzardensis*, sp. nov. Rough sketch of the broken block of wood, showing parts of at least eight concentrically arranged rings of secondary wood. × $\frac{2}{3}$. No. V. 5895.

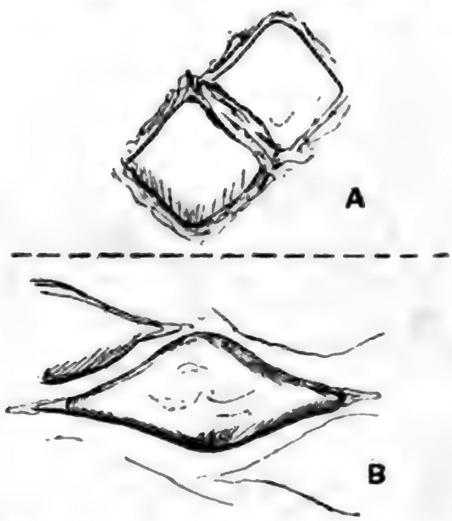
The *wood* is in distinct, concentrically arranged rings: in one specimen, which is very incomplete, there are three; in one of the types there are four, and in the other type there are at least eight woody cylinders (text-fig. 99). These wood-rings can be clearly recognised with the naked eye, and show well in the broken surface of the trunk (text-fig. 98, B, and text-fig. 99).

The microscopic section is so opaque that very little detail can be seen; the *tracheids*, however, can be recognised in places, and are arranged in regular radial sequence, each tracheid averaging 20–35 μ in diameter.

The *cortex* is very slender, and none of its tissues are well enough preserved for description.

The *leaf-bases* are laterally elongated rhomboids (text-fig. 98, A, and text-fig. 100) measuring 3·5 cm. in transverse, and about 1·5–1·8 cm. in vertical direction. Their rounded surfaces are broken by cracks in the matrix, but there is no indication of the number or character of the leaf-traces.

AFFINITIES.—It is evident that there is a very close likeness to *Cycadeoidea Yatesii* (p. 299) in the general vegetative character of this trunk. As there is no indication of fructification in



Text-fig. 100.—Outline sketch of the leaf-bases in A, *Cycadeoidea Yatesii*, Carr., and B, *C. buzzardensis*, sp. nov., showing the contrast between them both in size and shape, though they come from trunks of approximately the same diameter. × $\frac{2}{3}$. A=No. V. 5217; B=No. V. 6598.

either case, the species can only be provisionally diagnosed. While it is not impossible that *C. buzzardensis* may ultimately prove to be an older form of *C. Yatesii*, there is a strong presumption against that conclusion in the fact that, in two specimens of the respective species apparently of just about the same size, the differences in the shape and size of the leaf-bases and in the number of the vascular cylinders are conspicuous. The extent of the differences between the types of leaf-bases is indicated in text-fig. 100, where the outlines are drawn from leaf-bases attached to trunks apparently of the same diameter. Were these differences due to secondary growth of the stem, and consequent stretching of the leaf-bases, they would only become apparent in trunks which differed in size much more than do *C. Yatesii* and *C. buzzardensis*.

Both species to some extent resemble the living Cycads more closely than other described fossils, and *C. buzzardensis* in particular is very suggestive of affinity with such a form as *Cycas circinalis*. In his original account of the genus *Cycadeoidea*, Buckland (1828 A) noted the likeness to the trunk-anatomy of Cycads in his *C. microphylla*, which, with its two wood-rings, reminded him of the living *Cycas revoluta*. *Cycas circinalis*, as Buckland figured, has a large number of woody cylinders, and in this respect is paralleled by *C. buzzardensis*.

While it is impossible to do more than theorise in the absence of fructifications, these two species undoubtedly offer tangible points of comparison with true Cycads, not only in their internal anatomy, but also in their long, straight, and slender axes, which contrast with the characteristic *Bennettites*-axes and are like *Cycas*-trunks. It is curious that while the Cycadophyta, represented by the *Bennettites*-types, are so prevalent in the Mesozoic, true Cycads are almost unknown, and have long been sought in the Secondary rocks. It is not impossible that these two species are true representatives of the family.

V. 6598. Type-specimen. Figured, text-fig. 98, A & B, and text-fig. 100, B. The specimen is broken into two segments, the larger of which is figured in text-fig. 98, A. Together the two pieces reach a length of 13 cm. Part of the pith is preserved, and on one side is weathered out so as to show its characteristic surface-markings. Both in the broken and in the cut surface of the axis the wood-rings, four in number, can be clearly seen. The leaf-bases are worn away from one side, but when the two parts of the specimen are fitted together, about ten fairly well-preserved leaf-bases can be seen.

V. 6598 a. Transverse section from the cut surface of the smaller part of the type. This is very opaque. The pith and the four wood-rings can be seen clearly with the naked eye, but under the microscope very few of the actual cells remain. Some rows of tracheids can be made out clearly towards the middle of the section.

"Potton Sands," Lower Greensand; Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

V. 5895. Co-type. Figured, text-fig. 99. An irregularly broken piece of the axis showing eight or nine concentric wood-rings. The block measures 12 × 9 × 7 cm. and is much fractured. The weathered face shows the wood-rings recognisably both in transverse and various longitudinal directions.

"Potton Sands," Lower Greensand; Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

V. 5218. A large irregular fragment of the woody region of a trunk similar to the above, but showing less detail, measuring 16 × 7 cm.

V. 5251. A small wedge, measuring 6 × 4 × 3 cm., showing parts of the disintegrated leaf-bases and three rings of wood which show up very clearly on the polished face.

"Potton Sands," Lower Greensand: Leighton Buzzard.

Transferred from the Botanical Dept., 1898.

Genus **COLYMBETES,** nov.

There is only one specimen of this new type, so the genus and species are diagnosed together.

Colymbetes Edwardsi, sp. nov.

[Plates XXXI, XXXII; text-figs. 101–111.]

Diagnosis.—Founded on the inner portions of a trunk showing beautifully petrified anatomical details. Trunk probably cylindrical, reaching more than 12 cm. in diameter. Pith large, cellular, 7·5 cm. in diameter; numerous gum-canals, but no vascular strands in pith proper. Ground-tissue cells of pith large, relatively thin-walled, all alike, and without intercellular spaces; starchy contents frequent. Surrounding the pith and following the outline of the inner bays of secondary wood, is a broad perimedullary zone, with numerous anastomosing short radial series and groups of small tracheids. Outside the bays of the vertically running secondary xylem, successive zones, up to 10 in number and probably more, alternate, so that zones cut radially in the transverse section are cut transversely in the true radial section. All the tracheids have scalariform pitting on their radial walls, with wide borders and narrow slit-like pores. Leaf-traces numerous, conspicuous, running nearly straight out through the wood, and curving very slightly upwards, arranged in close spirals, each leaf-trace about 1 cm. distant from all its neighbours.

Horizon.—"Greensand" probably "Potton Sands," Lower Greensand.

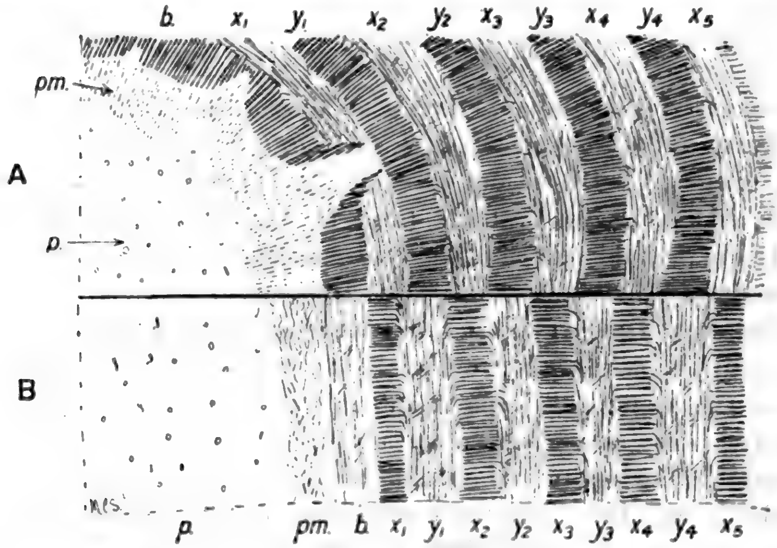
Locality.—Unknown. Leighton Buzzard is not impossible.

Type.—V. 6312 and slides V. 6312 *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *j*, *k*, *l*, cut from it in 1915, and old slides V. 7796–V. 7801 from the same block. Also V. 6127 (and all the slides cut from it in 1915) is probably part of the type-specimen itself, and if not is a co-type. British Museum (Nat. Hist.).

General Description.—Some large and very thick uncovered sections (V. 7796–7801), evidently cut long since, but transferred from the Botanical Department in 1898 without any history, showed, very imperfectly, an anatomical structure of great interest. Owing to the thickness of the sections little more could be seen than that there were four or five distinct zones of secondary wood surrounding a very large cellular pith, thus resembling superficially the specimens described above as *Cycadeoidea buzzardensis*, sp. nov. (p. 309). These old sections are unlabelled, but on one or two of them, cut in diamond into the glass, is "Greensand, M. E. G.," and on another is "Raumeria, M. E. G." Two other sections (V. 10156 and V. 10168), evidently cut from the same or a similar trunk, were found in the collections; these are equally thick, but have cover-glasses, and on them "Raumeria (Goeppert) Greensand, ? J. D. Hooker" is cut into the glass. Mr. Edwards sought for further remains of this interesting specimen, and found two pieces of a trunk, registered under two different numbers, but evidently of the same species, if not actually parts of the same trunk. One of these proved to be the block from which Hooker's old sections had been cut, and it bore an old label, much broken, on which the word "Greensand" is clearly to be seen, with a date, partly obliterated, but suggestive of 1856. In much more recent writing the words "from Kew, 1881" can be seen.

Both these blocks were cut, and a number of sections showed beautifully preserved tissues. I have named the species after Mr. W. N. Edwards in recognition of the trouble he took to obtain the pieces and all information possible about the specimen.

When the radial longitudinal sections were examined, the transverse and the longitudinal sections through the wood



Text-fig. 101.—*Colymbetes Edwardsi*, sp. nov. Diagram showing the arrangement of the stem-anatomy, in A, transverse, B, radial longitudinal section. *p.*, pith; *pm.*, perimedullary xylem zone; *b.*, bays of first, vertically running, secondary xylem; x_1, x_2, etc., zones of horizontally running secondary xylem cut in transverse section in the radial, and in radial section in the transverse section of the trunk; y_1, y_2, etc., longitudinally running secondary xylem, cut in transverse section in transverse and radial section in radial longitudinal section of the trunk.

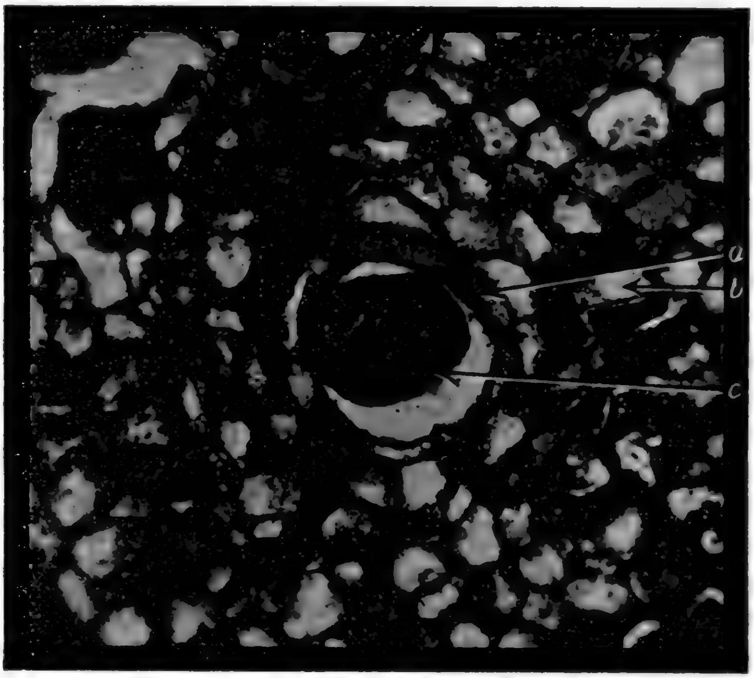
seemed to be identical, both showing several series of transversely cut series of secondary wood-elements. As this seemed incredible, I carefully oriented and marked another portion of the trunk to be cut again, and Mr. Joseph Lomax deserves much credit for the careful and accurate series of sections he obtained. These series of sections and a carefully rubbed-down piece of the block itself proved beyond a doubt that the first radial sections truly represented the astonishing fact, that the wood of this plant consists of alternating series of secondary wood-zones running alternately vertically and horizontally, so that in both longitudinal and transverse sections zones of perfectly transversely cut secondary wood are seen.

This is shown in text-fig. 101 in a diagrammatic way, and is illustrated in the text-figures and plates.

The *wood* cylinder consists of:—(*a*) the perimedullary zone, in which short radial series and groups of tracheids are loosely dispersed and ramify among large ground-tissue and medullary ray-cells; (*b*) the first ring of bundles of vertically running secondary wood, forming a series of bays of wood much as in *Bennettites*; (*c*) a series of cylinders of secondary wood alternating, first a series in horizontal direction, then a series in vertical direction, and so on, up to the number of nine or ten; and as the sections stop at the wood, showing neither phloem nor cortex, there is nothing to indicate how many more of these cylinders there may be. The broad medullary rays, like those in the Cycadophyta generally, run from one cylinder to the next, apparently bending over at right angles with the wood. While I am not quite certain of this, it appears that these alternating series were the product of a single cambium, which for some reason unknown, turned at right angles periodically. The large simple leaf-bases running out through the zones of wood tend to break into the regularly alternating series and carry the transverse bands out with them a little, as can be seen in text-fig. 107. But that the transversely running wood-zones in no way depend on the leaf-traces, or are to be correlated with the leaf-trace "girdles" in Cycads, can be seen in text-fig. 109, B, where the leaf-trace *l.t.* runs right through the horizontally running cylinder *x.* without disturbing it.

The full consideration which these extraordinary structures demand cannot be given here. The following short description covers only the more essential facts of the anatomical structure of the new species.

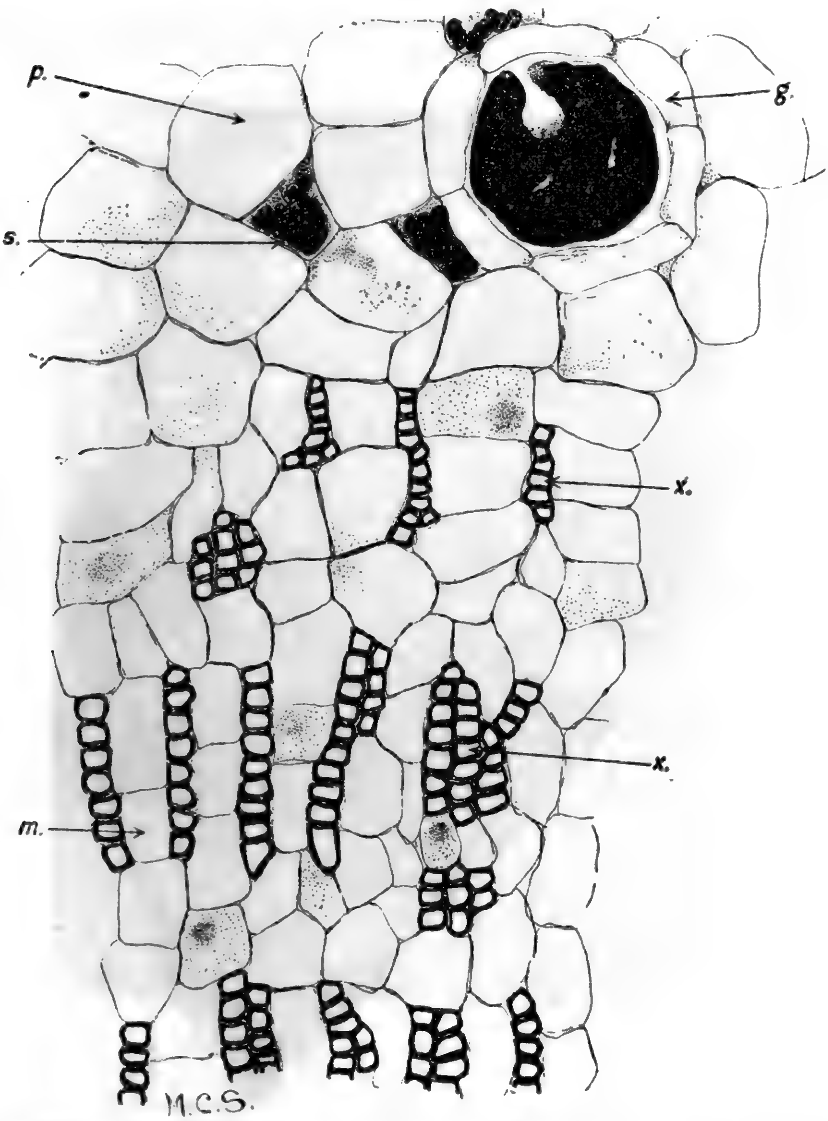
The *pith* measures not less than 7·5 cm. in diameter, and probably more. It is apparently quite uniform in structure, composed of large, irregularly roundish cells, with thin or very slightly thickened walls. The cells vary, but average about 150–300 μ in diameter. They fit together so as to leave few or no intercellular spaces, and are almost identical in shape in transverse and in longitudinal section. In a large number of cases they contain a dark granular contents (see text-fig. 103, *s.*), which is highly suggestive of starch-granules closely packed. Large numbers of starch-grains are recorded by Wieland in the American *Cycadella* (Wieland, 1906, p. 77) and other species. Larger, clearer, spherical or oval contents, apparently similar to structures



Text-fig. 102.—*Colymbetes Edwardsi*, sp. nov. Transverse section of a small part of the pith showing gum-canal and the ordinary pith-cells; *b.*, pith-cells; *a.*, lining cells of gum-canal; *c.*, blackened mass, contents of gum-canal. No. V. 6127 *c.*

described as vacuoles by Wieland, are also present in many of the cells. A large proportion of the cells show contents highly suggestive of protoplasm and nucleus.

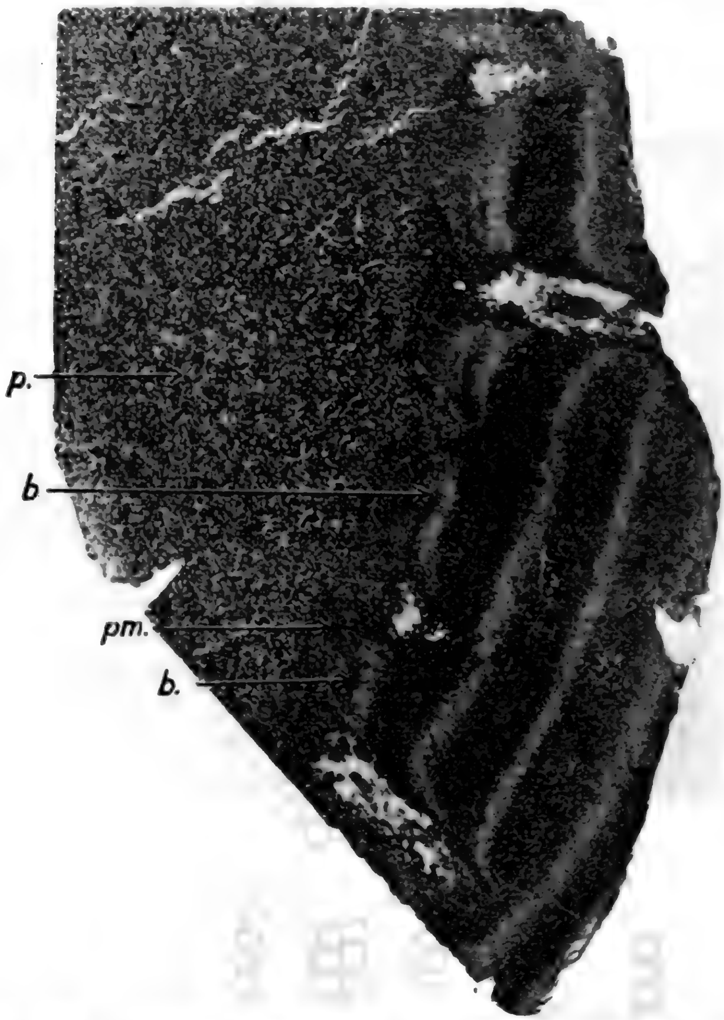
Gum-canals are very numerous and are freely dispersed among the pith-cells; each canal is formed by about six rather narrow lining cells (see *g.* and *a*, text-figs. 102, 103); and the contents of the canal are solid and very black. The canals must run for a very short distance in any given direction, for the longitudinal section of the trunk shows as many canals cut transversely as does the transverse section. Without any very



Text-fig. 103.—*Colymbetes Edwardsi*, sp. nov. Transverse section of a small part of the perimedullary zone of wood (cf. *pm.*, text-fig. 101); *x.*, groups and rows of xylem; *m.*, medullary rays and ground-tissue; *g.*, gum-canal; *p.*, pith-cells; *s.*, starch-containing pith-cells. No. V. 6127 *b*.

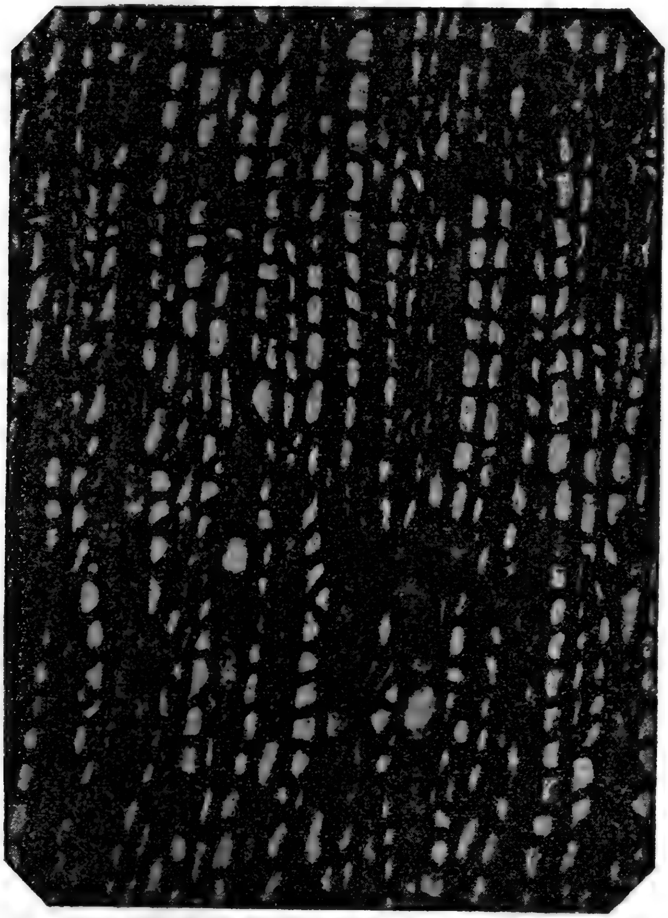
abrupt change the large-celled pith merges in the *perimedullary zone*, in which the ground-tissue cells are smaller and there are no gum-canals. This zone is specially characterised by the loosely arranged, anastomosing bands and groups of xylem-elements (text-figs. 101, 103, 109, *pm.*).

