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J. W. POWELL, DIRECTOR

FOSSIL WOOD AND LIGNITE

OF THE

POTOMAC FORMATION

BY

FRANK HALL KNOWLTON

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DEPARTMENT OF THE INTERIOR,
U. S. GEOLOGICAL SURVEY, DIVISION OF PALEOBOTANY,
Washington, February 23, 1889.

SIR: I have the honor to transmit herewith the manuscript of a paper by Prof. F. H. Knowlton, Assistant Curator of Botany and Fossil Plants of the U. S. National Museum, on the Fossil Wood and Lignite of the Potomac Formation, and to request its publication as a bulletin of the U. S. Geological Survey.

Very respectfully yours,

LESTER F. WARD,
Geologist in charge.

HON. J. W. POWELL,
Director U. S. Geological Survey.

FOSSIL WOOD AND LIGNITE OF THE POTOMAC FORMATION.

By F. H. Knowlton.

INTRODUCTION.

VALUE OF THE STUDY OF INTERNAL STRUCTURE, WITH BRIEF REVIEW OF ITS PROGRESS.

The value of paleontology to stratigraphy is so generally recognized that it hardly needs to be emphasized. Heretofore, however, the evidence most relied on has been derived from a study of animal fossils, the reason being chiefly that there have been more paleozoölogists than paleobotanists and more data of a paleozoölogic character have been accessible. But paleobotany is gradually coming into prominence, and within the last half century, particularly within the last decade, it has shown a wonderfully increased development. Some of the most eminent botanists of the age have devoted their lives to the interpretation of this class of facts, and it has developed into an important department of natural science. Much, of course, remains to be done, particularly in this country, but when the plant deposits are as thoroughly explored as the animal deposits have been, stratigraphic geology will receive much valuable aid.

In paleobotany two distinct lines of investigation have been followed, which may be called respectively the superficial method and the structural method.

I use the term superficial, not in the sense that the evidence obtained by it is untrustworthy, but because it takes cognizance of the external or superficial parts of plants. It deals with the form and nervation of leaves, the scars and striations on the stems, and the casts or impressions of stems, leaves, and fruits. On account of the many conditions necessary for the successful preservation of vegetable remains, it most frequently happens that they are capable of being studied only by this method. Its legitimate application is seen in the monographs of Heer, Ettingshausen, Unger, and Lesquereux.

The structural method, on the other hand, deals with what must be regarded as the most valuable of all evidence—that derived from internal organization. Leaving out of view the superficial considerations, it concerns itself with a microscopical examination of the histological elements that enter into the composition of vegetable tissues. The various tissue systems are dissected and carefully studied, the individual cells are measured and compared, and these, together with markings upon the cell walls and other like data, form a sure basis for the correct interpretation of the systematic position of plants. So valuable is this method that Prof. W. C. Williamson was led to say that "no determinations respecting fossil plants can have much absolute value save such as rest upon internal organization; that is the basis upon which all scientific recent botany rests, and no mere external appearances can outweigh the positive testimony of organization in fossil types."[1]

The interest attached to this class of investigations has been greatly enhanced of late, and it has been no doubt largely due to modern improvements in instruments and methods of research, but also to an increased appreciation of their value. Certain it is that the number of students in this field is being constantly augmented. In order to show that the growth of this department has been both natural and constant, I append a brief résumé of its progress from the time of its first mention in literature down to the close of the year 1886. In the preparation of this bibliographic review I have been greatly aided by the historic summaries of the literature given by Dr. Göppert in his Monographie der fossilen Coniferen,[2] and by that of Prof. Lester F. Ward in his admirable "Sketch of Paleobotany."[3] The former of these is particularly complete in the literature of the early or prescientific period, but closes, as indeed does the latter, with the year 1850. Consequently I have referred only briefly to the progress made prior to this date, but have aimed to make it as complete as space would permit for the time between 1850 and 1886.

It seems hardly probable, as Professor Ward has so pointedly suggested,[4] that such common objects as pieces of petrified wood escaped all observation for the first twelve centuries of the Christian era; but, as the literature of that period contains no mention of them, we must suppose that public attention, at least, was not directed to the subject. That travelers and people engaged in agricultural pursuits must have observed them is more than probable, since fossil forests are now known to exist in northern Egypt, and plant beds have been found in Italy, Dalmatia, and other countries of the Roman Empire. This fact is not, however, without its parallel in other departments of learning, for it has been often shown that the ancients possessed a much more extensive and profound knowledge of nature than did any of the so-called learned men of the Middle Ages.

Probably the earliest published account of petrified wood is that

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[1] On the organization of the fossil plants of the coal measures. Roy. Soc. London, Phil. Trans., vol. 161, part II, 1871, p. 492.