The *perimedullary xylem* consists of clusters or small groups of tracheids, and short radially running series of tracheids



Text-fig. 104.—*Colymbetes Edwardsi*, sp. nov. Transverse section showing clearly the bays of the first vertically running wood-ring, *b.*, and the steady alternation of vertically and horizontally running wood-rings. This should be compared with text-fig. 107, where the bands are more broken up by outgoing leaf-traces. *p.*, pith ; *pm.*, perimedullary wood-zone. × 2. No. V. 6132 *a*.

loosely dispersed through the ground-tissue (Pl. XXXI, fig. 1, *x*, and text-fig. 103, *x*). These are very similar to the wood abutting on the pith in *Bennettites,* but the zone of these elements is wider and more pronounced in the present fossil. In longitudinal section their rather wandering and anastomosing course can be seen (text-fig. 109, B, *pm.*). The tracheids are

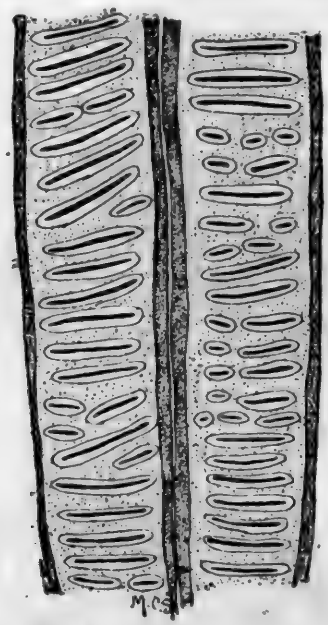


Text-fig. 105.—*Colymbetes Edwardsi,* sp. nov. Transverse section of small part of the wood enlarged, showing the rather irregular radial series of secondary tracheids. No. V. 6127 *a*.

very small, averaging only 18–20 μ in diameter, with very thick walls. They appear to have oval-scalariform or circular pits.

Even the larger series of tracheid-rows of this zone do not directly merge into the inner zone of the more solid wood, but are many times separated up by intervening ground-tissue.

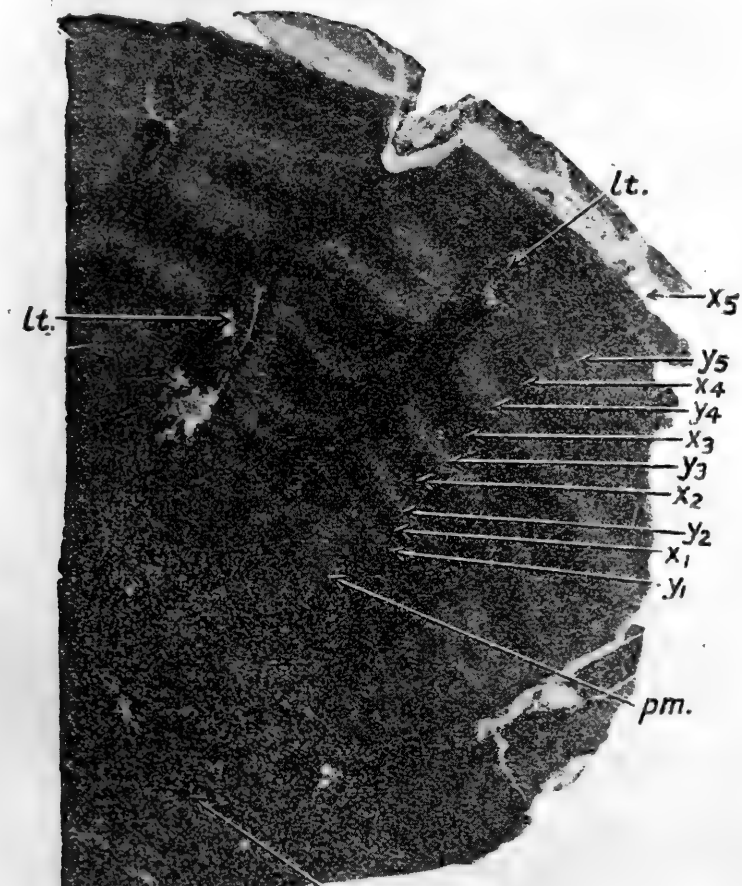
The *xylem* proper is composed first of bays of normally vertical secondary wood (text-figs. 101, 104, *b*.). This is composed of rather irregular but quite normal radial series of secondary tracheids, interspersed with medullary rays (text-fig. 105). The individual *tracheids* average up to 40–60 μ in diameter, and have a tendency to be wider radially than tangentially. Their walls are generally thinner than those of the perimedullary tracheids. The pitting of the radial walls is bordered-scalariform, or consists of series of wide, oval, bordered pits (text-fig. 106). A regular scalariform, with apparently a wide border



Text-fig. 106.—*Colymbetes Edwardsi*, sp. nov. A pair of tracheids showing the bordered scalariform pits in the radial walls. No. V. 6127 *a*.

and very narrow slit-like perforation, appears to be the commonest type of pitting.

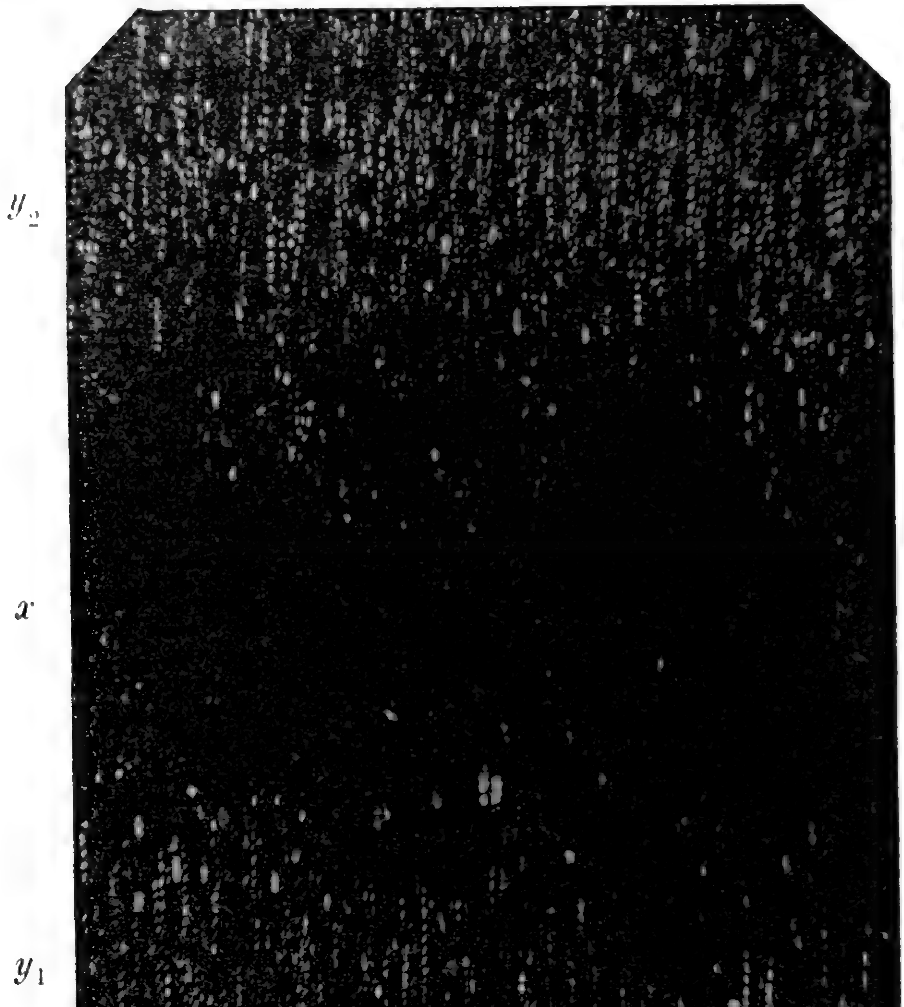
Alternating with these normal vertical series of secondary tracheids are the horizontally running series (*cf*. text-figs. 101, 107, 108). In transverse section the horizontally running elements show up as dark bands with the low power (text-figs. 107, 108, x_1, x_2, etc.), under the high power the pitting of the elongated vessels, which are crossed by radially cut medullary rays, can be seen in many places (Pl. XXXII, fig. 2). In the radial section of the trunk, where these bands are cut transversely (text-fig. 109, B, *x*), they show whitish zones like those of the transverse sections of the vertically running elements. The radial longitudinal sections of the trunk show



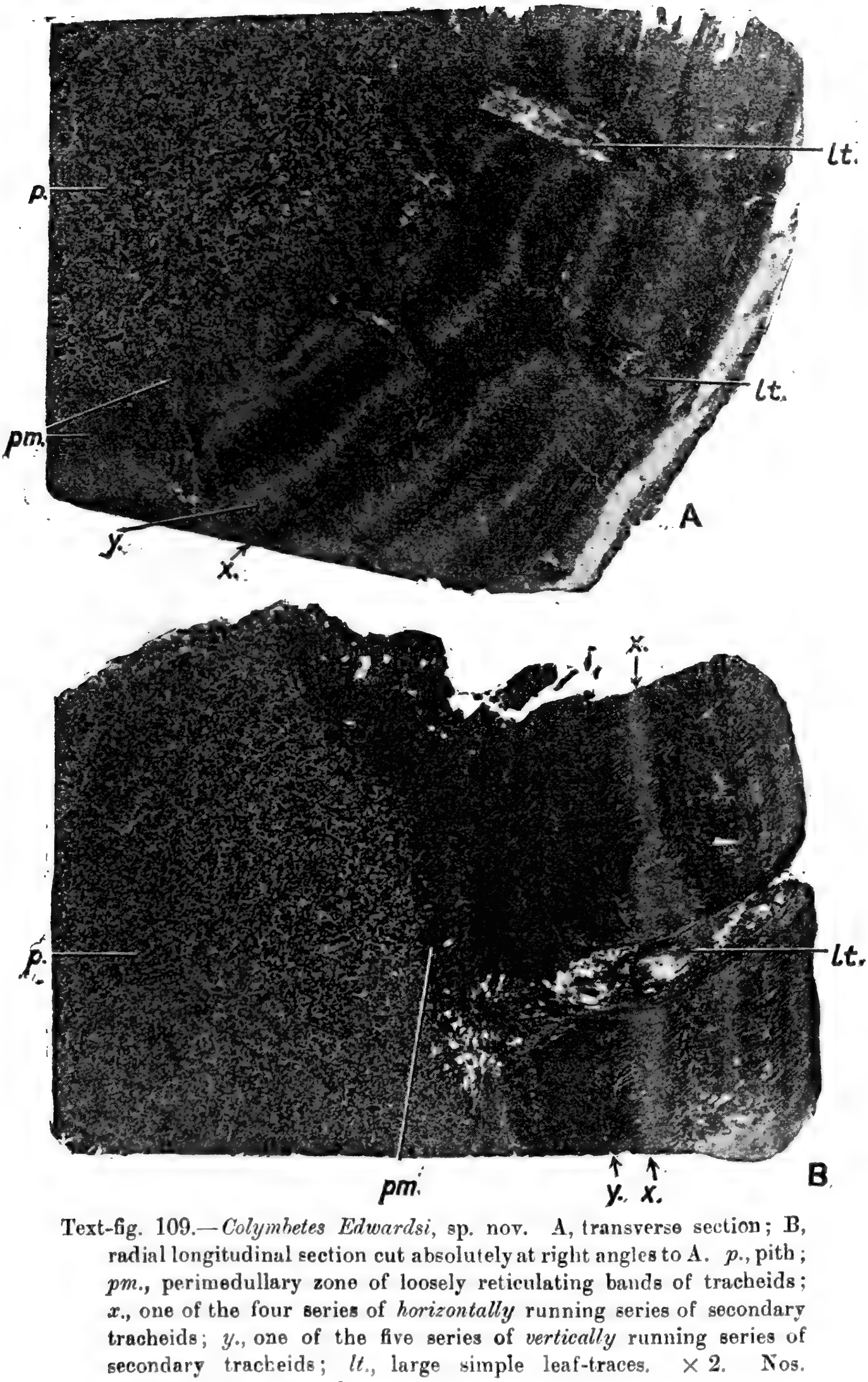
Text-fig. 107.—*Colymbetes Edwardsi*, sp. nov. Transverse section showing *ten* alternating zones of wood outside the perimedullary zone *pm.* y_1, y_2, y_3, y_4, y_5, vertically running xylem-series; x_1, x_2, x_3, x_4, x_5, horizontally running xylem-series; *p.*, pith; *lt.*, leaf-traces. Note the curving out of the strands toward the leaf-traces. × 2. No. V. 6127*f.*

transverse sections of these elements entirely similar to the normal transverse sections of the vertically running elements, as can be seen on comparing text-fig. 105 with Pl. XXXII, fig. 1.

Where the one zone passes into the next, a curving of the elements is frequently evident, and in a few cases it is quite



Text-fig. 108.—*Colymbetes Edwardsi*, sp. nov. Transverse section of axis showing two zones, y_1 and y_2, of vertically running wood cut in transverse direction, with a zone x of horizontally running wood cut in radial direction. No. V. 6127 *a*.



Text-fig. 109.—*Colymbetes Edwardsi*, sp. nov. A, transverse section; B, radial longitudinal section cut absolutely at right angles to A. *p.*, pith; *pm.*, perimedullary zone of loosely reticulating bands of tracheids; *x.*, one of the four series of *horizontally* running series of secondary tracheids; *y.*, one of the five series of *vertically* running series of secondary tracheids; *lt.*, large simple leaf-traces. × 2. Nos. V. 6127 *c* and V. 6127 *k*.

possible to trace a single radial series of tracheids through an angle of 90°, running in the same section, first as a transverse and then as a vertical series. One and the same medullary ray also can sometimes be followed, first in transverse and then in radial longitudinal section, which later again turns to true transverse. The inference is therefore drawn that there was but a single cambium, which had periodic changes of direction.

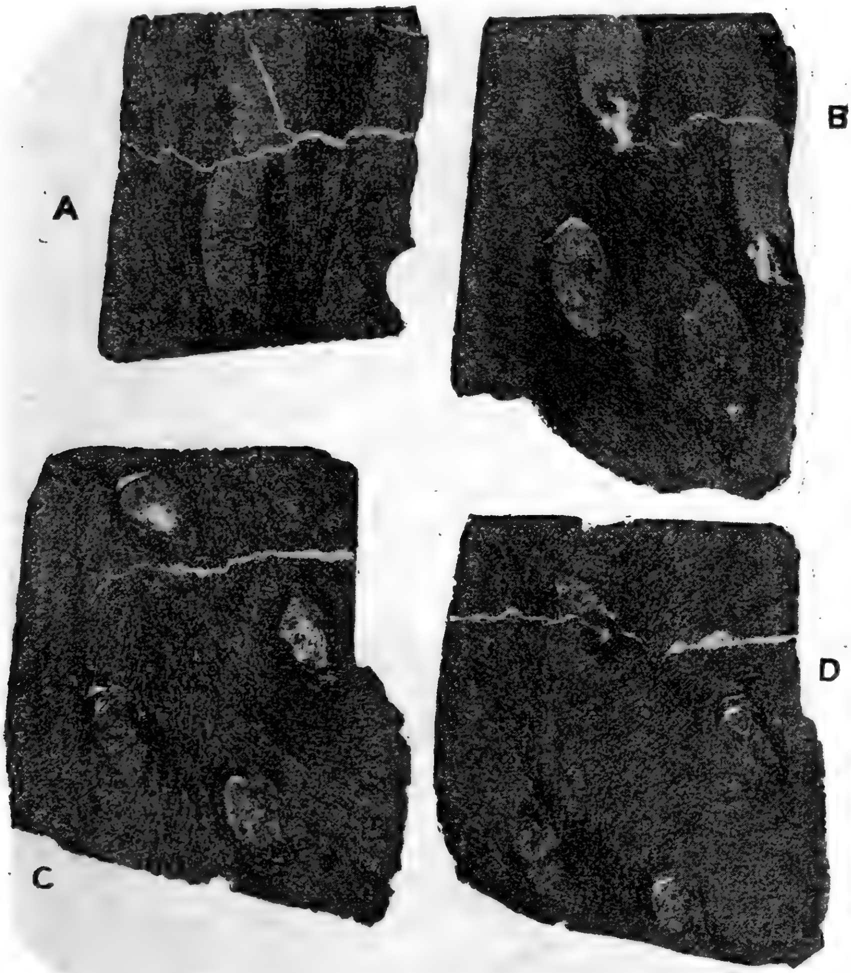
In tangential section the tracheids are seen to follow a very contorted course, sometimes to double back on themselves, and even to branch and loop in various ways (Pl. XXXI, fig. 2). This takes place not only in the neighbourhood of the leaf-traces, but apparently all through the wood, and more especially in the regions where the tangentially and horizontally running cylinders merge.

Medullary rays are very numerous. They are principally *biseriate*, a few are irregularly multiseriate by the addition of two or three extra cells. They are various in height, many being as low as 4, or as high as 30 cells in vertical series, the majority averaging about 20 cells high. The individual ray-cells are large, up to about 60×150 μ or more; with nearly straight end-walls, and apparently without special thickening or pitting of any of the walls. I have seen something suggestive of large oval pits in several of the radial walls, but cannot feel sure that they are not petrifact.

Many of the larger ray-cells show the most beautifully preserved vacuolated protoplasmic contents and nuclei which I have ever seen petrified. They rival the most carefully fixed living material.

Phloem and *cortical tissues* are not preserved.

The *leaf-traces* are conspicuous in every section, and are large and numerous (text-figs. 109, 110, and 111). The individual trace is a solid oval-cylindrical mass as it passes nearly straight out through successive zones of wood (text-fig. 109 B, *lt.*), and curves very slightly upwards in its course. In actual distance the leaf-traces are about 1 cm. apart, apparently arranged in regular spirals (text-fig. 110). The traces vary somewhat in size, but average about 3 mm. across by 4–6 mm. in vertical height. Each trace consists of a compact mass of tissues much resembling the ground-tissues of the perimedullary zone, but more compact and smaller-celled. The gum-canals of the pith are entirely absent, but there are several kinds of cells unrepresented in the pith; among them are thick-walled stone-cells, and groups and isolated cells with very dark contents which look as if they had contained mucilage, though they are not particularly elongated.



Text-fig. 110.—*Colymbetes Edwardsi*, sp. nov. A series of photographs of the same leaf-traces in their passage outwards through the wood-rings. A, in the perimedullary wood-zone; B, in the first wood-ring; C, in the second vertically running wood-ring; D, in the fourth wood-zone, *i. e.* the second horizontally running wood-ring. × 2. No. V. 6132*g–k*.

In some of the tangential sections of the trunk, which show the leaf-traces in transverse section, the xylem-elements can be seen in one or two irregular patches of tracheids arranged in more or less regular radial rows. These masses of secondary wood are not visible in the traces in the inner wood-zones—as, for example, in the trace photographed in text-fig. 111, where no definite xylem-mass can be detected.

Text-fig. 111.—*Colymbetes Edwardsi*, sp. nov. A leaf-trace passing out through the wood, in tangential section. No. V. 6132*j*.

Affinities.—The extraordinary alternation of successive horizontal and vertical wood-cylinders in the new fossil, is a feature unlike any in living or fossil plants with which I am acquainted. While the transverse section, with its successive rings of secondary wood, appears similar to *Cycadeoidea*, particularly to *C. buzzardensis* (p. 309), the resemblance is not a true one, because in *Cycadeoidea* the successive zones appear to be like those of the living *Cycas circinalis*, formed of fresh cambiums, so that each vascular zone is complete with a region of phloem outside each wood. In the new fossil, the zones of tissue between the successive vertical cylinders of wood are horizontal cylinders of wood. It is, also, too unlike *Bennettites* vegetatively to be included in that genus without the compelling evidence of the fructification, nothing of which is known at present. The cortical tissues and leaf-bases, which also might have afforded useful evidence, are unfortunately not represented, but so far as the leaf-traces go they seem different from *Bennettites*, both in their mode of exit and their constituent tissues.

The perimedullary zone of wood in this new fossil, while to some extent paralleled by the wood-elements adjacent to the pith in *Bennettites*, is much more extensive and specialised a feature than in *Bennettites*. The species described by Wieland (1906) as *Cycadeoidea Jenneyana*, having wood "as extensive and compact as that of *Cordaites*," seems to show something in the way of annual rings or special zones in its wood, but without the evidence from thin sections nothing of use in the present comparison can be deduced from the specimen.

The leaf-traces in the present fossil are placed so close together that, if one leaf-trace went to each leaf-base, the leaf-bases must have been exceptionally small for this group. Without some indication of what happened in the cortex, however, it is not possible to discuss the point.

Concerning the most noticeable feature of the new plant, the alternating cylinders of wood, but little can be said. As no similar phenomenon appears to have been discussed for recent plants, it is not clear how much systematic or phylogenetic importance, and how much physiological importance, is to be attached to this anatomical peculiarity. Among the Cycads which do have series of cambiums, the various rings of wood bear no relation to seasonal growth, and an ancient trunk shows a maximum of ten or a dozen wood-rings. It is also probable that the phenomenon in the new fossil is not a seasonal one. If the alternations of the wood-cylinders do not depend on the seasons, however, it is difficult to suggest any cause for their appearance. They are far too regular to be compared with the very erratic courses sometimes followed by the anomalously formed secondary bundles in *Dracæna* *, though *Dracæna* seems to be the only plant with which even comparison can be suggested.

De Bary (1884, pp. 471 *et seq.*) notes that in woods there is very frequently a torsion of the longitudinal elements, so that they do not run quite vertically, and he mentions that this torsion is right-handed in *Æsculus hippocastanum* and left-handed in *Populus pyramidalis.* He also says that "in many kinds of trees, as Pines and Firs, the direction of the fibres changes, becoming reversed after a number of similarly inclined layers." But the amount of torsion in the chestnut or pine woods is not comparable in degree to that in the fossil, though it is not impossible that it may be to some extent similar in kind, for, as was pointed out in the description (p. 326), there seem to be grounds for thinking that the successive cylinders of the fossil are formed from one cambium. If this is so, the cambium direction must have turned over at right angles to the normal growth of the cylinders at remarkably regular intervals. I can offer no suggestion as to why it should have done this.

As in living Cycads the "girdles" of the leaf-traces, which run half-way round the stem, are so conspicuous a feature, it is noteworthy that in the fossil the horizontally running cylinders disregard the leaf-trace (text-fig. 109, B, *lt.*). It appears probable that these cylinders have nothing to do with the leaf-traces in the fossil, though it is not impossible that there may be some phylogenetic connection between them and the girdles in living Cycads.

Finally, the inclusion of this plant in the Cycadophyta is self-evident, but while in some respects it is like both *Bennettites* and *Cycadeoidea*, the fossil represents a new genus, of which the degree of remoteness from the known Mesozoic Cycadophyta cannot be estimated without some knowledge of its fructification.

* I am indebted to Prof. Oliver for *Dracæna* material and for calling my attention to the peculiarity of the bundle-courses in its secondary wood.

V. 7796–V. 7801. Old sections from the type-specimen V. 6132.

V. 7796. A thick uncovered section of 5 × 3 cm. in diameter, chiefly through the pith, and on one side showing parts of four broken rings of secondary wood. Cut into the glass, probably in Sir Joseph Hooker's writing, is "Raumeria M.E.G."

V. 7797. A similar uncovered section, rather smaller, but showing more of the wood, and also a leaf-trace passing out through the whole width of the wood-zones. Also has "Raumeria M.E.G." cut into the glass.

V. 7798. A similar, rather larger, and still thicker uncovered section.

V. 7799. A large, very thick section, 10·5 cm. across by a maximum of 3 cm. in width. This is extremely thick and opaque, but shows parts of the wood-zones on opposite sides of the wide pith, which measures a little over 7 cm. in diameter.

V. 7801. A much larger and more nearly perfect section, obviously of the same specimen, though there is no writing on the glass. The trunk is apparently nearly circular in outline and about half of it is represented in the section, which has an area of 11 × 6·5 cm. With the naked eye, four or five rings of wood can be seen surrounding the large pith, 7·5 cm. in diameter; under the microscope the tissue is too opaque and thick to show much detail, but locally small zones of tissue can be clearly seen. The details visible prove the specimen to be the same as trunk V. 6132, from which sections were recently cut. No history.

Transferred from the Botanical Dept., 1898.

V. 10156. A thick covered section, apparently from the same material. Cut into the glass, in the same handwriting as is mentioned above, are the words "Raumeria (Goeppert), Greensand? J. D. Hooker." No history.

Transferred from the Botanical Dept., 1898.

V. 10168. A rather thick covered slide, a transverse section of about one-fourth of the trunk. The anatomical details can be seen fairly well, though the tissues are black and rather opaque. The alternating wood-zones, as described from the recently cut sections, are here quite apparent. Cut into the glass is "Raumeria (Goeppert), Greensand? Hooker." No history.

Transferred from the Botanical Dept., 1898.

V. 6132, V. 6127 are probably parts of the same trunk, if not they are co-types.

V. 6127. Type (or co-type). This block was almost entirely cut up into series of sections in different directions, so that only a very small part of it now remains, measuring $3 \times 2 \times 2$ cm. This small piece includes part of the pith and about 8 alternating wood-zones. Two surfaces are cut at right angles to each other, transversely and longitudinal-radially to the main axis of the trunk, and these faces have been partly filed smooth. When held facing the light these two surfaces can be seen simultaneously, and the gleam of the transversely cut wood-zones is apparent to the naked eye, and is seen to *alternate* in the two surfaces as is figured in text-fig. 101.

V. 6127 a. Figured, Pl. XXXII, fig. 2; text-figs. 105, 106, & 108. Transverse section of the trunk, showing the pith, perimedullary wood-zone, and the alternating series of wood-rings, all well preserved. The pitting of the horizontally running tracheids can be well seen in many places.

V. 6127 b. Figured, text-fig. 103. Transverse section similar to the above, in which the perimedullary wood-zone is very well preserved.

V. 6127 c. Figured, text-figs. 102 & 109, A. Transverse section similar to the above, showing all the characteristic features very well preserved.

V. 6127 d. Transverse section similar to the above, in which a larger number of leaf-traces are present, breaking up the zones of wood. The perimedullary wood-zone is conspicuous and well preserved.

V. 6127 e. Figured, Pl. XXXI, fig. 1. Transverse section similar to the above, a little broken but locally exceedingly well preserved.

V. 6127 f. Figured, text-fig. 107. Transverse section similar to the above, in which the alternating wood-rings and leaf-traces are well seen.

V. 6127 g, h. Parts of the same transverse section, which was broken in mounting and placed on separate slides. All the tissues are well preserved.

V. 6127 j. Radial longitudinal section showing a large area of the pith. The wood-zones are much fractured and incomplete.

V. 6127 k. Figured, Pl. XXXII, fig. 1; text-fig. 109, B. Radial longitudinal section through the pith and wood-zones, and also through an outgoing leaf-trace. The anastomosing leaf-strands of the perimedullary wood, and the alternating zones of secondary wood can be well seen, in particular one zone of horizontally running wood (here cut in transverse section), which shows that it is undisturbed by the massive outgoing leaf-trace. The normal, vertically running wood-zones are cut in radial section and show their tracheid-pitting and medullary ray-cells well preserved.

V. 6127 l. Tangential longitudinal section showing a considerable area of the wood well preserved, and parts of eight leaf-traces more or less broken out. The cut ends of the medullary rays and the very erratic course of the tracheids can be well seen.

V. 6127 m. A smaller tangential longitudinal section similar to the above, showing five well-preserved leaf-traces. In several of these the irregular masses of secondary vascular tissue can be well seen.

V. 6127 n. Figured, Pl. XXXI, fig. 2. A small tangential section showing parts of three leaf-traces. The nature of the tracheids and medullary rays of the wood can be well seen.

V. 6132. Type (or co-type). Three portions of the trunk which have been cut in various directions for the making of series of sections. The specimen was friable and had to be soaked in balsam, but the original surface can be seen in the largest of the three pieces.

V. 6132 a. Figured, text-fig. 104. Transverse section showing most of the anatomical details described above. The section has been marked by small saw-cuts on one side, in order to be carefully correlated with the radial longitudinal section *c*, cut absolutely at right angles to it.

V. 6132 b. A similar transverse section, which is carefully marked to show the direction of the radial and the tangential longitudinal sections cut from the same block.

V. 6132 c. Radial longitudinal section in which saw-cuts correspond to those in slide V. 6132 *a*, so that the alternation of the wood-zones can be clearly seen.

V. 6132 d. A more imperfect radial section, much of which broke away in the cutting.

V. 6132 e. A small radial section in which the anastomosing bands of perimedullary xylem are well seen.

V. 6132 f. A radial longitudinal section showing some of the wood-zones in good transverse section.

V. 6132 g. Figured, text-fig. 110, A. Tangential longitudinal section of four leaf-traces just passing out from the pith in the inner wood-zones.

V. 6132 h. Figured, text-fig. 110, B. Tangential longitudinal section of the same four leaf-traces further out, in the position marked B on slide V. 6132 *b*. The leaf-trace tissues, though a little broken, can be well seen.

V. 6132 j. Figured, text-fig. 110, C, & text-fig. 111. The same four leaf-traces in a tangential section still further out, in position marked C on slide V. 6132 *b*. One of the leaf-traces shows its tissues very completely, and is specially figured on p. 328.

V. 6132 k. Figured, text-fig. 110, D. The same four leaf-traces still further out, in position marked D on slide V. 6132 *b*. In this section the traces show some strands of secondary xylem.

V. 6132 l. Tangential section of two of the same four leaf-traces, still further out, in position marked E on slide V. 6132 *b*. The mass of secondary xylem in one of the leaf-traces is conspicuous. The medullary rays and tracheids of the wood of the main axis are well seen in this section. No history of block, save old label on which "Greensand" and "from Kew, 1881" are written.

Transferred from the Botanical Dept., 1898.

Genus **BENNETTITES,** Carruthers.

[See p. 23.]

Bennettites inclusus, Carruthers sp.

[Text-fig. 112.]

1870. *Mantellia inclusa*, Carruthers, Trans. Linn. Soc. Lond., vol. 26, p. 703, pl. lxiii, figs. 2, 3.

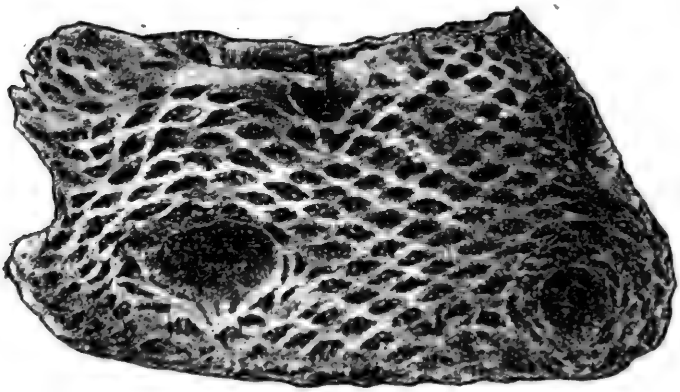
1874. *Cycadoidea inclusa*, Schimper, Traité Paléont. Végét., vol. 3, p. 556.

Diagnosis.—Founded on external features of a fruiting trunk, the internal tissues of which appear to be partly petrified. The diagnosis given by Carruthers (1870) is as follows:—"Trunk small, cylindrical; medulla abundant; wood-cylinder slender; cortical layer large, penetrated by numerous small, ascending, vascular bundles; bases of the petioles regularly lozenge-shaped, three-eighths of an inch broad by a little more than an eighth deep; secondary branches large; fruit included in the bases of the petioles."

Horizon.—"Potton Sands," Lower Greensand; but probably derived from Wealden.

Locality.—Potton, Bedfordshire.

Type.—Originally in William Reed's collection, and now in the York Museum.



Text-fig. 112.—*Bennettites inclusus* (Carr.). External view of part of the trunk showing the leaf-bases and the embedded cones. × ½. After Carruthers.

As I have not been able to see the original specimen, I cannot supplement Carruthers's description of this species. It is evidently a *Bennettites*, having a single slender cylinder of wood (Carruthers, 1870, pl. lxiii, fig. 2), laterally extended leaf-bases, and embedded cones, all entirely characteristic of this genus so far as can be judged without microscopic sections. The size of the leaf-bases appears to be unusually small. This is evidently not due to immaturity (if Wieland's deduction that the plants fruited but once, and that at the end of their lives, be true) for the cones are conspicuous.

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PLATE I.

Bennettites Allchini, sp. nov. External appearance of the trunk, showing small leaf-bases, among which are embedded cones. The pith-cast, much disintegrated and broken, projects above the leaf-base zone, indicating that the trunk may have been much taller.—Lower Greensand; near Ightham, Kent. Photo by H. Elgar, Esq., 1912. ½ natural size. Type-specimen: original in Maidstone Museum, plaster cast in British Museum (Nat. Hist.), No. V. 13201 (p. 47).

BENNETTITES ALLCHINI sp. nov.

PLATE II.

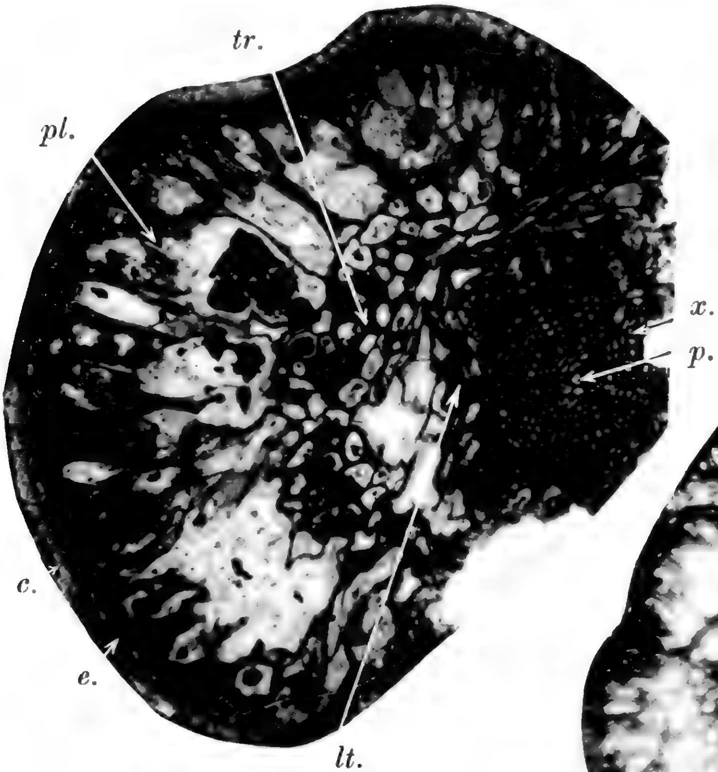
Sequoia giganteoides, sp. nov. Small twig.—
Lower Greensand; Luccomb Chine, Isle of Wight.

Fig. 1. Transverse section of the whole twig, showing axis surrounded by leaves. No. V. 13230 *a* (p. 70).

Fig. 2. Single leaf of the same, enlarged to show the large central resin-canal and the two groups of transfusion-tissue, one on either side. No. V. 13230 *a* (p. 70).

Fig. 3. Leaf from another section, cut nearer the base to show the loss of the resin-canal and the joining up of the two masses of transfusion-tissue to form one broad band. Stopes Coll., no. SB, *aa* (p. 73).

In all the photos the lettering is as follows:—*c.*, cuticle; *e.*, epidermis; *lt.*, leaf-trace; *p.*, pith; *pl.*, palisade layer of leaf; *r.c.*, resin-canal; *tr.*, transfusion-tissue; *x.*, xylem.



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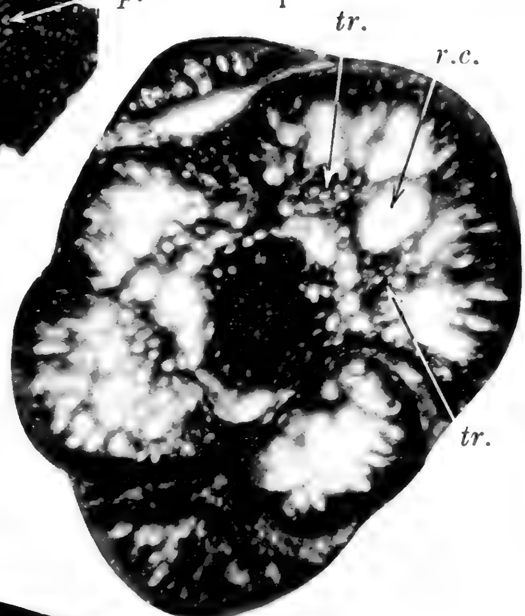

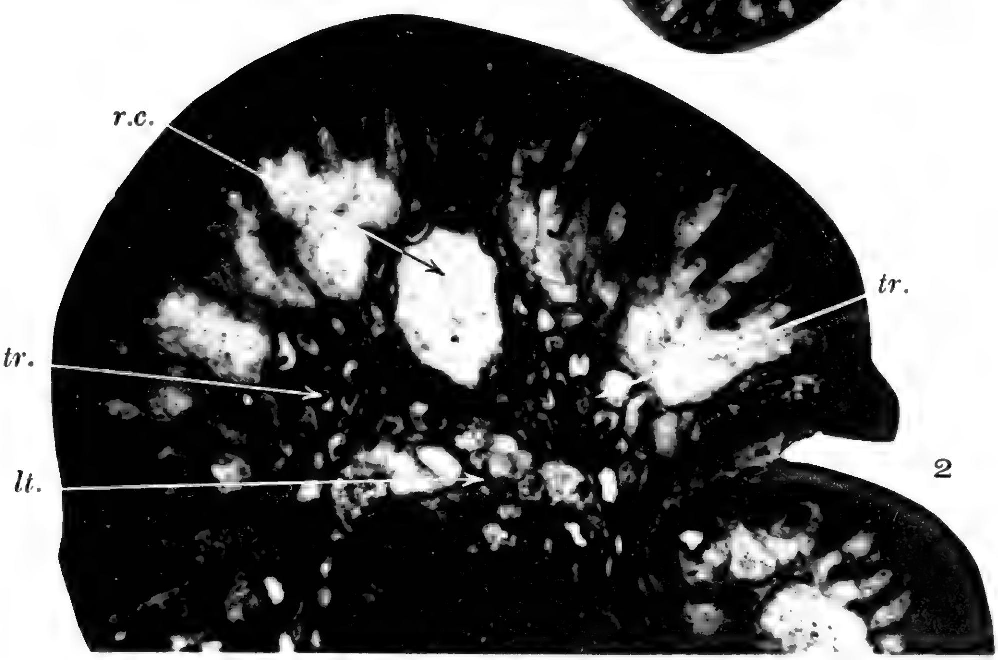

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SEQUOIA GIGANTEOIDES. sp. nov.

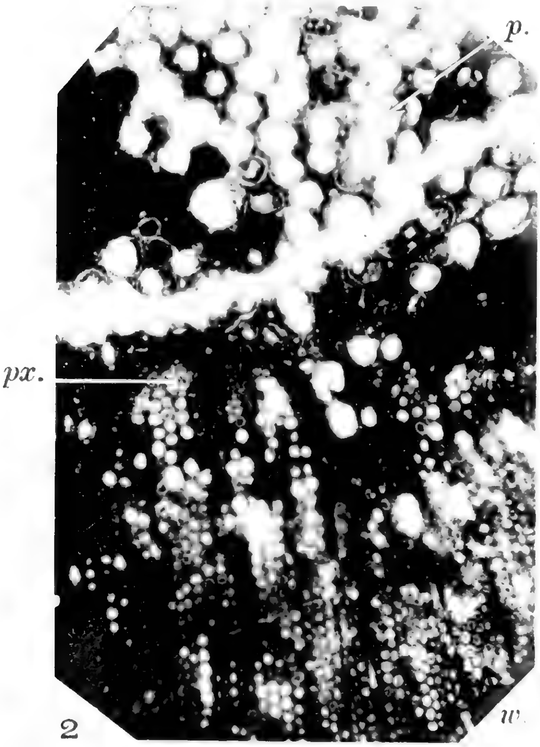
PLATE III.

Protopiceoxylon Edwardsi, sp. nov. Woody branch.—
Lower Greensand; Berwick Green, Sussex.

Fig. 1. Transverse section, showing the stem with the centre of the axis preserved and surrounded by well-marked growth-rings. No. V. 4859 (p. 81).

Fig. 2. Enlargement of part of the centre of the stem. *p.*, pith; *px.*, protoxylem and primary wood; *w.*, secondary wood. No. V. 4859 *a* (p. 81).

Fig. 3. Part of the secondary wood, showing the broad zone of thickened autumn wood in the well-marked growth-rings. *r.c.*, resin-canals in the autumn wood. No. V. 4859 *a* (p. 81).



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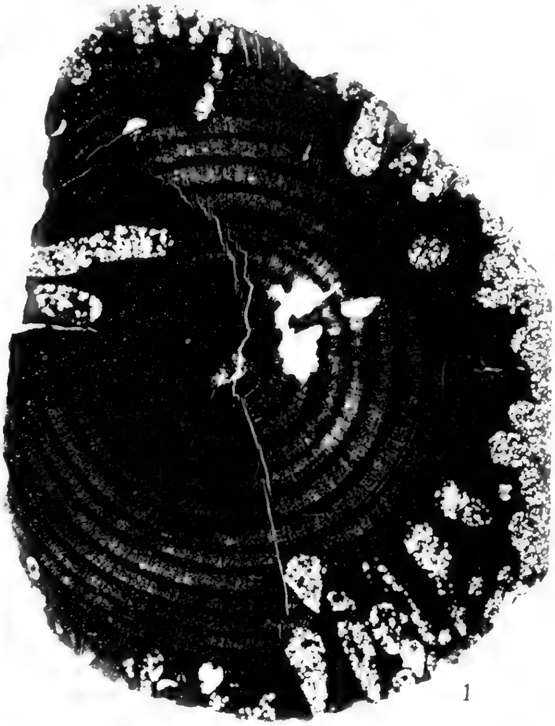
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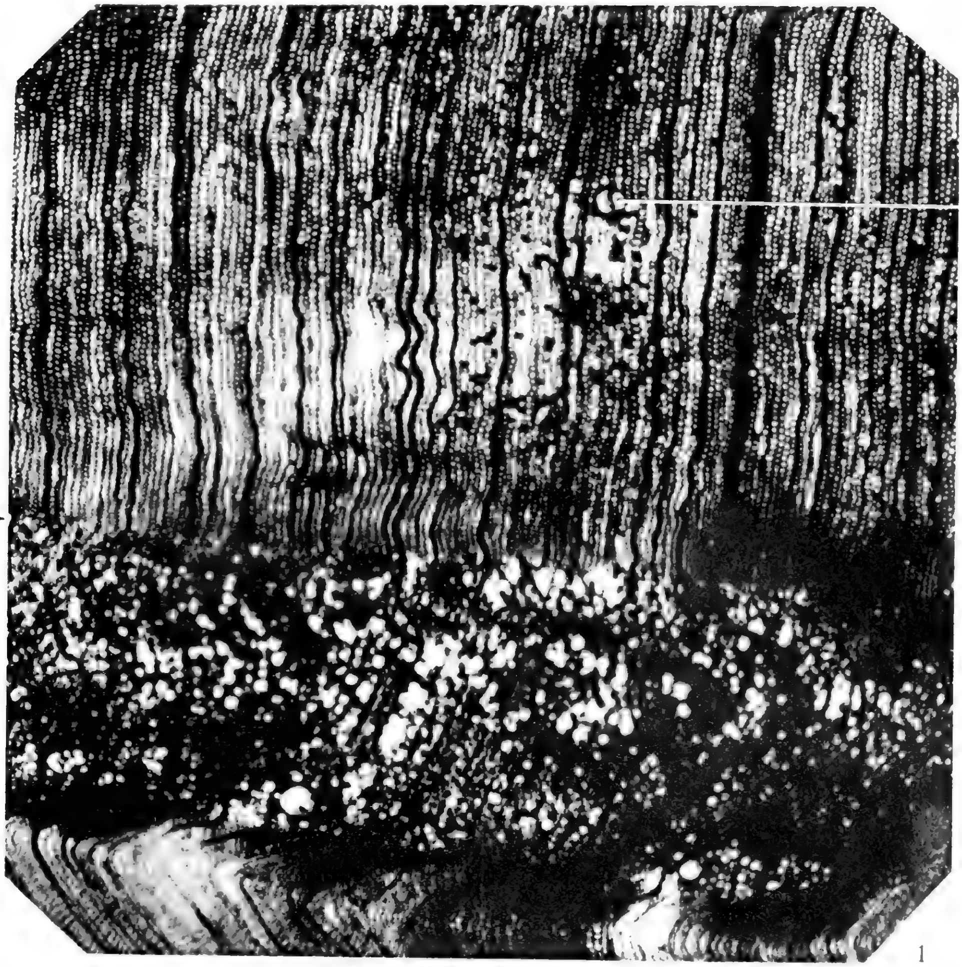
PROTOPICEOXYLON. EDWARDSI sp. nov.

PLATE IV.

Pityoxylon Sewardi, sp. nov. Part of trunk.—
Lower Greensand; Ightham, Kent.

Fig. 1. Transverse section. *a.*, limit of annual ring, crushed spring wood adjacent to autumn wood; *r.c.*, isolated resin-canal in the midst of wood. No. V. 1440 *a* (p. 95).

Fig. 2. Transverse section. *a.*, limit of annual ring. Near this are seen groups of resin-canals, *r.c.a.*, surrounded by patches of parenchyma. No. V. 1440 *a* (p. 95).



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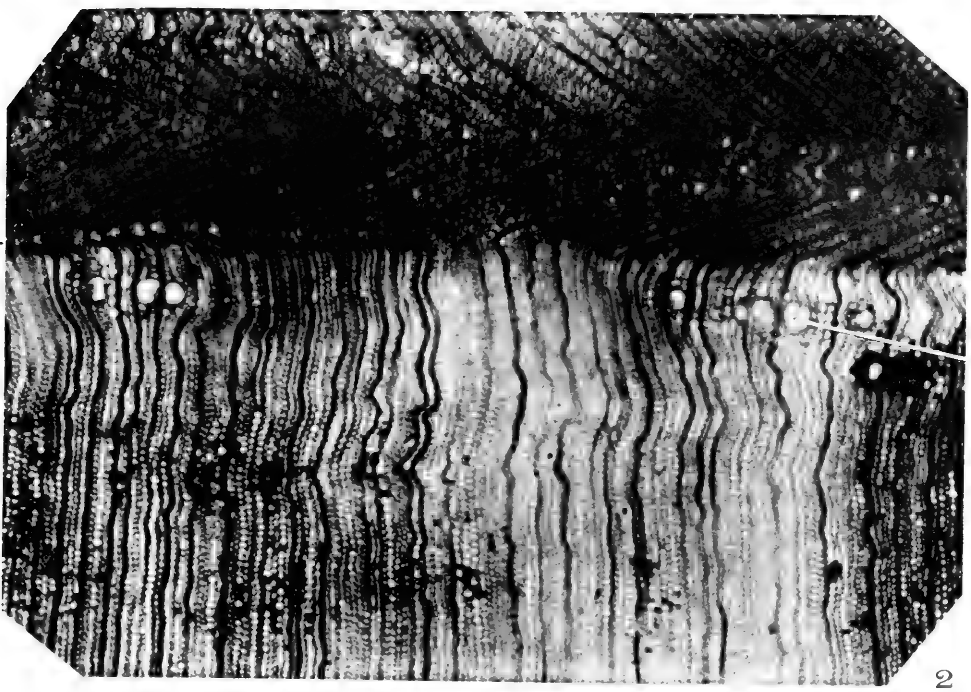

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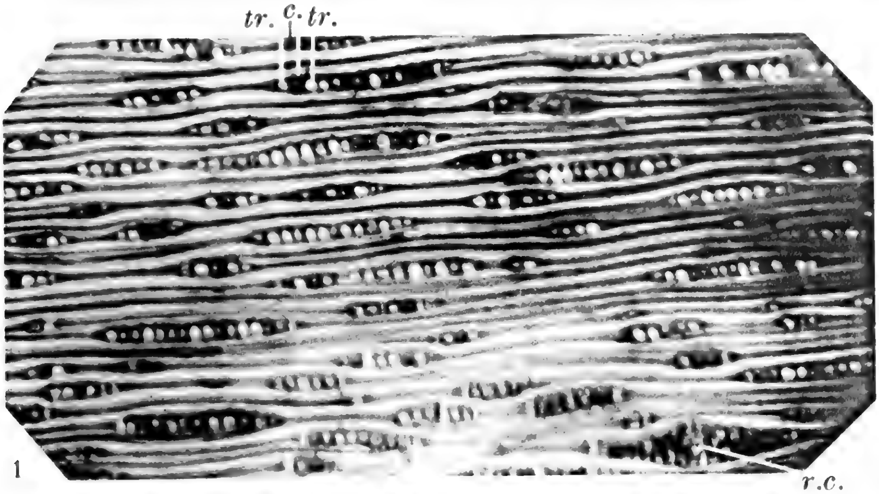
PITYOXYLON SEWARDI sp. nov.

PLATE V.

Fig. 1. *Pityoxylon Sewardi*, sp. nov. Tangential section showing the numerous uniseriate medullary rays.—Lower Greensand; Ightham, Kent. *r.c.*, resin-canal in multiseriate ray; *tr.*, ray-tracheids alternating with contents-containing parenchyma, *c.* No. V. 1440 *c* (p. 95).