[2] Leiden, 1850. Pp. 71–166.

[3] U. S. Geol. Surv., Fifth Ann. Rep., Washington, 1885, pp. 363–469.

[4] Op. cit., p. 387.

given by Albertus Magnus[1] in the thirteenth century, although the first mention of it has been attributed to Agricola (1494–1555). The writers of this period, however, were concerned more with the processes of fossilization than with the affinity of the objects described. Thus Agricola supposed petrification to take place by penetration of a succus lapidescens into the tissues of plants and animals, and Kentmann[2] (1518–1568) described a process by which fossils could be produced artificially. Imperatus,[3] Boyle,[4] and Bromel[5] likewise wrote of the process of fossilization, and Cordus,[6] Klein,[7] and Matthiolus[8] in his letter to Bauhin also described specimens which came into their possession or expressed views concerning them.

The following writers, although principally interested in the origin of the fossils, actually described specimens. Agricola obtained what he supposed to be fossil ebony (Ebenholz) from Hildesheim. Gesner[9] compared specimens which he obtained with the following living species: Fir (*Elatites*), alder (*Clethrites*), beech (*Phegites*), and oak (*Dryites*). Under the name of *Stelechites* he also described a stem which showed rudiments of branches. Albinus[10] described a large birch from Krakewitz, in Bohemia.

The first book devoted entirely to the subject of fossil wood was published by Franciscus Stelluti, in Rome, in 1637, with the following title: "Trattato del legno fossile minerale nuovamente scoperto, nel quale brevemente si accenna la varia e mutabil natura di detto legno rappresentato con alcune figure che mostrano il luogo dove nasce, la diversità delle onde che in esso sive dono e le sue così varie e maravigliose forme." Stelluti recognized the resemblance between these and recent woods, but concluded that they differed so widely, in having neither roots nor branches, in burning with a clear flame and giving out more heat, and in other particulars, that it was impossible to suppose they had ever been living.

In the seventeenth century the writers and observers began to be more numerous. Thus we find Worman,[11] Robert Hook,[12] Balbinus,[13]

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[1] Beati Alberti Magni de mineralibus Tractatus I, Caput VII, Opera, Lugduni, 1651, vol. 2, p. 216.

[2] Nomenclatura rerum fossil., Tiguri, 1565.

[3] Hist. natur. Neapel, 1599; Venedig, 1672; Cöln, 1695.

[4] Exerc. de util. et præst. Phil. natur.

[5] Lith. Svec. spec. 2. Cap. I, § III.

[6] Valer. Cordi adnot. in Pedacii Dioscovid., etc., sylva qua rerum fossilium in Germania, etc., 1651.

[7] Balthasar Klein mentioned in Göppert's Monographie der fossilen Coniferen, p. 73. I have not been able to consult the book directly.

[8] Matthioli epistol. edit. Bauhini, Lugd., 1564.

[9] Gesneri de rerum fossilium, lapidum, et gemmarum maxime figuris et similitudinibus liber, etc. Tiguri, 1565.

[10] Meissnischen Land- und Bergchronik im 22. Tit., S. 170. Dresden, 1589.

[11] Museum. Wormian. Lugd. Batav., 1655.

[12] Micrographia, 1667.

[13] Bohuslav Balbinus. Miscell. hist. regni Bohem. Prag, 1679.

Abbé de la Roque,[1] Westphal,[2] De la Hire,[3] and John Morton[4] all mentioning or describing specimens. Edward Lhwyd[5] was the first to apply the term *Lithoxylon* to petrified wood. He seems also to have been the first to appreciate fully the value of paleontology to stratigraphy.

As the theories of fossilization had gradually succeeded and replaced one another (the generatio æquivoca of Aristotle, the vis lapidifica of Avicenna in the tenth century, and the virtus formativa of Albertus Magnus in the thirteenth century), so were they supplanted in turn by the not less fanciful flood theory, which, strangely enough, seems to have been first propounded by Martin Luther.[6] The idea that the plant and animal petrifactions brought to light were the remains of the Noachian deluge and had been tossed about and mingled by the angry waters did not meet with immediate acceptance, so widespread had become the other delusive hypotheses. But gradually it began to find followers, and we note that Gesner, Imperatus, Woodward, and Lhwyd gave it credence. Its chief exponent, however, was Johann Jacob Scheuchzer, whose famous book, Herbarium Diluvianum, appeared in 1709.

Scheuchzer violently attacked all the other theories and brought forward such a mass of seemingly overwhelming evidence in support of the flood theory that the world was fairly taken by storm, and many years passed before those even who saw the fallacy in it dared to stem public opinion and break away from it.