Fig. 2. *Pityoxylon Benstedi*, sp. nov. Radial section showing numerous medullary rays.—Kentish Rag; near Maidstone, Kent. *r.t.*, ray-tracheids; *r.c.*, resin-canal, with, *e.*, its thick-walled epithelium. *Cf.* text-fig. 26. No. 38353 B *f* (p. 105).



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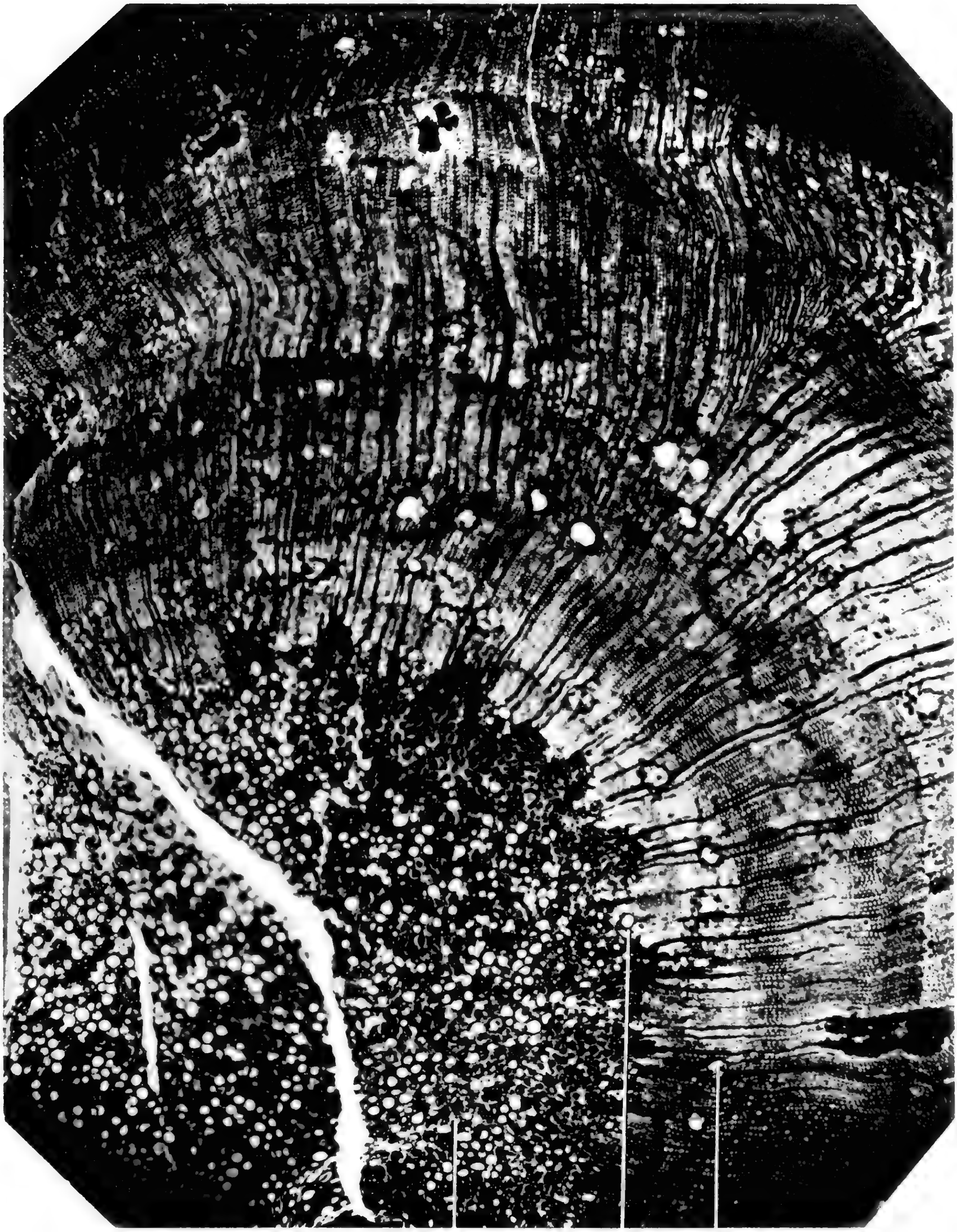
I. PITYOXYLON SEWARDI sp. nov.
& 2. P BENSTEDI sp. nov.

PLATE VI.

Pityoxylon Benstedi, sp. nov. Transverse section of inner part of the stem showing the large pith.—Kentish Rag; near Maidstone, Kent. *p.*, pith ; *p.r.c.*, resin-canal in primary bundle ; *r.c.*, resin-canal of secondary wood. No. 38353 *a* (p. 105).



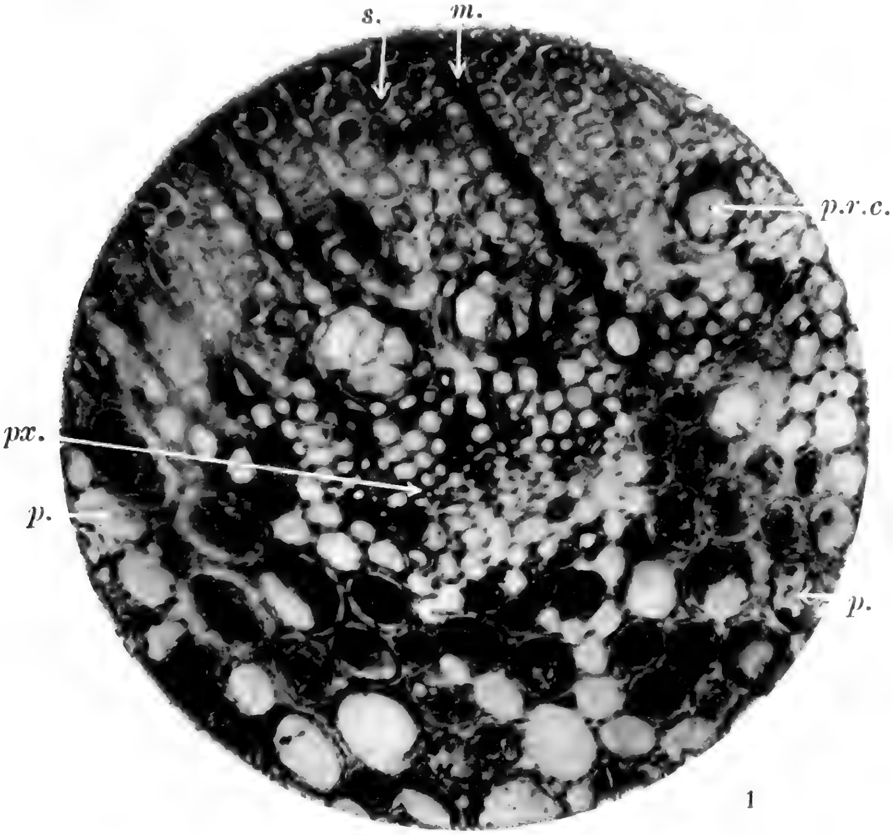
PITYOXYLON BENSTEDI sp. nov.

PLATE VII.

Pityoxylon Benstedi, sp. nov. Transverse section of wood.—Kentish Rag; near Maidstone, Kent.

Fig. 1. Primary bundle. *p.*, pith-cells, showing their thickened and pitted walls; *px.*, protoxylem of primary bundle; *p.r.c.*, resin-canal in primary bundle; *m.*, medullary ray; *s.*, beginning of secondary wood. No. 38353 B *b* (p. 107).

Fig. 2. Resin-canals from secondary wood. *s.*, secondary wood; *m.*, medullary ray; *t.*, tyloses, filling resin-canal; *e.*, thick-walled epithelium of resin-canal. No. 38353 B *c* (p. 109).



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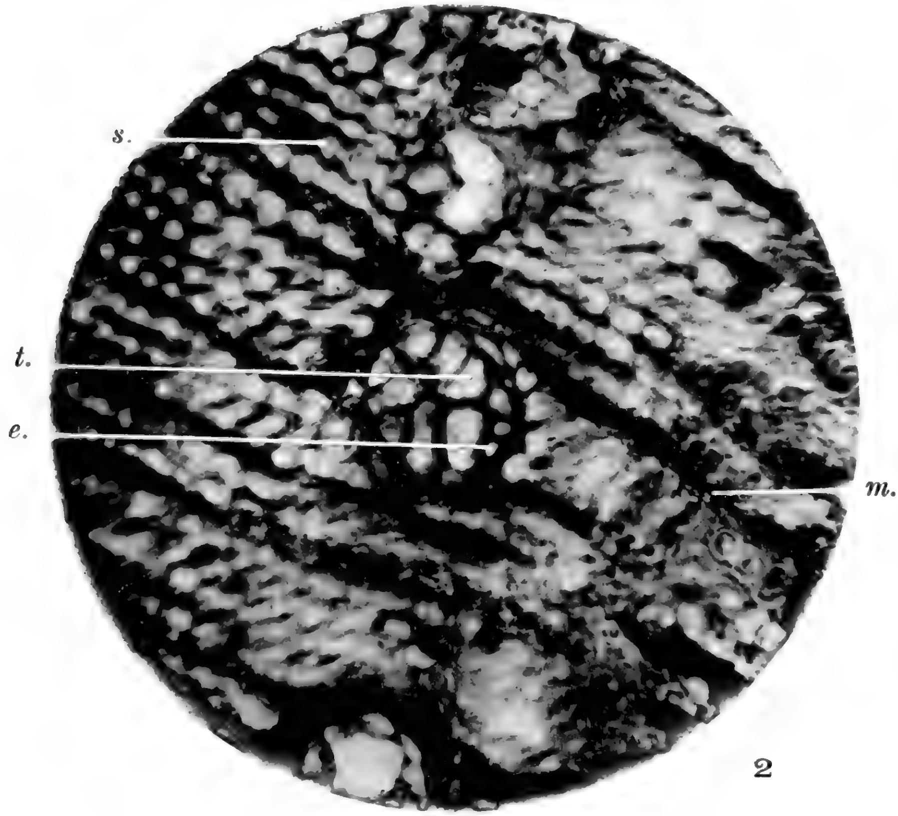

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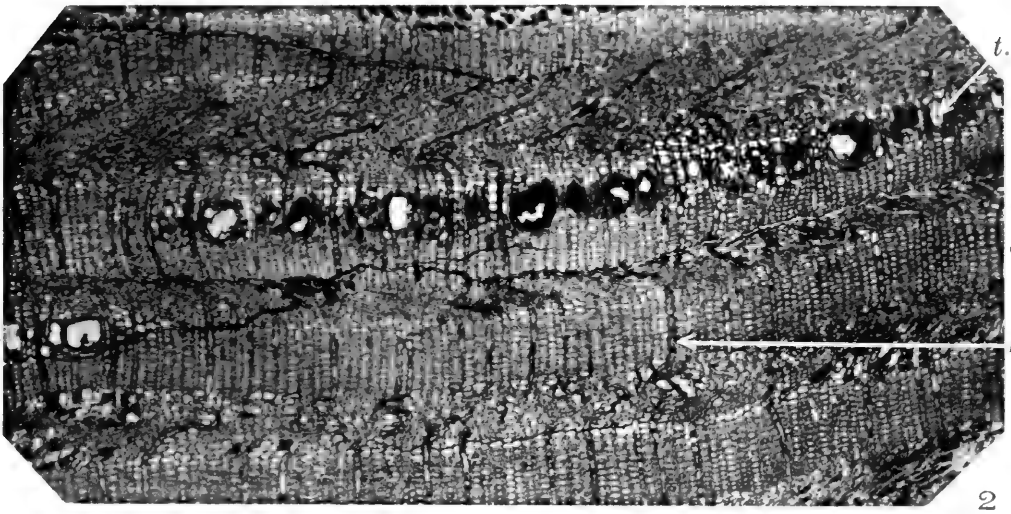
PITYOXYLON BENSTEDI sp. nov.

PLATE VIII.

Pityoxylon Woodwardi, sp. nov. Transverse section of wood.—Lower Greensand; Woburn, Bedfordshire.

Fig. 1. General view of wood in transverse section, the large white spaces being the resin-canals. No. V. 5429 *a* (p. 116).

Fig. 2. Small area of wood to show part of two alternating tangential bands of vertically running resin-canals, *t. a.*, autumn wood; *s.*, spring wood, which is crushed; *m.*, noticeable uniseriate medullary ray. No. V. 5429 *a* (p. 117).



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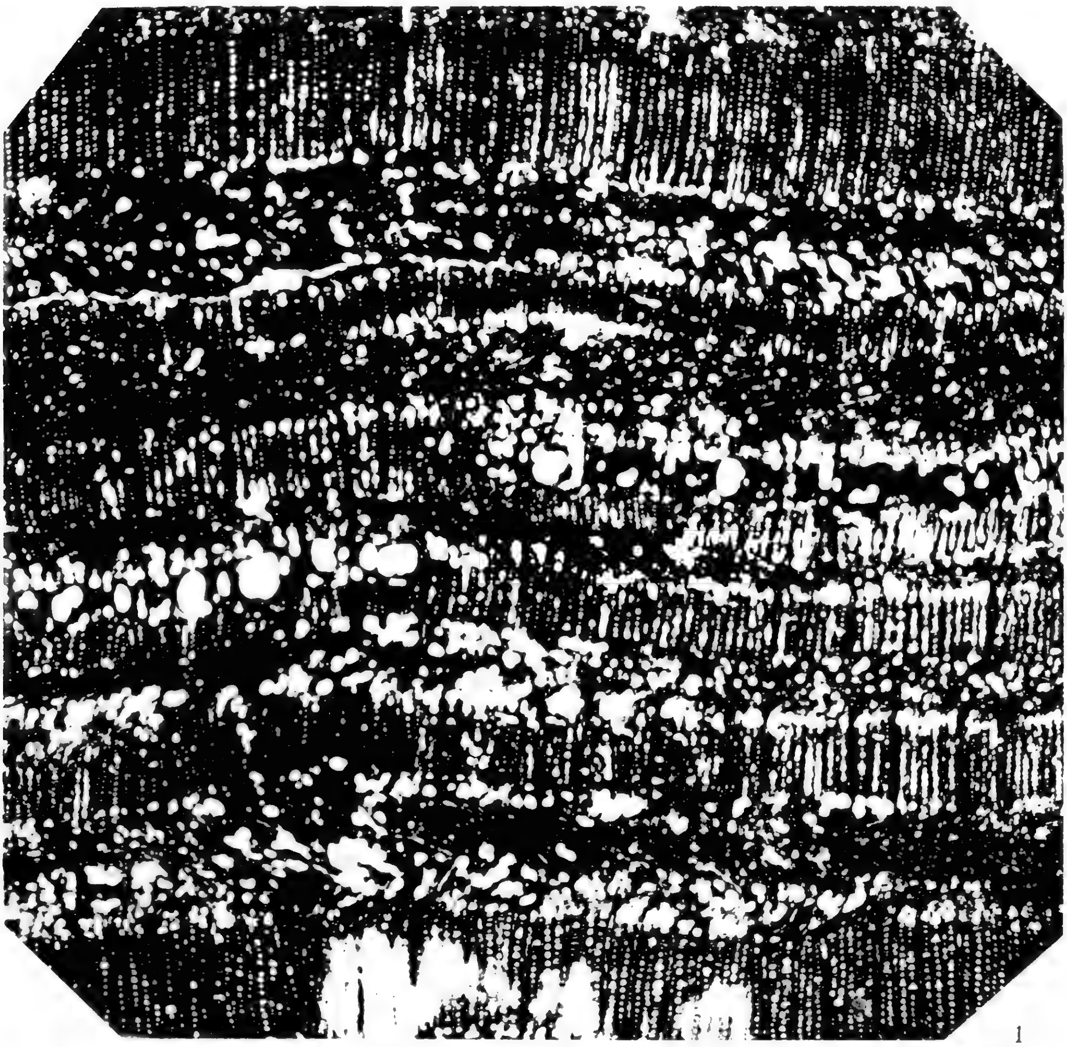

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PITYOXYLON WOODWARDI sp. nov.

PLATE IX.

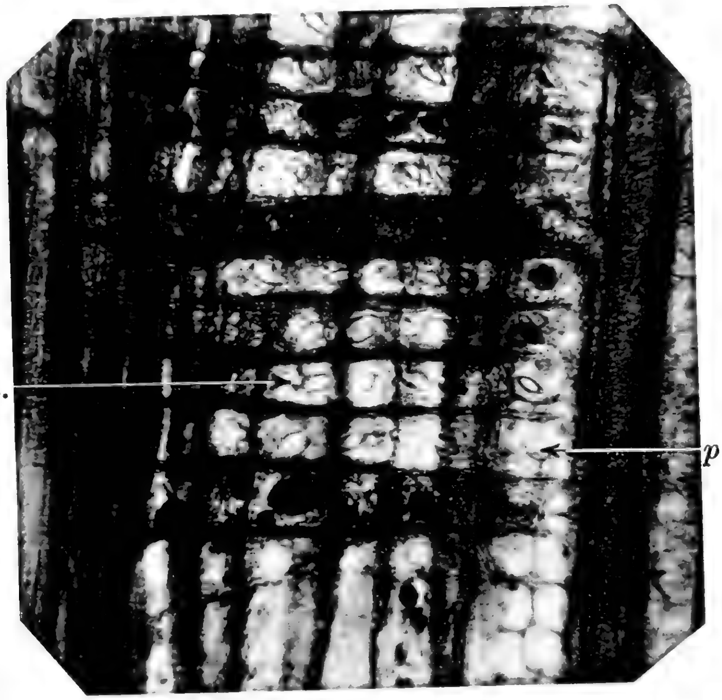
Pityoxylon Woodwardi, sp. nov. Radial sections of wood.—Lower Greensand; Woburn, Bedfordshire.

Fig. 1. Radial section showing pitting of tracheids. *a.*, elements with large, round, isolated pits; *b.*, "twin-pits" in a similar element. No. V. 5429 *b* (p. 116).

Fig. 2. Radial section showing pitting of tracheids. *a.*, as above; *c.*, pits in adjacent pairs. No. V. 5429 *b* (p. 117).

Fig. 3. Radial section showing the medullary ray, with horizontally running black bands formed by contents-containing cells. *p.m.*, pitted cells in which the large definite oval pits are well seen, each surrounded by a very faint border. No. V. 5429 *b* (p. 119).

p.m.



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p.m.

a. 2 c.

a. b. a. 1

PITYOXYLON WOODWARDI sp. nov.

PLATE X.

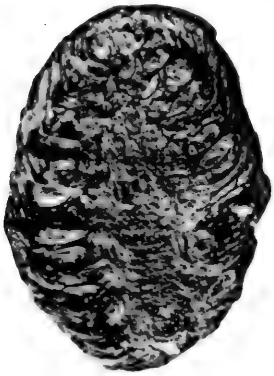
Fig. 1. *Pinostrobus Benstedi* (Mantell). The cone split open, natural size.—Kentish Rag; near Maidstone, Kent. No. 39107 (p. 130).

Figs. 2–4. *Pinostrobus sussexiensis* (Mantell). Cone.—Lower Greensand; Selmeston, Sussex.

Fig. 2. External view of part of the cone. No. V. 3349 (p. 123).

Fig. 3. Upper end of the same specimen, showing the axis, scales, and seeds irregularly broken across.

Fig. 4. Transverse section of upper part of the same cone. *s.*, seed and its pair, borne on scale, *sc.*; *w.*, wings of seeds just separated from inner surface of scale; *x.*, scale on which the tissues of the wings show particularly well; *z.*, scale which shows the vascular bundles particularly well. No. V. 3349 *a* (p. 123).



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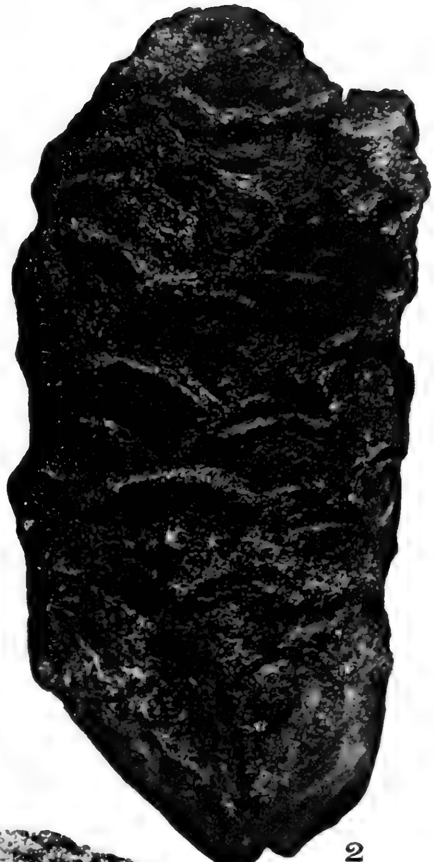

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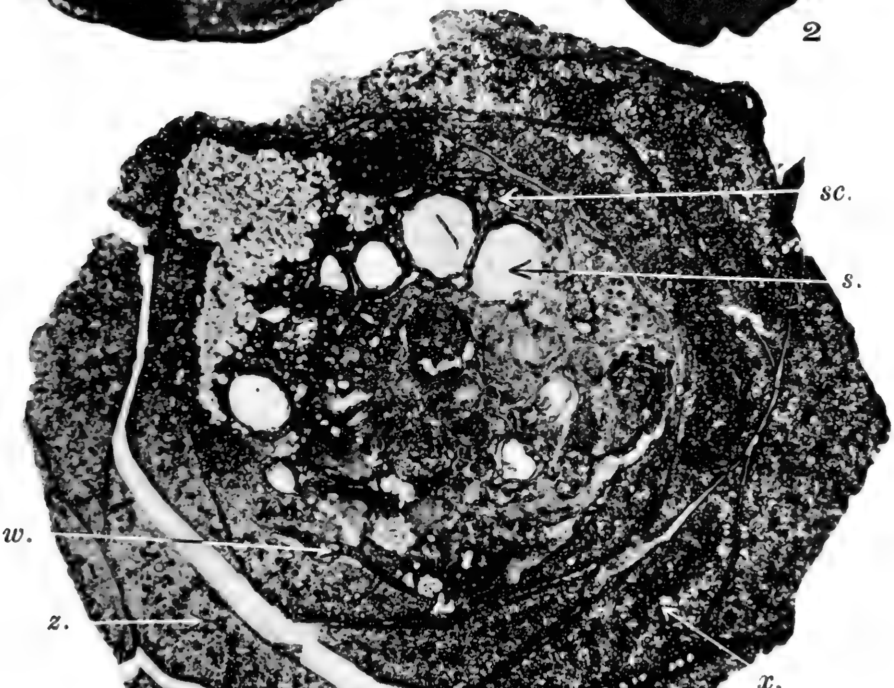


4

1. PINOSTROBUS BENSTEDI. 2. 3. 4. P. SUSSEXIENSIS.

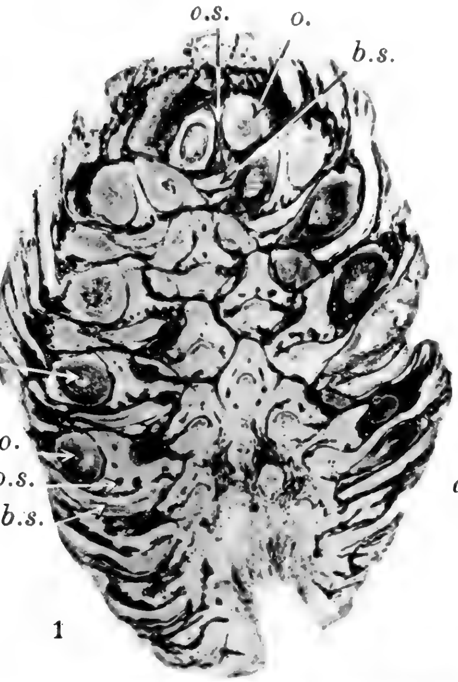
PLATE XI.

Pinostrobus Benstedi (Mantell). Longitudinal sections of cone.—Kentish Rag; near Maidstone, Kent.

Fig. 1. Tangential longitudinal section of the cone. ***end.***, area of broken-down endosperm within the ovule, ***o.***; ***os.***, ovuliferous scale; ***bs.***, bract-scale. No. 39107 *b* (p. 132).

Fig. 2. Nearly median longitudinal section of the cone. ***o.***, ovule; ***os.***, ovuliferous scale; ***bs.***, bract-scale; ***a.***, axis. No. 39107 *a* (p. 131).

Fig. 3. *Pinostrobus sussexiensis* (Mantell). Transverse section of part of the overlapping scales from the outer part of the cone.—Lower Greensand; Selmeston, Sussex. ***v.b.***, vascular bundles of scale; ***r.c.***, resin-canals; ***scl.***, sclerised tissue of scale; ***w.***, wing of seed, split off from scale. *Cf.* text-fig. 30. No. V. 3349 *a* (p. 126).



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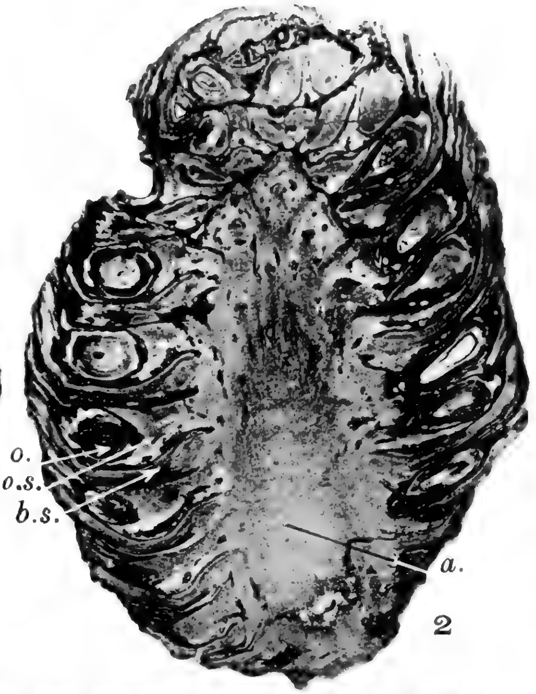

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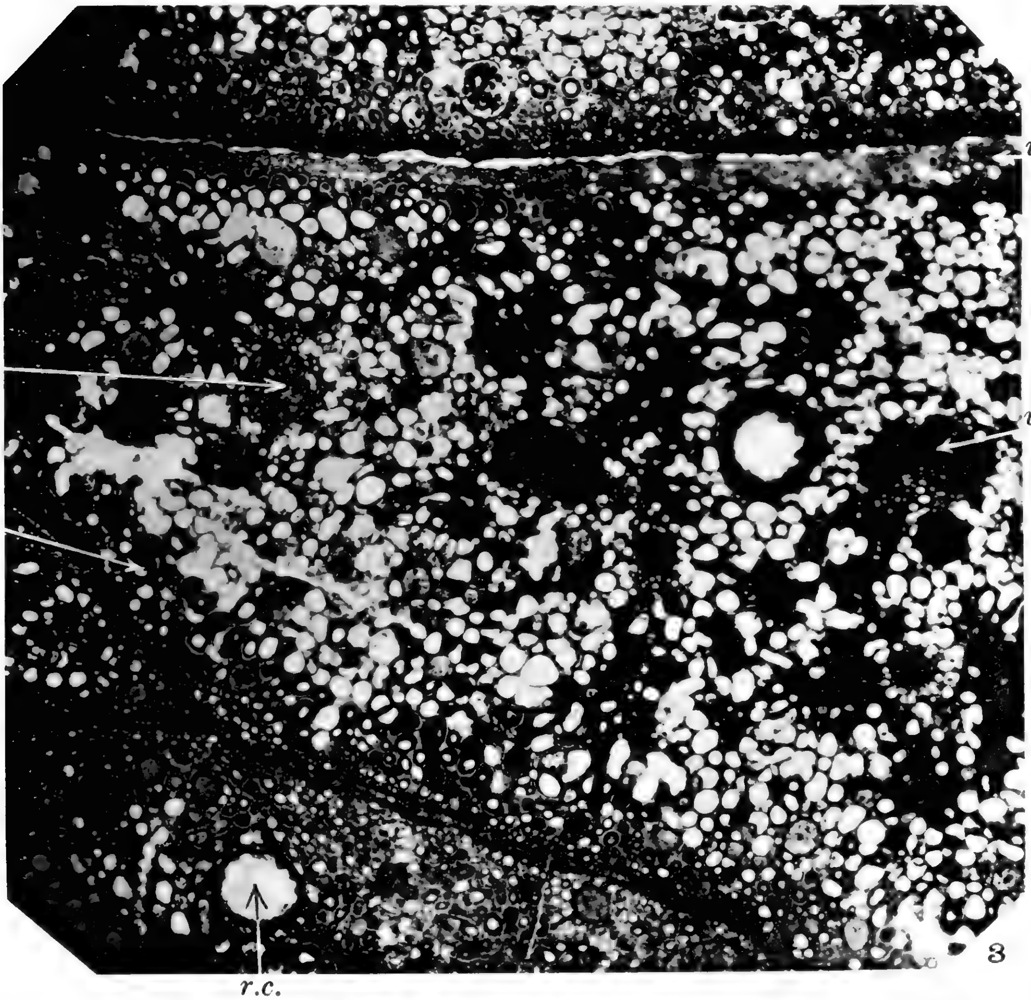

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I.2. PINOSTROBUS BENSTEDI. 3. P. SUSSEXIENSIS.

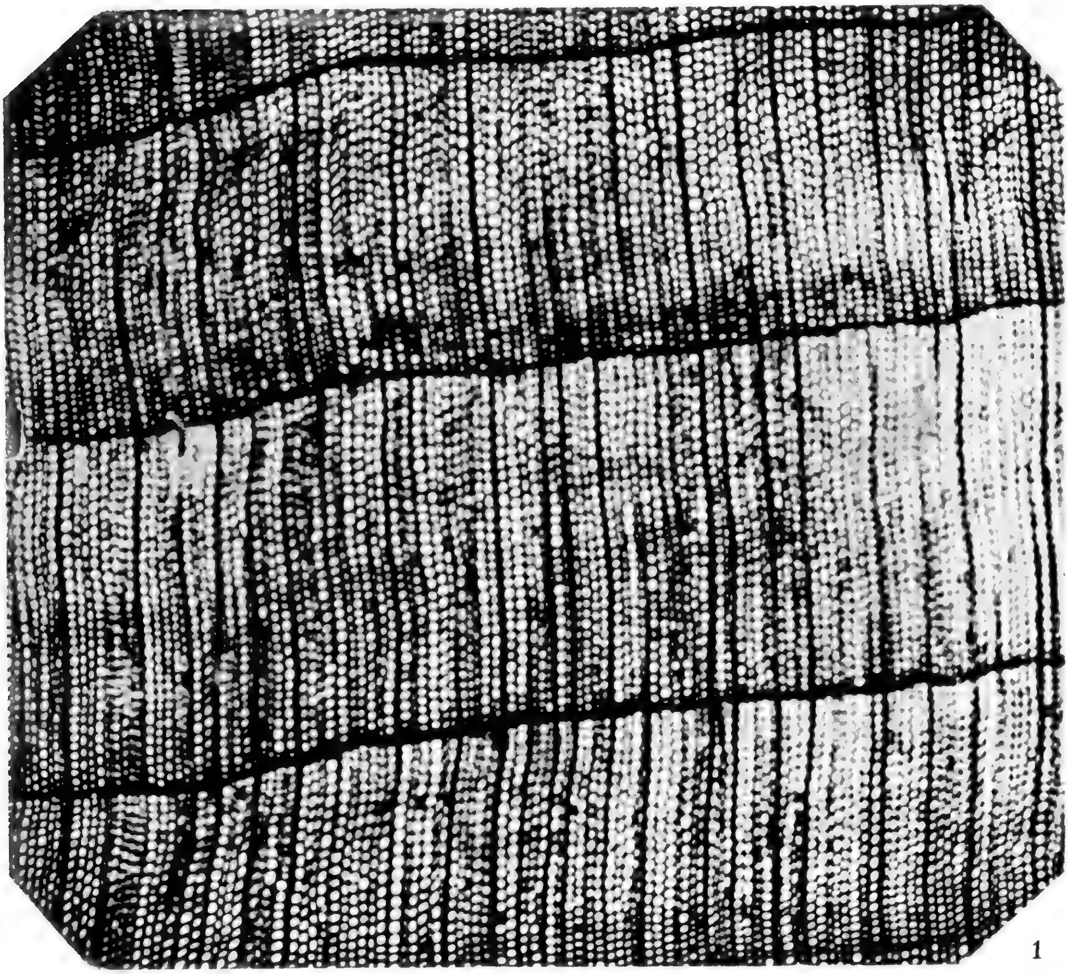
PLATE XII.

Cedroxylon maidstonense, sp. nov. Sections of wood.—
Kentish Rag; Iguanodon Quarry, Maidstone.

Fig. 1. Transverse section of secondary wood, showing the very narrow zones of thick-walled autumn wood at *a*. No. 1769 *a* (p. 149).

Fig. 2. Radial section showing the small, round, bordered pits of the tracheids, with "Sanio's rims" at *s*. *m*., medullary ray showing group of small round pits in tracheid-field. *Cf.* text-fig. 43. No. 1769 *c* (p. 152).

2



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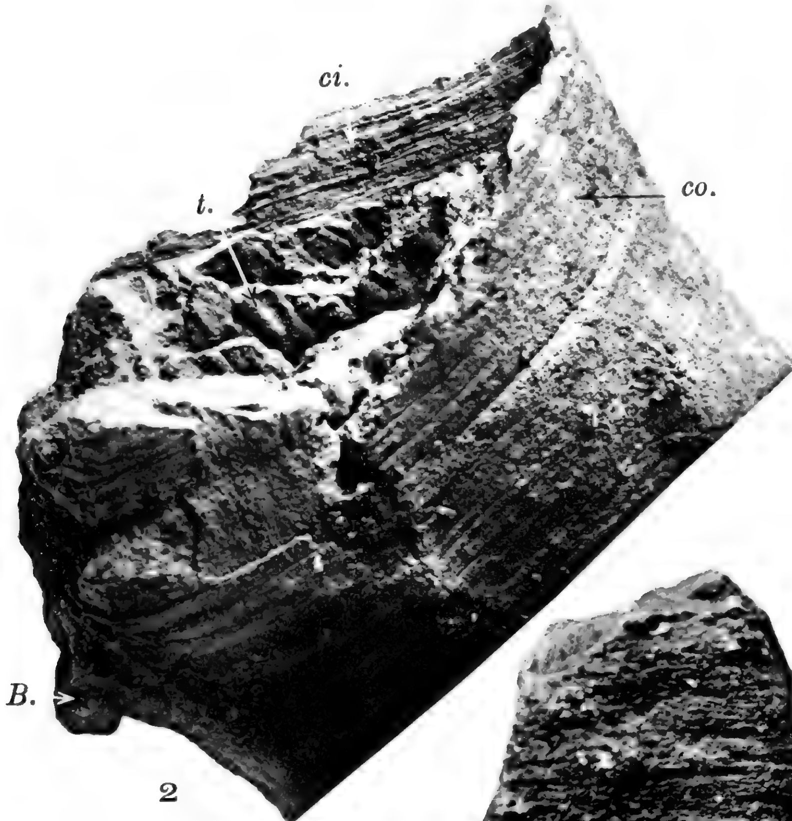
CEDROXYLON MAIDSTONENSE sp. nov.

PLATE XIII.

Fig. 1. Abietinean trunk in "*Benstedtia*" condition, showing the transverse external corrugations, *co.*; and the decayed wood within, which breaks through on one side, *w*. Part of the large broken-up specimen.—Kentish Rag; Iguanodon Quarry, Maidstone. No. 1765 (p. 159).

Fig. 2. Abietinean trunk in "*Benstedtia*" condition. Upper part of the same specimen as is figured in Pl. XIV, figs. 1 & 2. B, the side branch illustrated in Pl. XIV. *co.*, the external transverse corrugations; *ci.*, similar corrugations on the *inner* side of the hollowed-out end; *t.*, narrow teredo-borings running vertically and corresponding to the tubercles outside the specimen (*cf.* Pl. XIV, fig. 1). In Maidstone Museum, plaster cast in British Museum (Nat. Hist.). No. V. 13202 (p. 165).



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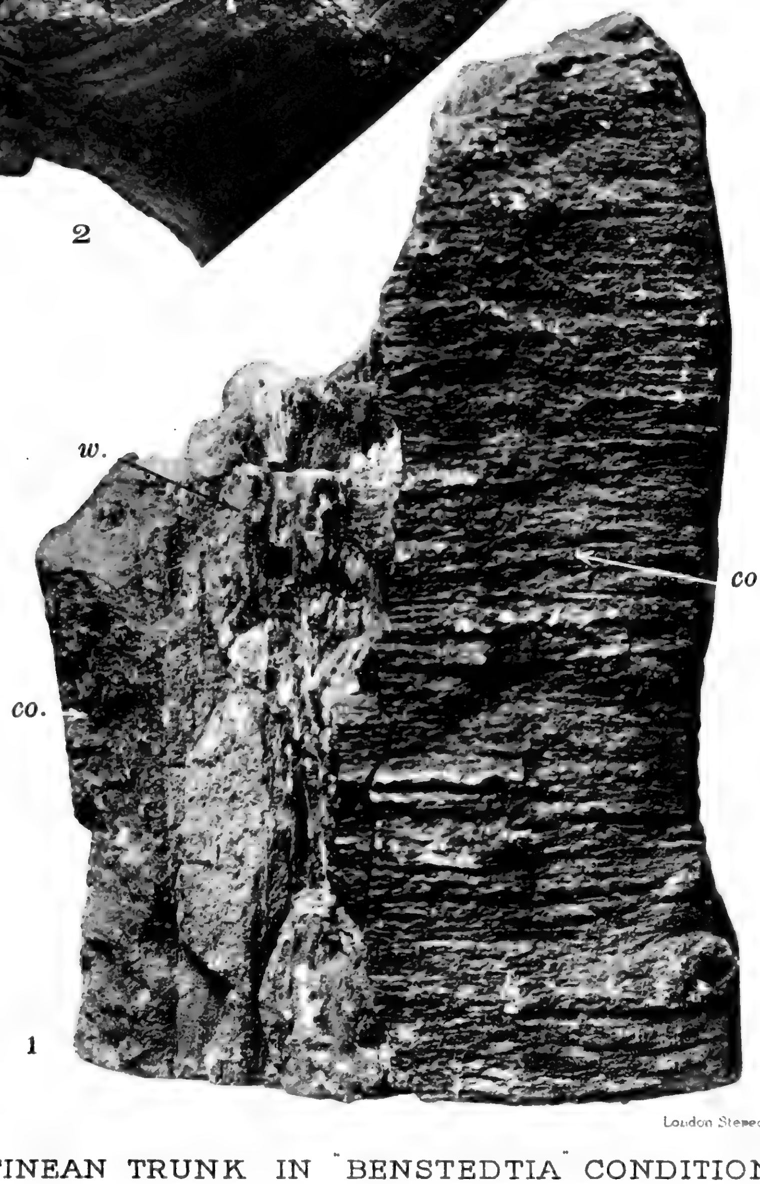

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ABIETINEAN TRUNK IN "BENSTEDTIA" CONDITION.

PLATE XIV.

Abietinean trunk in the "*Benstedtia*" condition.—Kentish Rag; Iguanodon Quarry, Maidstone. In Maidstone Museum, plaster cast in British Museum (Nat. Hist.). No. V. 13202 (p. 165).

Fig. 1. Surface-view of one side, showing the transverse corrugations and the tubercles. At B is a side-branch (*cf.* fig. 2). At the lower left-hand corner some of the decayed wood can be seen.

Fig. 2. Part of the same specimen from one side, showing the flattening and also showing very clearly the base of the lateral branch at B.

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ABIETINEAN TRUNK IN "BENSTEDTIA" CONDITION.

PLATE XV.

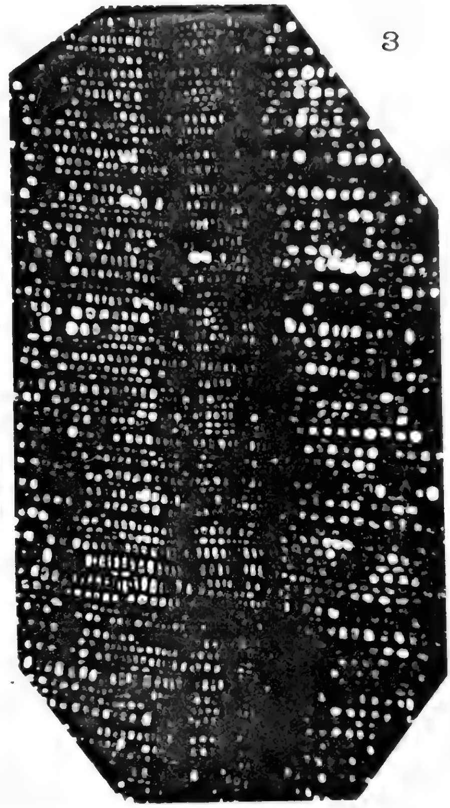
Cupressinoxylon vectense, Barber. Sections of stems.—
Lower Greensand; Shanklin, Isle of Wight.

Fig. 1. Transverse section of branching specimen, slightly enlarged. No. V. 13192 *a* (p. 169).

Fig. 2. Transverse section of a similar specimen, showing the very well-marked growth-rings. *r.p.*, resin-containing parenchyma scattered throughout the wood. No. V. 13193 *a* (p. 171).

Fig. 3. Part of the autumn wood of another portion of the same specimen as the above, to show the "composite" ring. No. V. 13193 *a* (p. 177).

1



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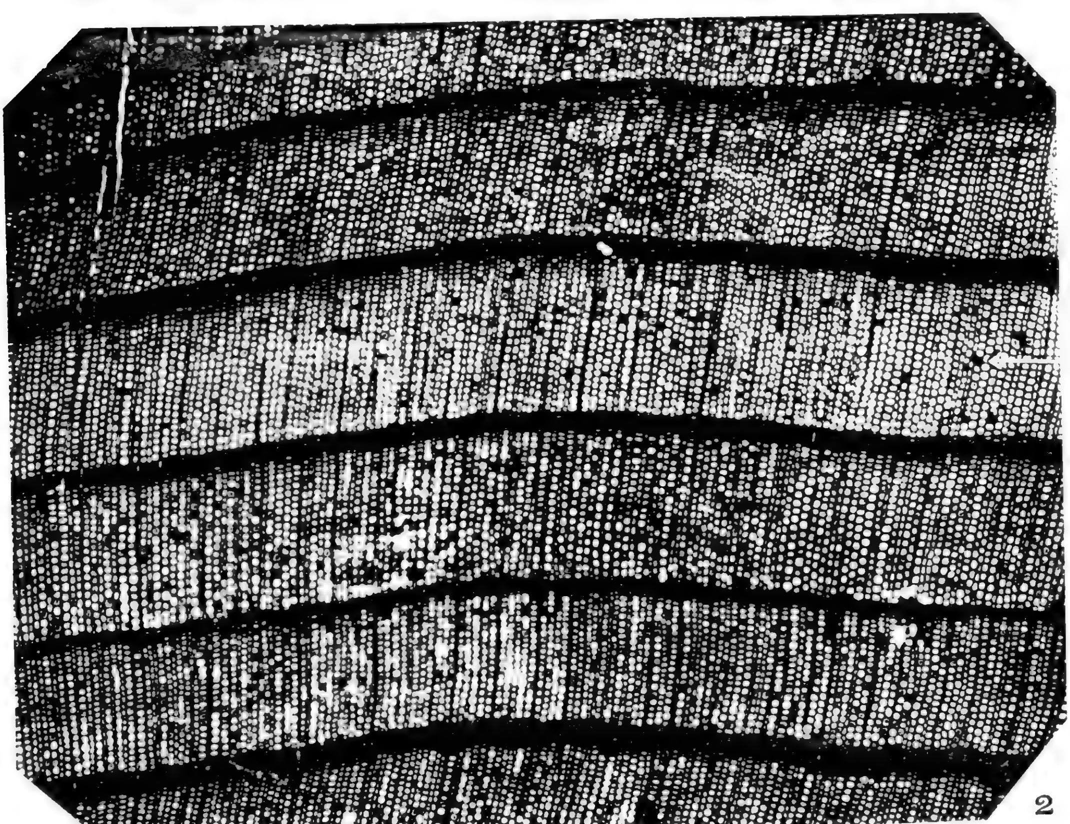

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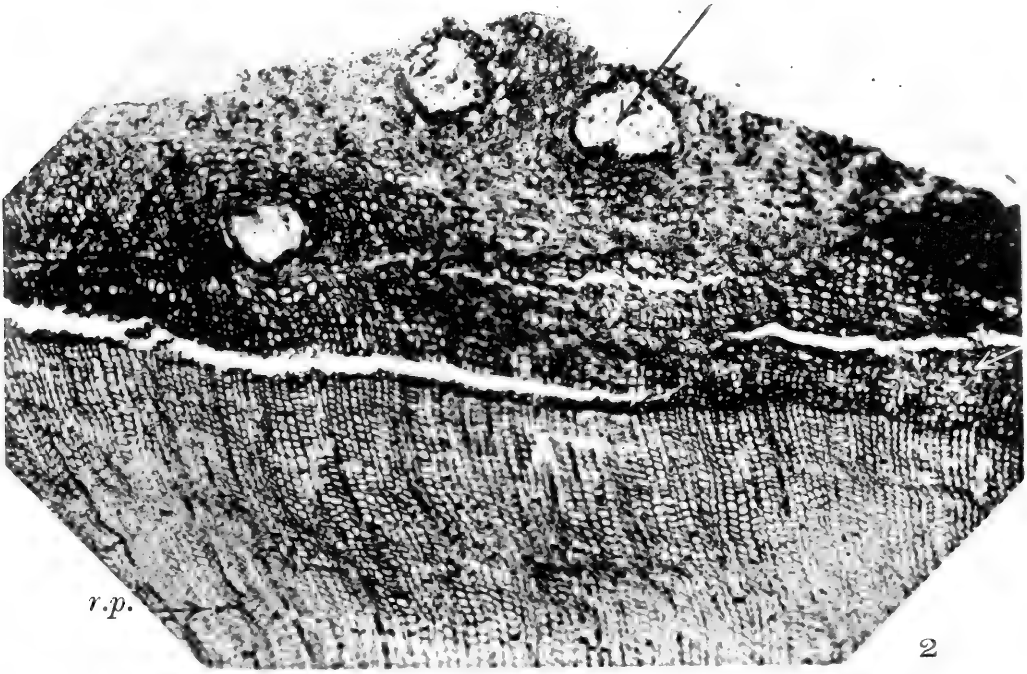
CUPRESSINOXYLON VECTENSE, Barber.

PLATE XVI.

Cupressinoxylon cryptomerioides, sp. nov. Transverse sections of wood.—Kentish Rag; Iguanodon Quarry, Maidstone.

Fig. 1. Transverse section of inner part of the wood. *p.*, pith; *p.x.*, bundles of primary xylem projecting into the pith; *r.p.*, resin-containing xylem-parenchyma scattered through the secondary xylem. No. V. 13208 *a* (p. 186).

Fig. 2. Transverse section of outer part of the same specimen. *r.p.*, resin-parenchyma in the secondary xylem; *c.*, cambium-layer; *ph.*, phloem; *r.c.*, large resin-canals in the cortex. No. V. 13208 *a* (p. 187).



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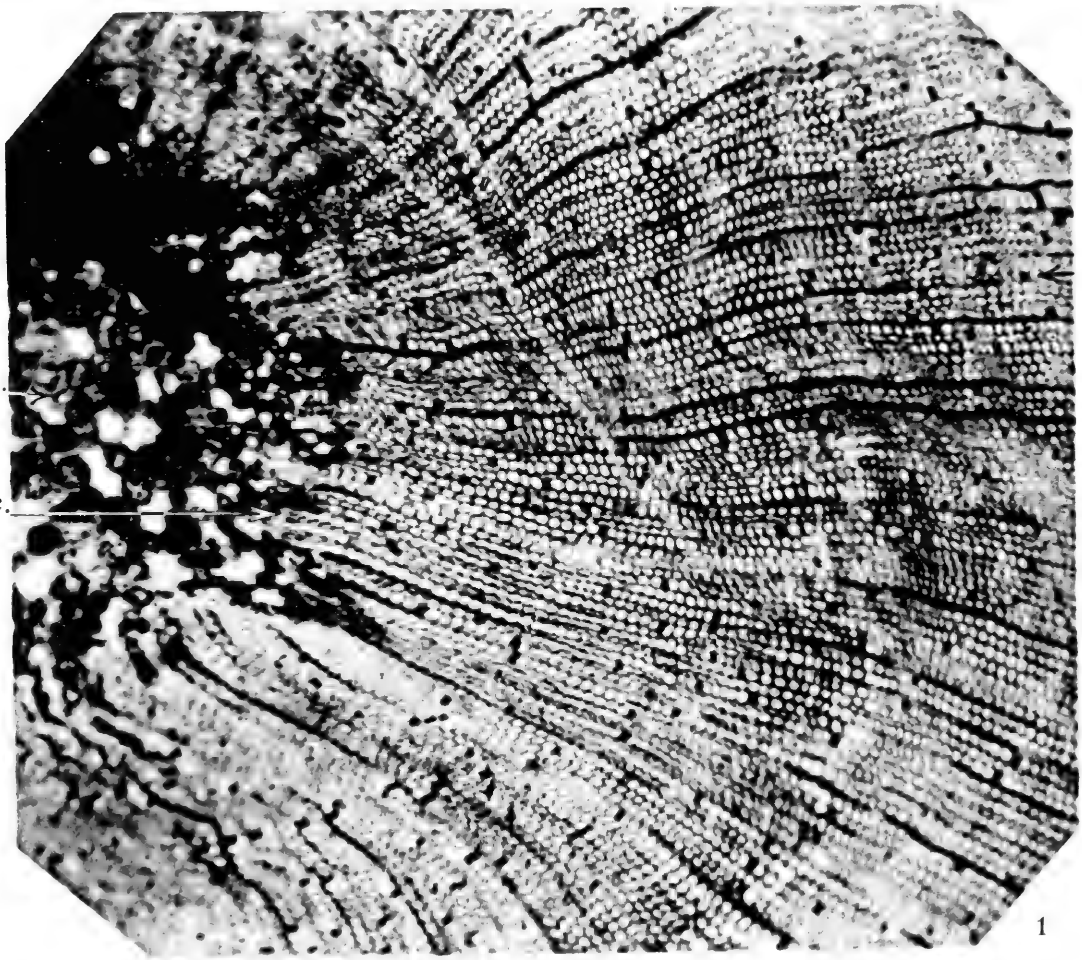


1

CUPRESSINOXYLON CRYPTOMERIOIDES sp. nov.

PLATE XVII.

Cupressinoxylon cryptomerioides, sp. nov. Radial longitudinal section of wood.—Kentish Rag; Iguanodon Quarry, Maidstone.

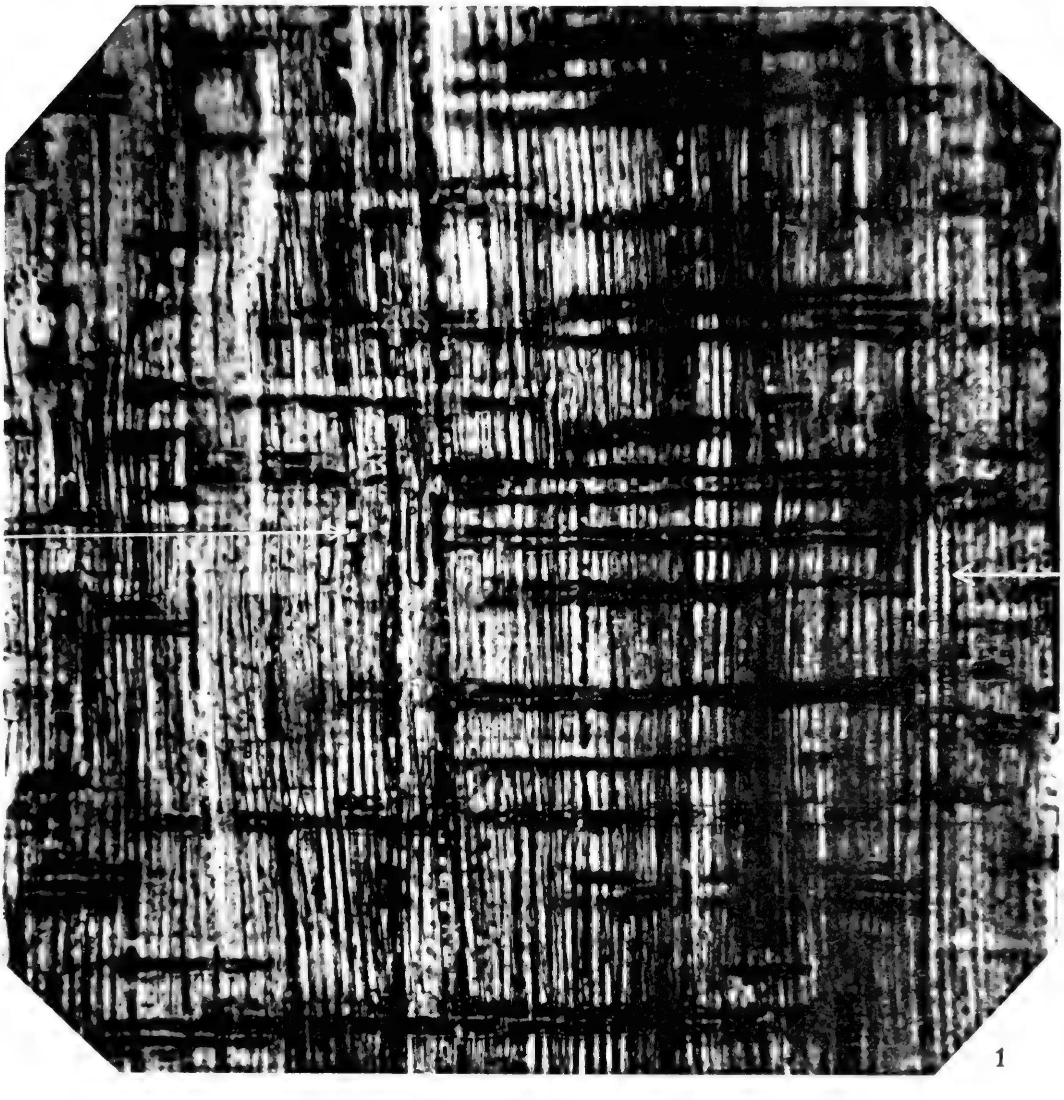
Fig. 1. Radial longitudinal section through the wood, showing the numerous low medullary rays. *r.p.*, resin-containing xylem-parenchyma; *tp.*, tracheid, showing round bordered pits. No. V. 13208 *c* (p. 189).

Fig. 2. Further enlarged portion of the same section just outside pith, showing a thick strand of protoxylem elements (*p.x.*) in the centre of the field. At *x* the larger pits of the secondary tracheids can be seen. No. V. 13208 *c* (p. 188).

p x.

x.

2



r.p.

t.p.

1

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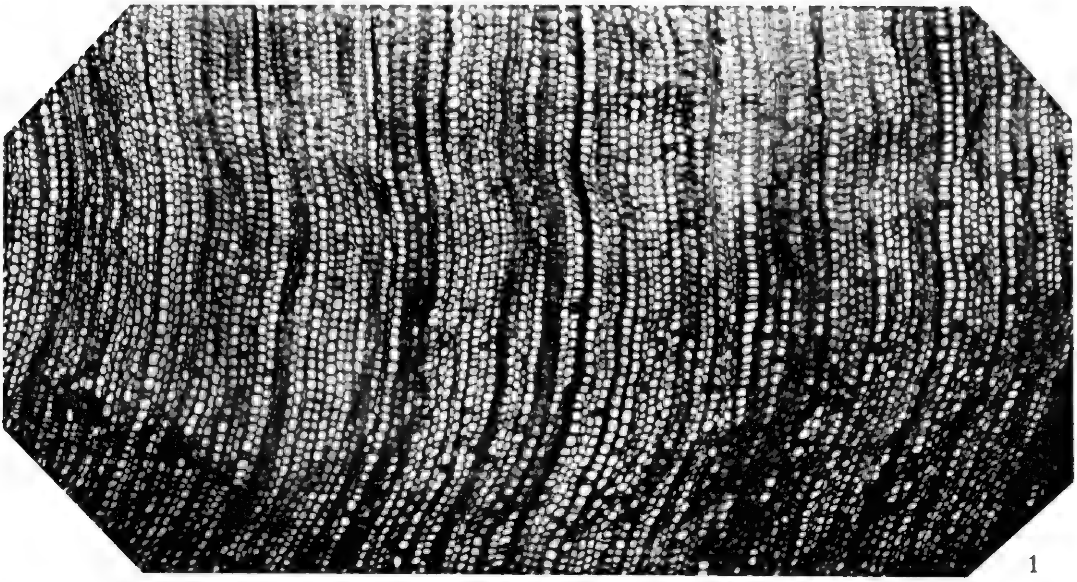
CUPRESSINOXYLON CRYPTOMERIOIDES sp. nov.

PLATE XVIII.

Cupressinoxylon Hortii, sp. nov. Sections of wood.—
Lower Greensand; Woburn Sands, Bedfordshire.

Fig. 1. Transverse section of part of one annual ring, showing the broad numerous rays. The dark elements scattered through the wood are the resin-containing xylem-parenchyma. No. V. 11847 *a* (p. 194).

Fig. 2. Tangential section showing the exceptional nature of the uniseriate and multiseriate rays, and their large number. *m.*, multiseriate ray, which is uniseriate lower down; *b.*, bifurcating ray. No. V. 11847 *c* (p. 198).



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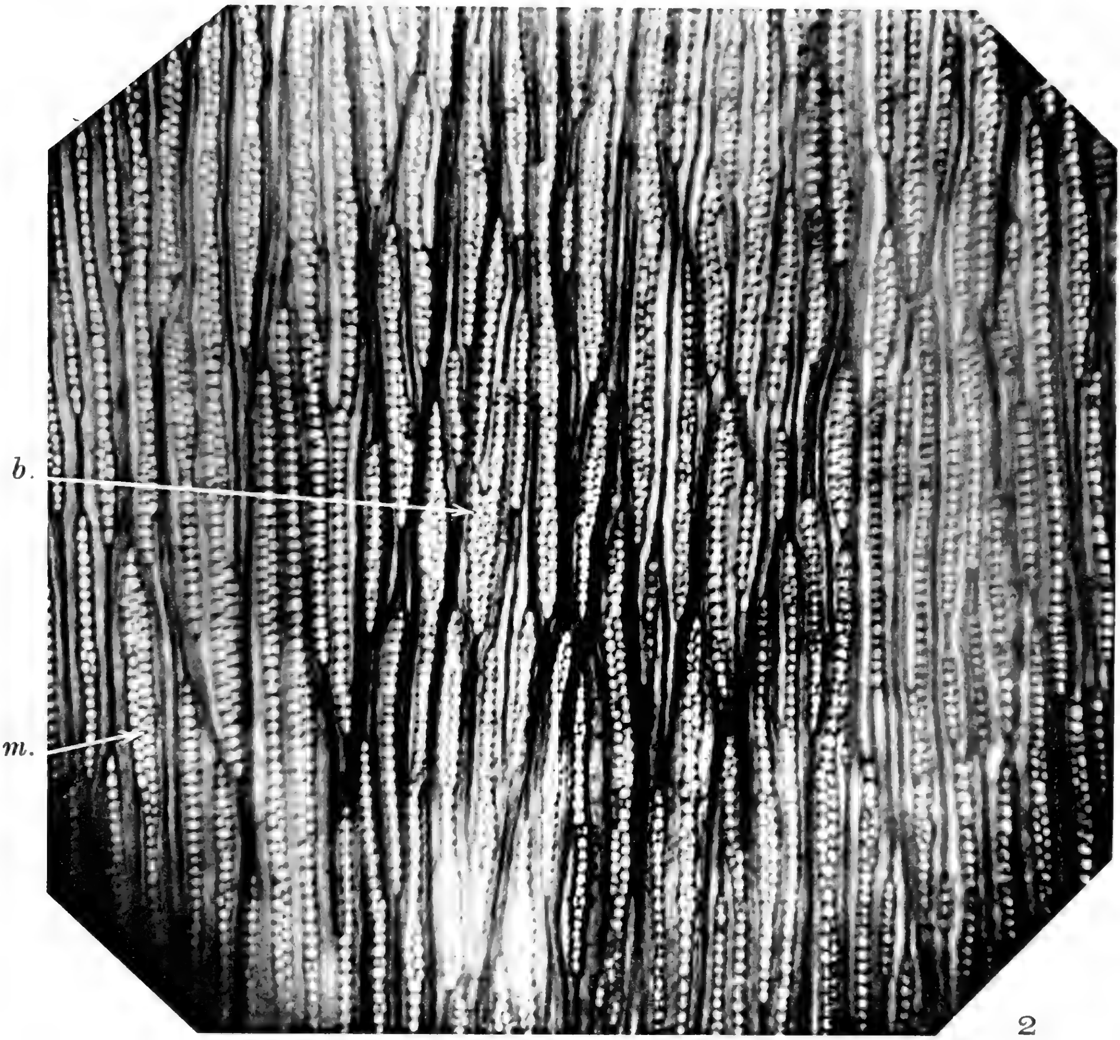

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CUPRESSINOXYLON HORTII sp. nov.

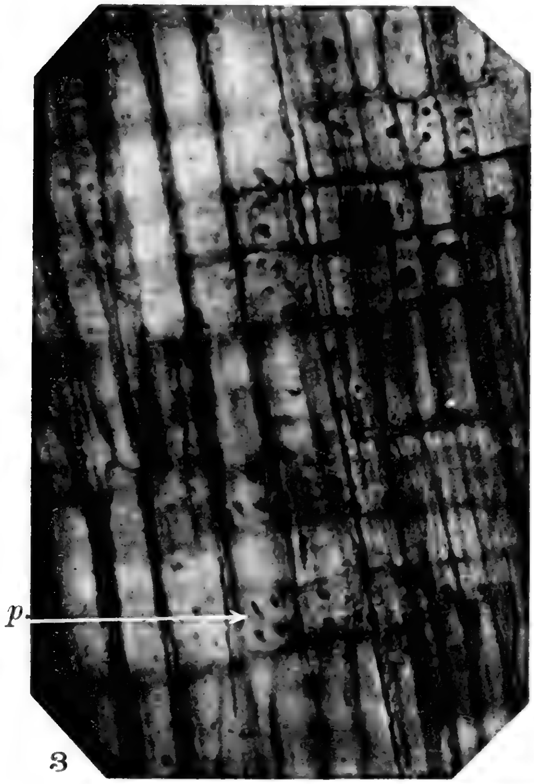
PLATE XIX.

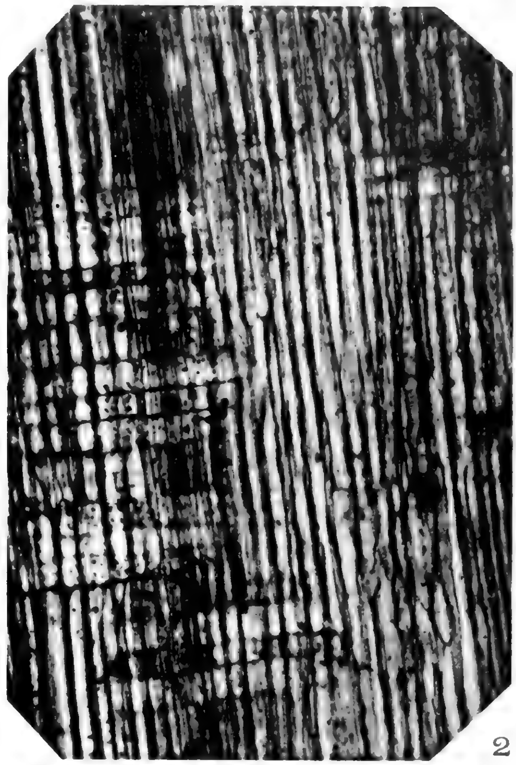
Taxoxylon anglicum, sp. nov. Sections of wood.—
Lower Greensand; Woburn Sands, Bedfordshire.

Fig. 1. Transverse section of the secondary wood, showing the well-marked regular rings and the narrow zone of autumn wood. No. V. 5459 *b* (p. 204).

Fig. 2. Radial section of above. To the left of the photo can be seen three or four rays connected by short irregular tracheids. In each tracheid-field of the ray-cells 2 to 4 small pits can be clearly seen in the radial walls. No. V. 5459 *c* (p. 207).

Fig. 3. Higher power view of a pair of similar rays. At *p.* the pits in the ray-cells can be very clearly seen, and in this and the neighbouring cell on the right the border round the pits can be made out. No. V. 5459 *c* (p. 207).





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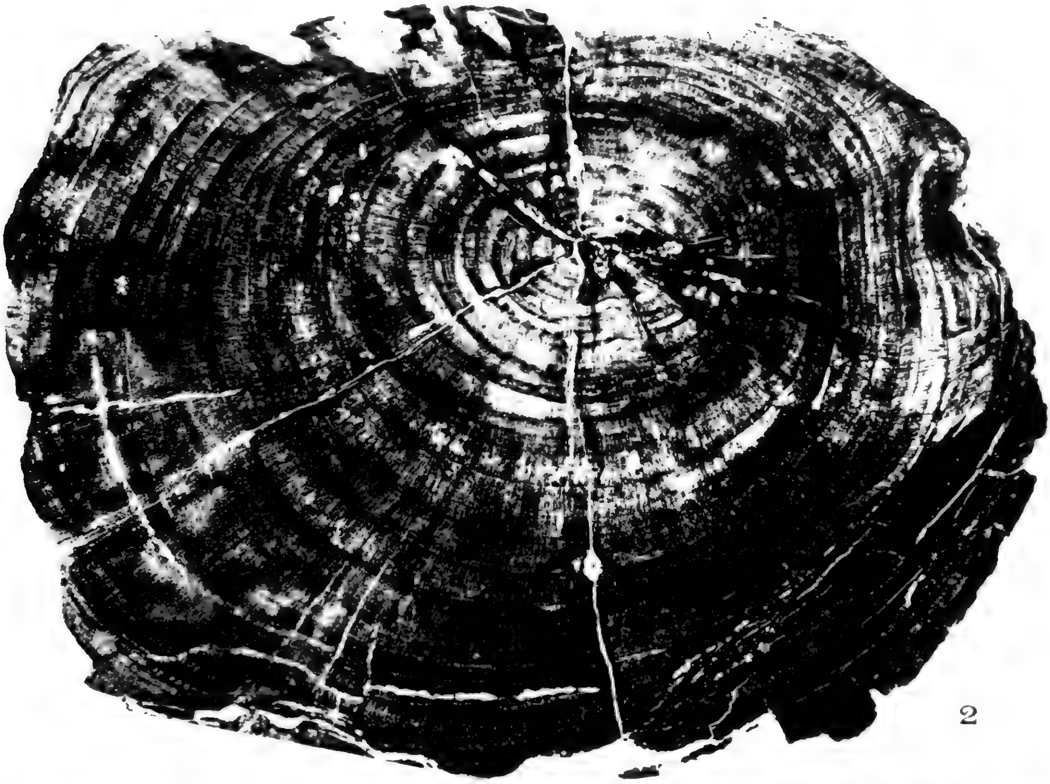
TAXOXYLON ANGLICUM sp. nov.

PLATE XX.

Podocarpoxylon woburnense, sp. nov. Transverse sections of wood.—Lower Greensand; Woburn, Bedfordshire.

Fig. 1. Transverse section of the secondary wood, showing the well-marked annual rings, conspicuous medullary rays, and resin-containing parenchyma-cells, *rp.*, scattered among the tracheids. No. V. 5451 *a* (p. 211).

Fig. 2. Transverse section of a branch, showing the centre of the axis surrounded by well-marked rings of secondary wood. × 1·8. No. V. 4876 (p. 214).



2

1

PODOCARPOXYLON WOBURNENSE. sp. nov.

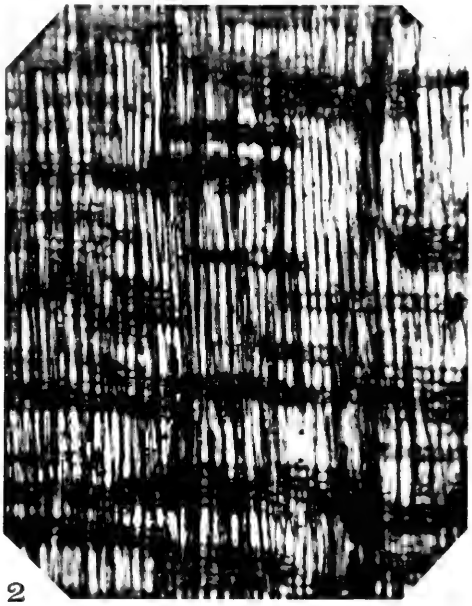
PLATE XXI.

Podocarpoxylon bedfordense, sp. nov. Sections of wood.—
Lower Greensand; Woburn, Bedfordshire.

Fig. 1. Transverse section, showing the regular wood-texture and annual rings. No. V. 13191 *a* (p. 223).

Fig. 2. Radial longitudinal section of the same, showing the numerous low medullary rays. No. V. 13191 *d* (p. 225).

Fig. 3. Small part of the radial section, enlarged to show the pitting of the radial walls of the tracheids. At *p.* a tracheid can be seen with two short chains of adjacent pits, the tracheid to the left of it shows a longer chain of pits. No. V. 13191 *d* (p. 226).



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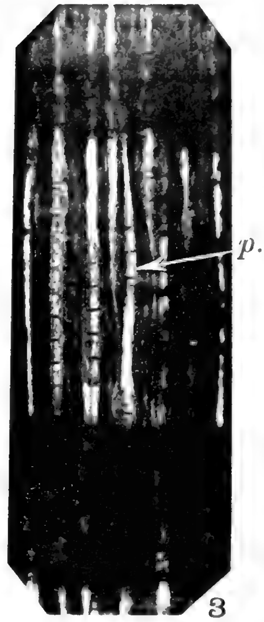

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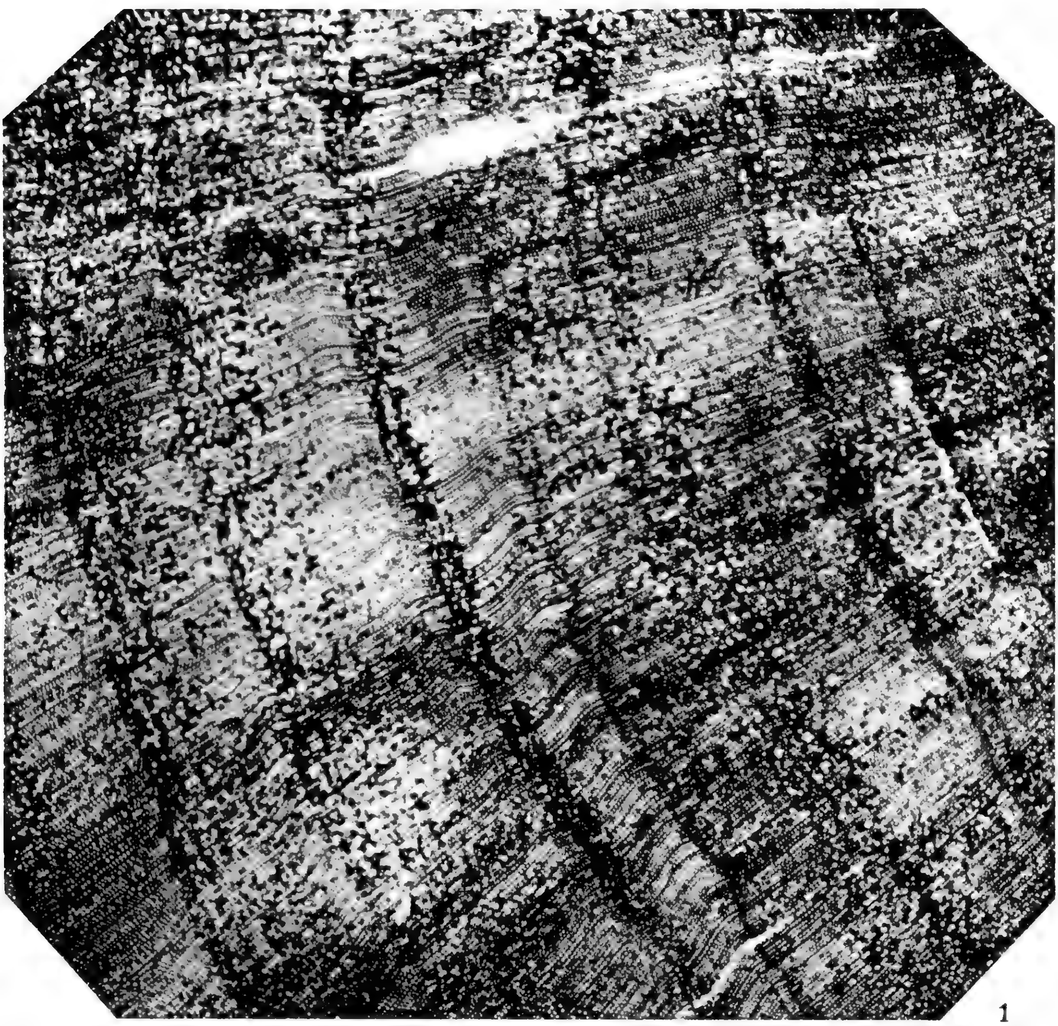

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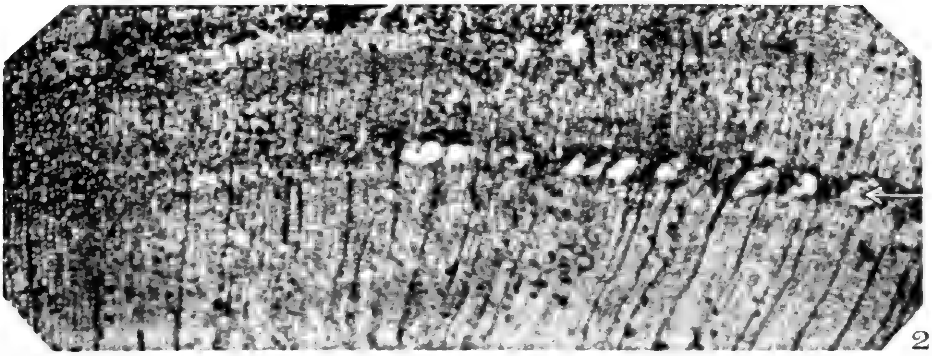
PODOCARPOXYLON BEDFORDENSE sp. nov.

PLATE XXII.

[?] *Podocarpoxylon Solmsi*, sp. nov. Sections of secondary wood.—Lower Greensand; Luccomb Chine, Isle of Wight.

Fig. 1. Transverse section of secondary wood, showing the well-marked growth-rings and narrow zone of autumn wood. *r.p.*, resin - containing wood - parenchyma. No. V. 2117 *a* (p. 234).

Fig. 2. Transverse section of a small part of the secondary wood, showing a row of traumatic resin-canals, *r.c.* No. V. 5427 *a* (p. 238).



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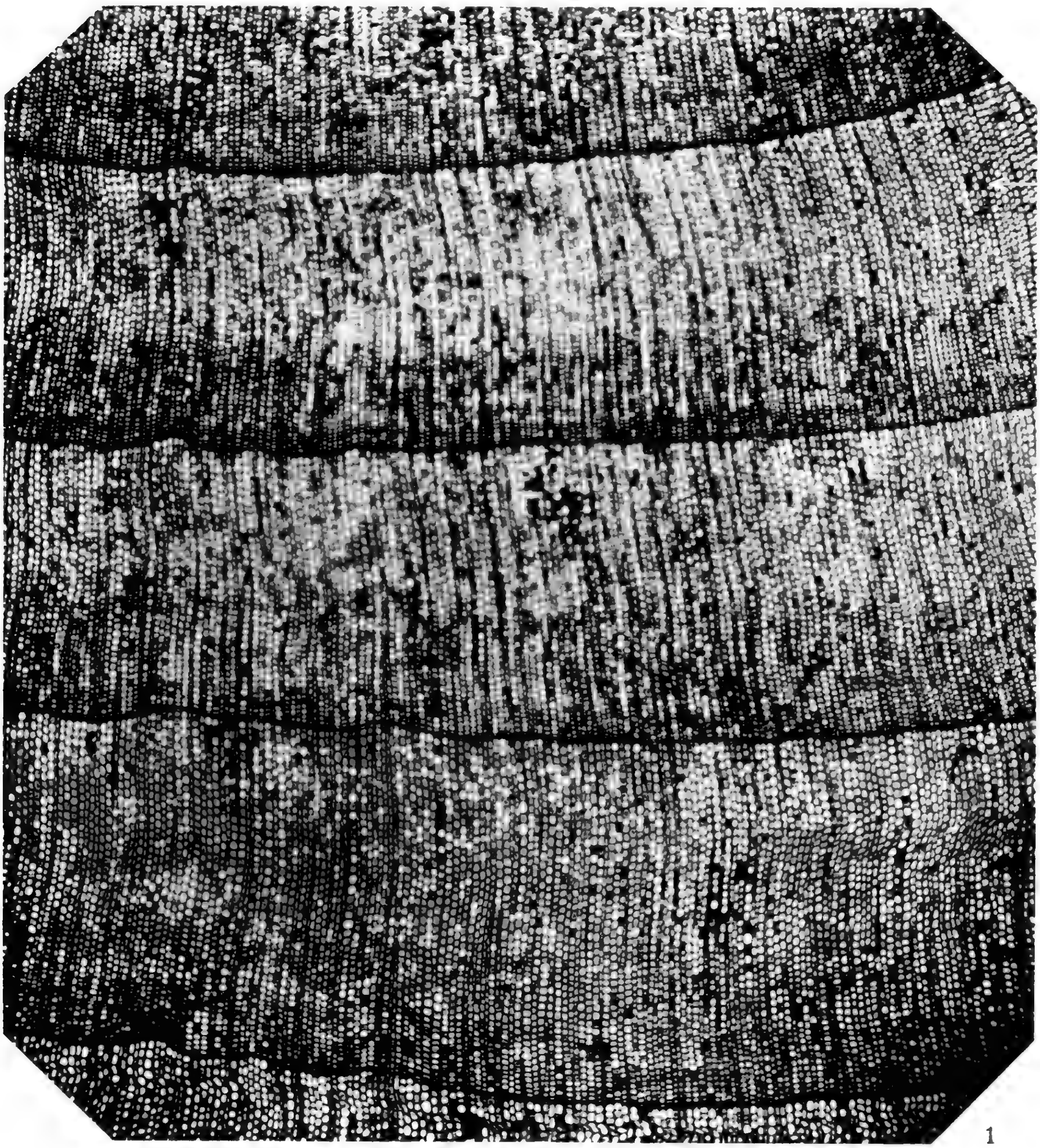

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(?) PODOCARPOXYLON SOLMSI sp. nov.

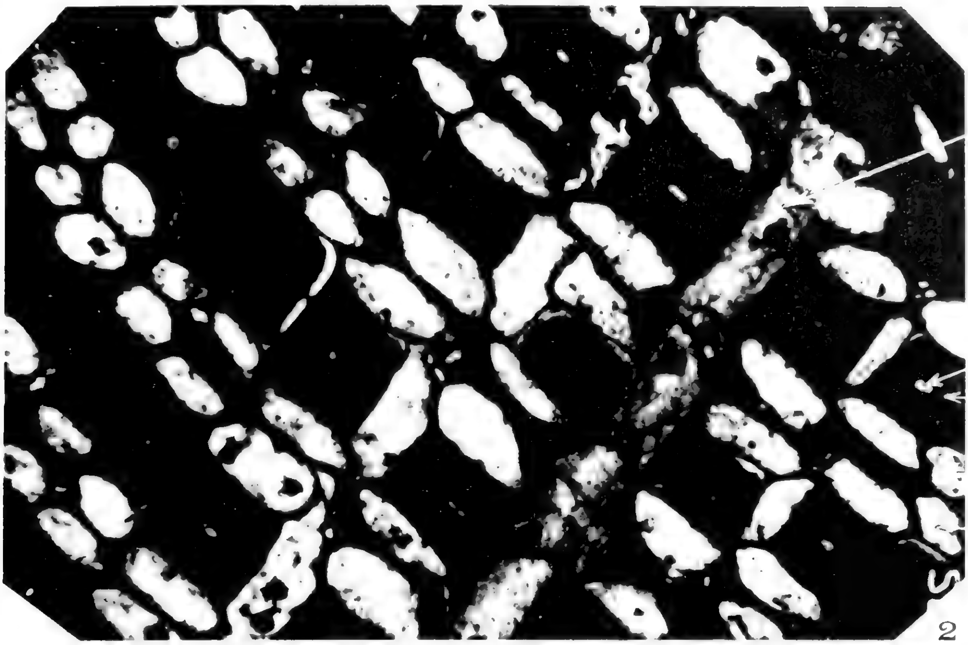
PLATE XXIII.

Vectia luccombensis, gen. et sp. nov. Sections of part of tissues.—Lower Greensand; Luccomb Chine, Isle of Wight.

Fig. 1. Transverse section, showing a low-power view of a number of bands of the tissue.

Fig. 2. Transverse section, a small part much enlarged.

Lettering in both figures:—v^1, v^2, pairs of vessels alternating with much sclerised elements, *s.*, in which the lumen is very small, *l.*; *m.*, medullary ray. No. V. 13230*a* (p. 247).



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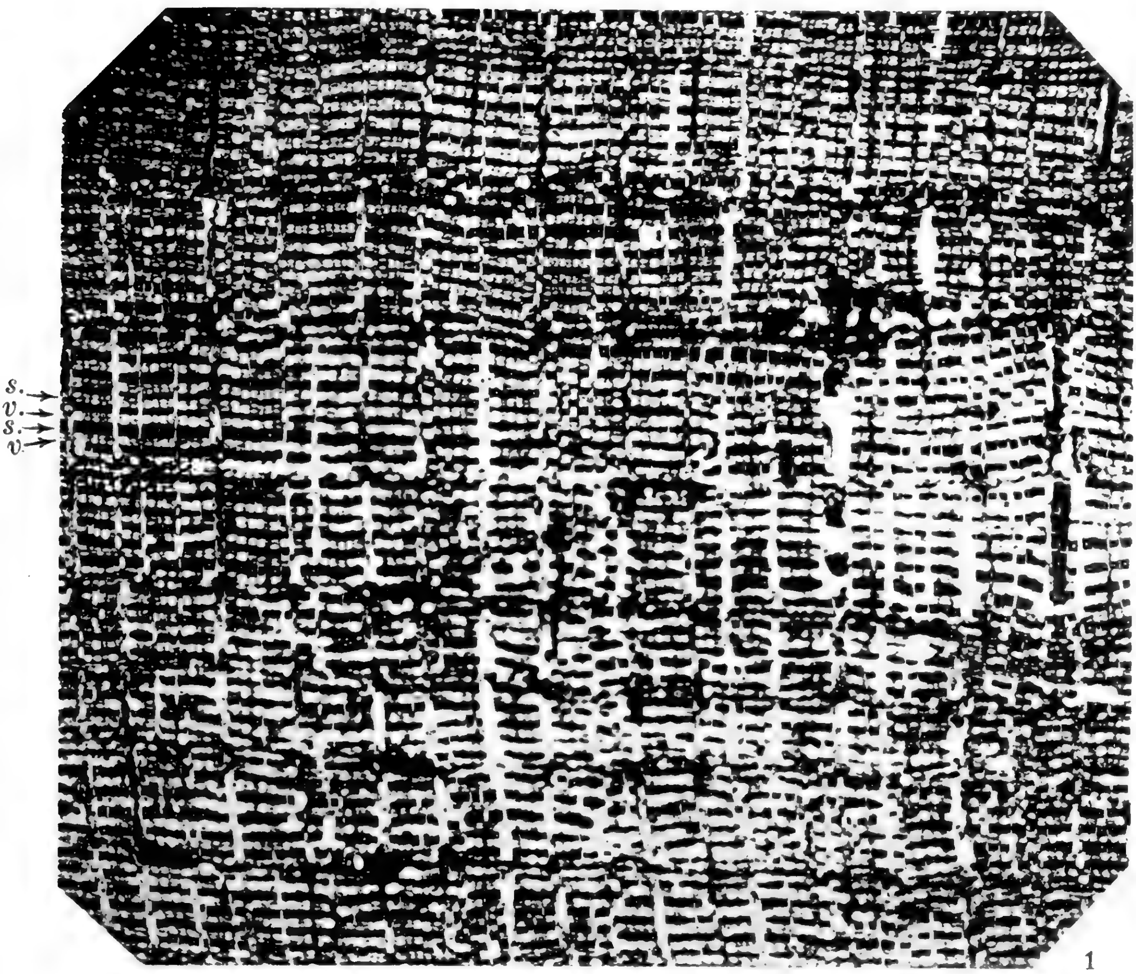


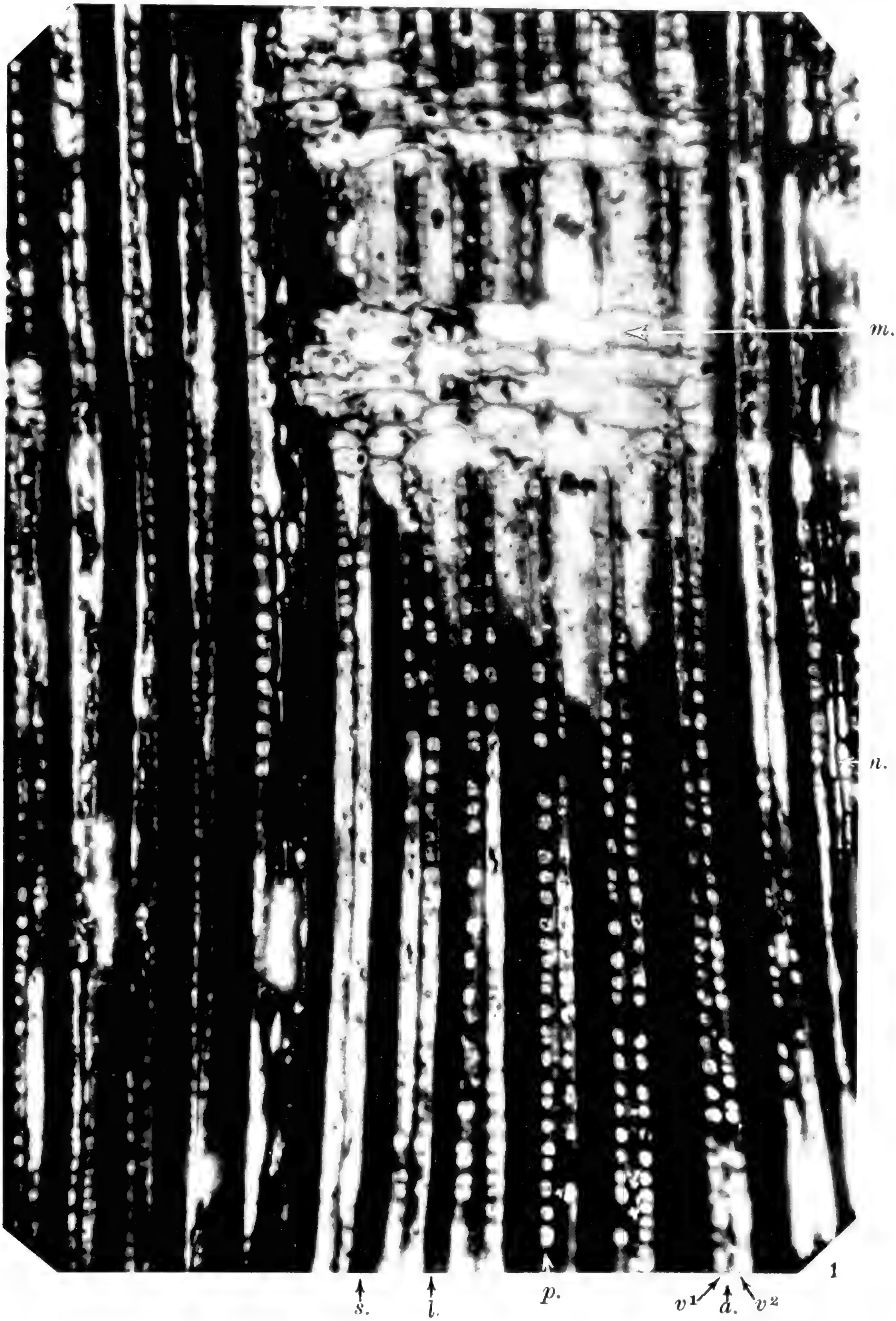
1

VECTIA LUCCOMBENSE. gen. et sp. nov.

PLATE XXIV.

Vectia luccombensis, gen. et sp. nov. Radial longitudinal section, showing the pitted vessels and fibres crossed by medullary rays.—Lower Greensand; Luccomb Chine, Isle of Wight.

v^1, v^2, the pairs of vessels, *p.* the rows of pits in their radial walls; *s.*, the fibres with narrow lumen, *l.*; *a.*, narrow parenchyma-cells lying in places between the pairs of vessels; *m.*, medullary ray-cells; *n.*, short narrow elements of the cork-like layer. No. V. 13230 *b* (p. 252).



VECTIA LUCCOMBENSE. gen. et sp. nov.

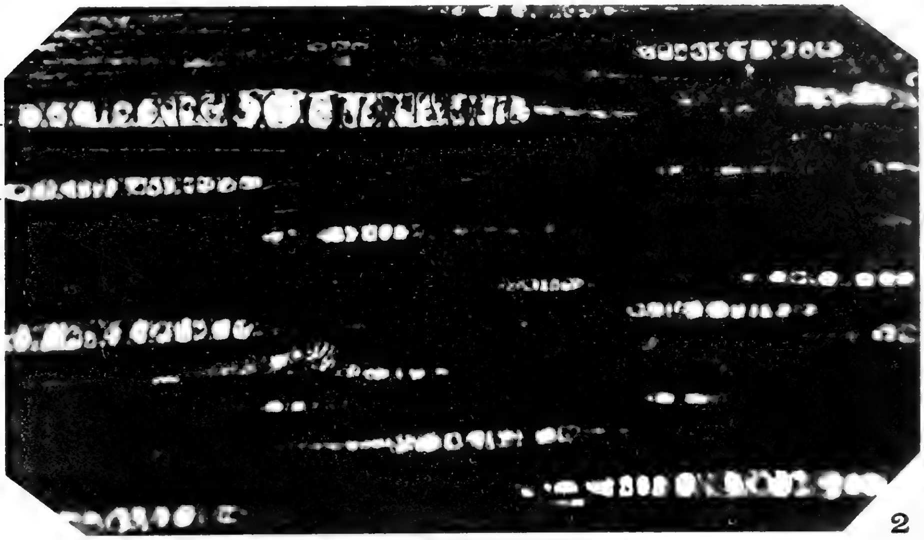
PLATE XXV.

Vectia luccombensis, gen. et sp. nov. Sections of part of tissues.—Lower Greensand; Luccomb Chine, Isle of Wight.

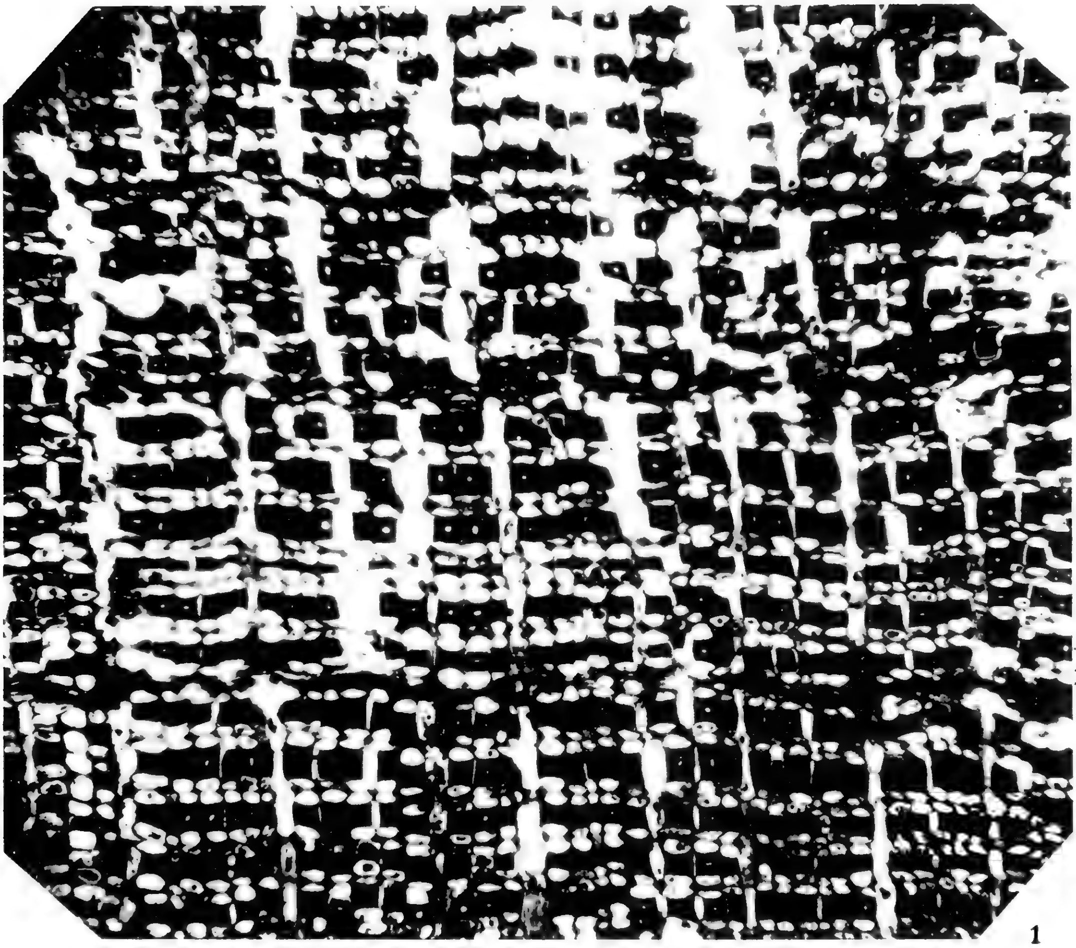
Fig. 1. Transverse section showing the arrangement of the tissues. *s.*, fibres; v^1, v^2, pair of thinner elements (sieve-tubes); *m.*, medullary ray, in which the end-walls of the cells can be seen (p. 249).

Fig. 2. Tangential section showing the uniseriate medullary rays. *x.*, ray composed of small cells; *y.*, ray composed of large cells. No. V. 13230 *c* (p. 250).

y.
x.



2



s.
v^1
v^2

m.

1

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VECTIA LUCCOMBENSIS. sp. nov.

PLATE XXVI.

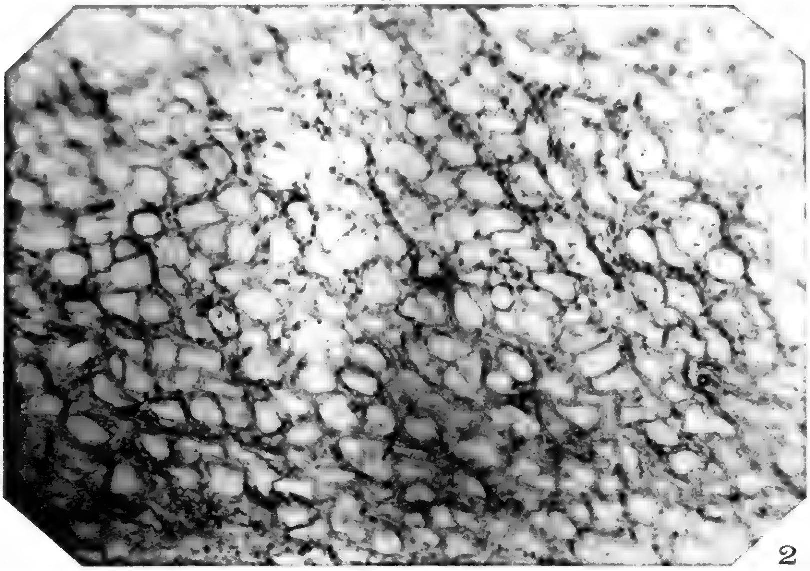
Cantia arborescens, gen. et sp. nov. Sections of secondary wood.—Folkestone Beds; near Ightham, Kent.

Fig. 1. Transverse section of the wood, showing the even distribution of the numerous vessels and the narrow zones of autumn elements, *a–a* (p. 260).

Fig. 2. A small portion of the same section, further enlarged, showing the rather crumpled isolated vessels with very small quantities of fibres and parenchyma between them. The narrow uniseriate rays can be seen rather crushed and distorted between the vessels. No. V. 13231 *a* (p. 262).

a.

a.



2

a.

a.

a.

a.

1

a.

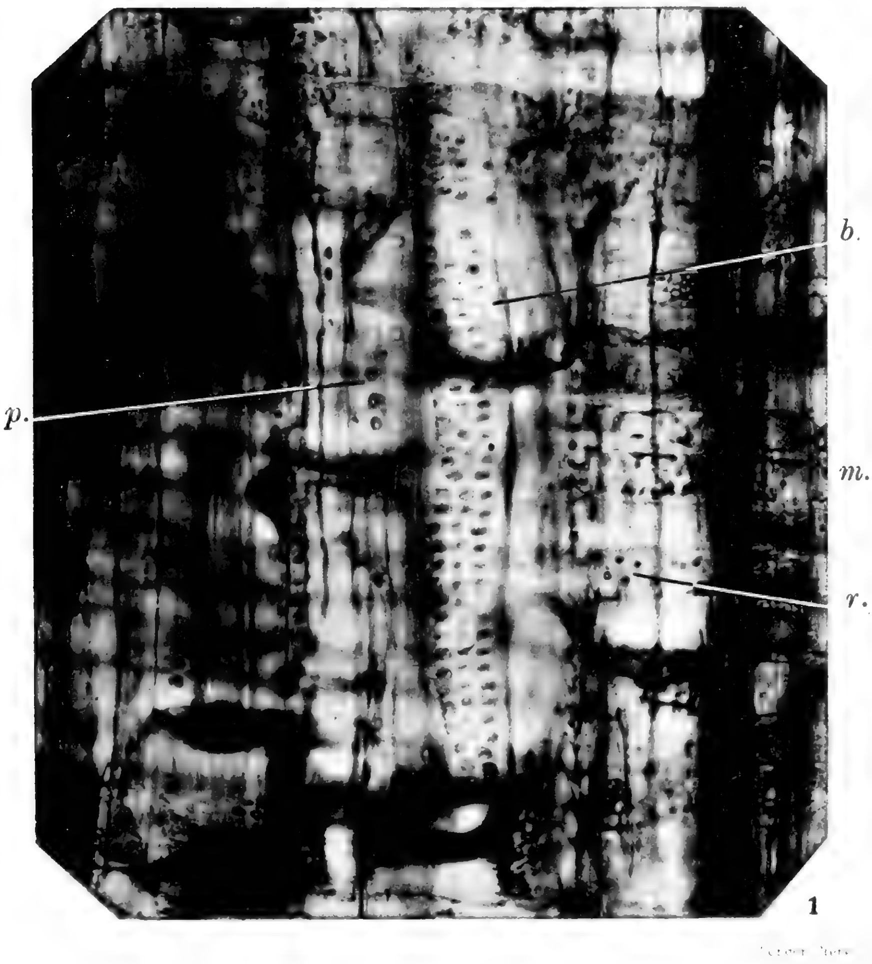
CANTIA ARBORESCENS. sp. nov.

PLATE XXVII.

Cantia arborescens, gen. et sp. nov. Sections of secondary wood.—Folkestone Beds; near Ightham, Kent.

Fig. 1. Radial longitudinal section, showing the pitting of various types of elements; *b.*, the oval bordered pits of the vessels; *p.*, the isolated, round, bordered pits of the wood-fibres; *m.*, the thickened walls of the medullary ray-cells, with, *r.*, groups of radial pits in their walls. × 200. No. V. 13231 *d* (p. 263).

Fig. 2. A small portion of the same section, further enlarged, showing the scalariform bar-pitting, *s.*, of the wood-vessel; *p.*, the round bordered pits of the wood-fibres. × 400. No. V. 13231 *d* (p. 263).



CANTIA ARBORESCENS. sp. nov.

PLATE XXVIII.

Cantia arborescens, gen. et sp. nov. Sections of secondary wood.—Folkestone Beds; near Ightham, Kent.

Fig. 1. Radial longitudinal section, showing the numerous medullary rays, the pits in the vessels *v.*, and the tyloses filling the vessels *t.* No. V. 13231 *c* (p. 263).

Fig. 2. Part of a medullary ray, enlarged; radial view of the cells showing their thickened and pitted walls. *a.*, the pits in the end-walls; *m.*, the pits in upper and lower walls of adjacent ray-cells; *r.*, the groups of round pits in the radial wall. × 350. No. V. 13231 *d* (p. 263).

a. m. r.

2

t. t. v.

1

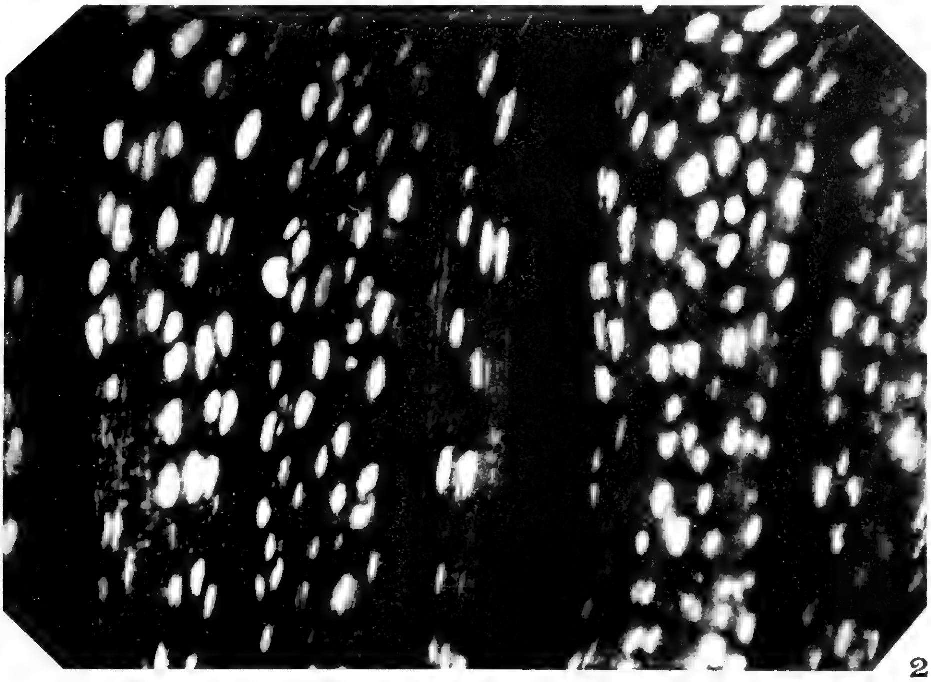
CANTIA ARBORESCENS. sp. nov.

PLATE XXIX.

Hythia Elgari, gen. et sp. nov. Sections of secondary wood.—Hythe Beds; near Maidstone, Kent.

Fig. 1. Transverse section of part of the large block, showing the crumpling and contortions of the wood with its broad rays. At the bottom right-hand corner of the photograph the vessels can be seen. × 2. No. V. 13232 *a* (p. 279).

Fig. 2. Transverse section of a small portion of the wood, showing the broad rays and the numerous rather crushed vessels between them. No. V. 13232 *d* (p. 278).



2

1

HYTHIA ELGARI. sp. nov.

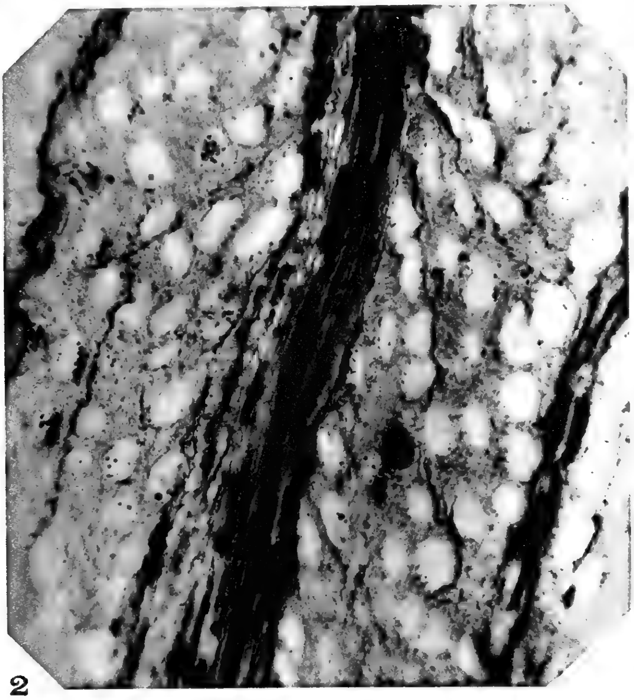
PLATE XXX.

Hythia Elgari, gen. et sp. nov. Sections of secondary wood.—Hythe Beds; near Maidstone, Kent.

Fig. 1. Transverse section of part of the wood. In the neighbourhood of *a*. the small-celled wood-fibres and parenchyma can be seen almost uncrushed. No. V. 13232 *b* (p. 282).

Fig. 2. Transverse section of a small part of the wood, showing the thin-walled nature of the wood-vessels; also the long and very narrow cells composing the medullary ray. × 60. No. V. 13232 *c* (p. 281).

Fig. 3. Longitudinal section of a vessel, showing the round, oval, and elongated pits in its wall. × 100. No. V. 13232 *e* (p. 281).



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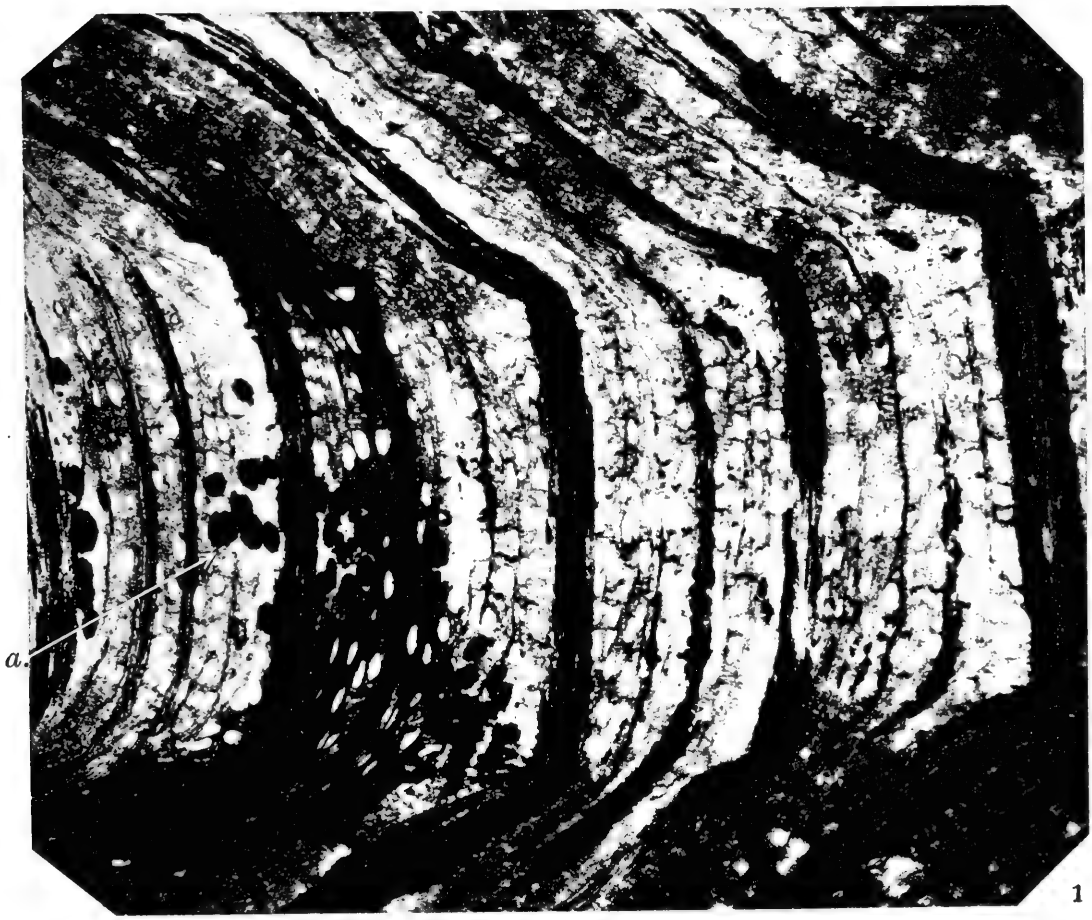

1

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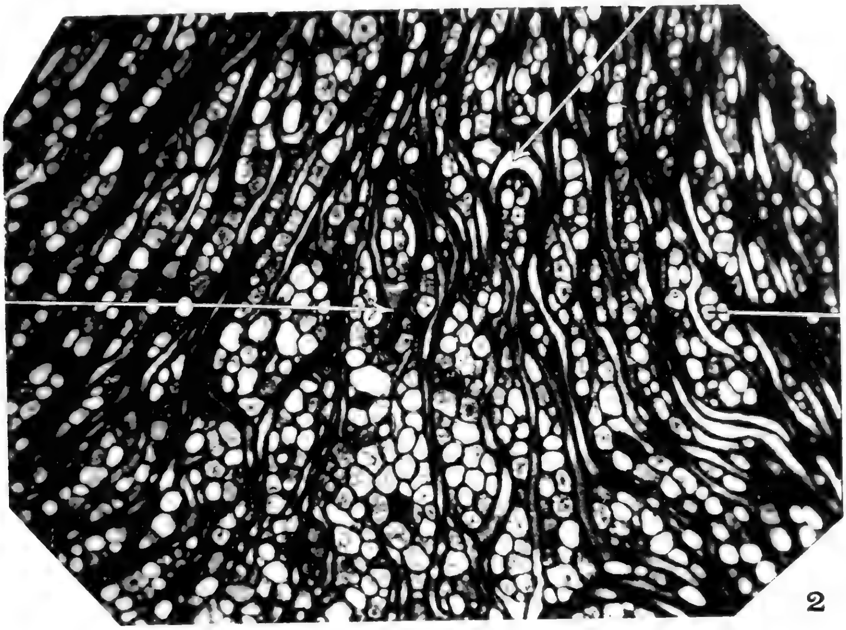
HYTHIA ELGARI. sp. nov.

PLATE XXXI.

Colymbetes Edwardsi, gen. et sp. nov. Sections of portion of trunk.—Lower Greensand; perhaps from Leighton Buzzard.

Fig. 1. Transverse section, showing the pith and surrounding scattered xylem-zone. *p.*, pith-cells; *x.*, isolated groups and clusters of tracheids; *s.*, series of tracheids, widely separated by large quantities of ground-tissue. No. V. 6127 *e* (p. 314).

Fig. 2. Tangential longitudinal section of an outer zone of secondary wood, showing the large quantity of medullary rays, *m.*, with the narrow curving tracheids between them. At *t.* the tracheids may be seen to loop and branch. No. V. 6127 *n* (p. 326).



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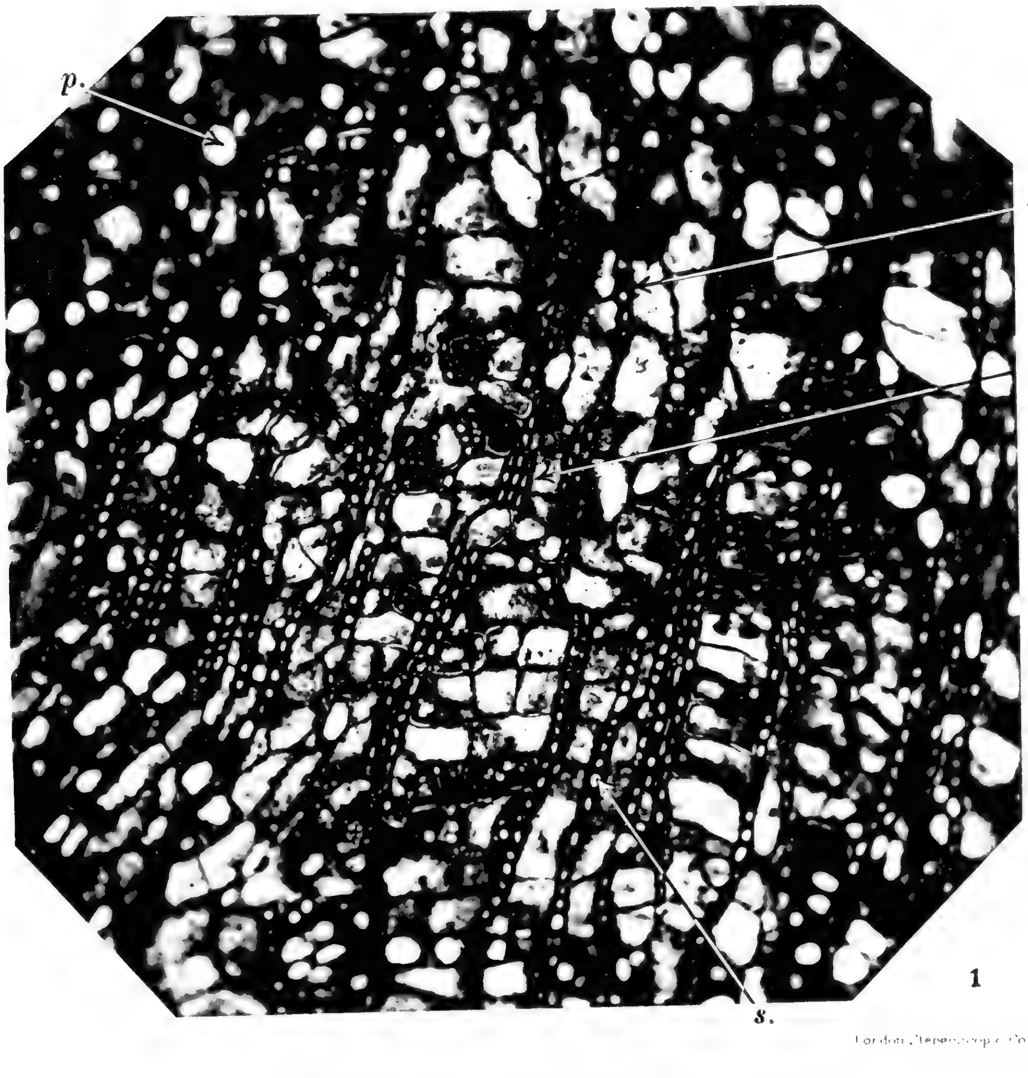

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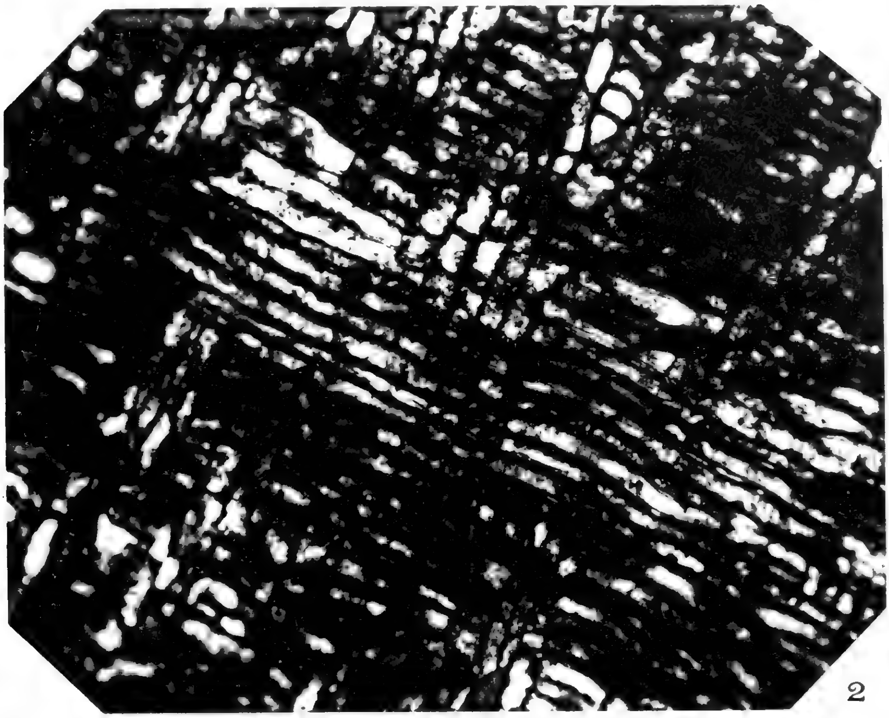
COLYMBETES EDWARDSI sp. nov.

PLATE XXXII.

Colymbetes Edwardsi, gen. et sp. nov. Sections of portion of trunk.—Lower Greensand; perhaps from Leighton Buzzard.

Fig. 1. Radial longitudinal section of the trunk, cut absolutely at right angles to the true transverse section and showing one of the bands of wood cut in absolutely transverse section. Note the normal radial series of tracheids with the medullary rays between (*cf.* text-fig. 109 B, p. 325). No. V. 6117 *k* (p. 316).

Fig. 2. Absolutely transverse section, showing the radial view of the longitudinally cut zones which alternate with the normal transverse zones (*cf.* text-fig. 105, p. 321). No. 6127 *a* (p. 316).



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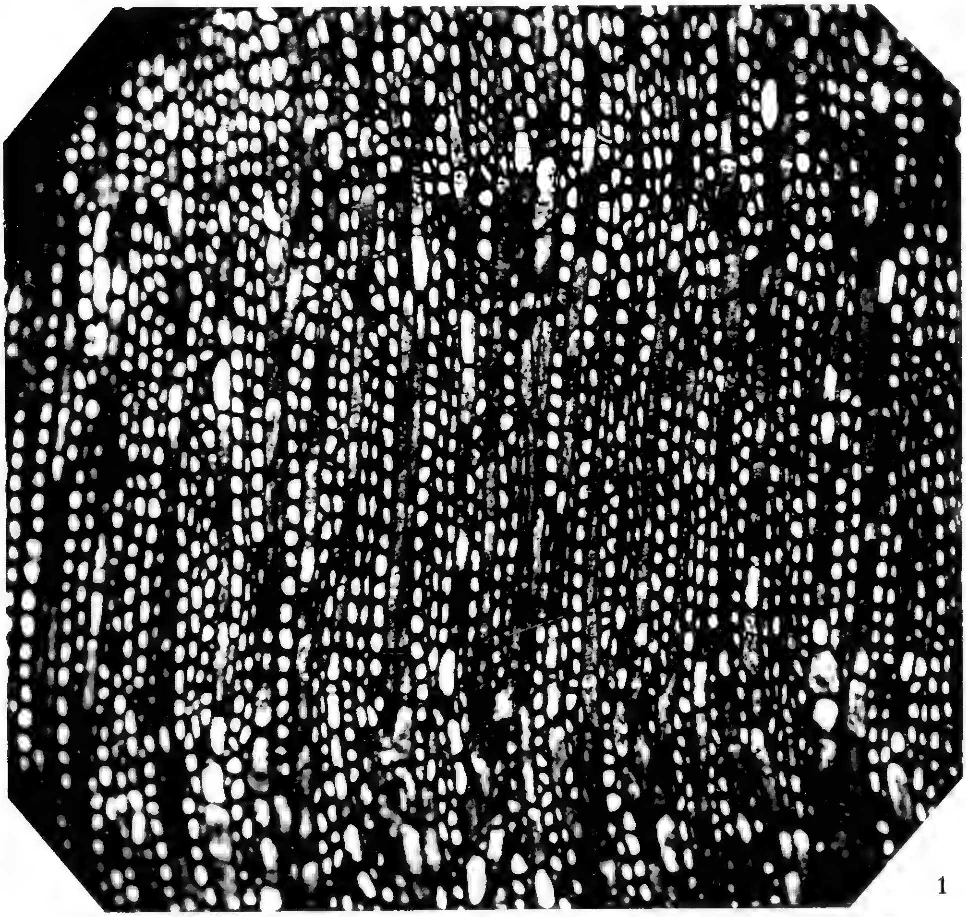

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COLYMBETES EDWARDSI sp. nov.