In 1723 an edition of his work was published at Leyden, in which all the objects described in the edition of 1709 as well as in his Museum Diluvianum, were arranged according to the botanical system of Tournefort, which had appeared in the mean time. The fossil wood was arranged in the following manner:

CLASSIS XVIII.

Arbores et frutices floribus apetalis.

This included only a leaf and a piece of wood of Fraxinus and the wood of Buxus.

CLASSIS XIX.

Arbores et frutices floribus apetalis amentaceis.

This class embraced specimens which he considered to belong to *Ostrya*, *Quercus*, *Abies*, *Pinus*, *Betula*, and several leaves, fruits, and cones of the same.

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[1] Zodiacum medico gallicum Gener., 1680. Part IV.

[2] J. Casp. Westphal. ephem. nat. curios. dec. II, an. VIII, 1689.

[3] Académie Paris, Mém., 1692.

[4] Roy. Soc. London, Phil. Trans., 1706.

[5] Evuardi Luidii Lithophylacii britannici ichnographia, sive lapidum aliorumque fossilium britannicorum singulari figura insignium * * * distributio classica. Londini et Lipsiæ, 1699.

[6] Gründliche und erbauliche Auslegung des ersten Buchs Mosis. Halle, 1739, vol. I, p. 176.

CLASSIS XXI.

Arbores et frutices foliis rosaeceis.

Only a single specimen, "Frustum ligni tiliæ petrifactum."

PLANTÆ INCERTÆ.

Here were included the woods which could not be relegated to any of the other classes. This list was of course the larger, including more than one hundred and fifty miscellaneous examples, from various parts of the world, one even from the island of Antigua, in the West Indies. The term Lithoxylon was applied in a few cases (e. g., number 465, "Lithoxylon nigricans in saxo arenario duriosi ex Agro Altorffino,' but generally they were simply called "lignum fossile."

To enumerate the multitude of writers who made mention of fossil wood, or described specimens of it, during the eighteenth century would be to expand this chapter far beyond the limits assigned to it.[1] We must confine our sketch from this time forth to those more important writers whose works mark distinct epochs in the progress of paleodendrology. A few of the principal writers are Volkmann,[2] Henkel,[3] Schröter,[4] and Walch.[5]

The era of true science then may be said to have begun with the opening of the nineteenth century. Escaping from the influence of the superstitions and dogmas of the Dark Ages the keynote was struck, and from this time on the progress was constant and rapid. The true origin and nature of fossils were explained, and once on the right track the energy of investigators was directed to an interpretation of the paleontological facts, even in the most distant parts of the globe, and the result has been to furnish a pretty correct and comprehensive view of the faunas and floras of the different ages of the world's history.

In rapid succession were published the works of Voigt[6] (1807), who discussed the so-called *Psarolithes*, which he at first regarded as polyps; Weppen[7] (1808), who described fossil wood from Europe, Siberia, and the East Indies; and Martin[8] (1809), who described fossil trunks from Great Britain. In 1814 Kieser published his valuable "Mémoire sur l'organisation des plantes," in which, among other important

[1] See H. R. Göppert. Monographie der fossilen Coniferen, pp. 81–86.

[2] Georg Anton Volkmann. Silesia subterranea. Leipzig, 1720.

[3] Flora saturnizans, 1755.

[4] Lithographische Beschreibung von Ingolstadt und Dettwiz. Jena, 1768.

[5] Die Naturgeschichte der Versteinerungen zur Erläuterung der Knorrischen Sammlung, etc. Nürnberg, 1768–1773.

[6] Johann K. W. Voigt. Kurze mineralogische Bemerkungen. Leonhard's Taschenbuch für Mineralogie, erster Jahrgang, pp. 120–124.

[7] J. A. Weppen. Nachricht von einigen besonders merkwürdigen Versteinerungen und Fossilien seines Kabinets. Leonhard's Taschenbuch, vol. II, p. 178.

[8] William Martin. Petrificata Derbiensia, or Figures and Descriptions of Petrifactions Collected in Derbyshire. Wigan, 1809.

facts, he first pointed out the characteristic structure of coniferous wood and correctly explained the nature of the concentric circles or bordered pits which are to be observed on the walls of the wood cells. These pits or pores had been observed by Malpighi[1] and others as early as 1685, but their exact nature had remained unexplained. An important work on the origin and nature of amber, by Dr. J. F. John, of Cologne, appeared in 1816. He supposed the amber to have been produced by a species of pine which he concluded had become extinct. About this time appeared several works by Jakob Nöggerath[2] on certain upright trunks and other fossils of the Carboniferous age. In the two principal works of the year 1820, by Rhode[3] and Schlotheim,[4] only incidental mention is made of fossil wood, and then only from a consideration of external characteristics.

Passing rapidly over several minor English and American papers we come, in 1828, to the publication of what was unquestionably the most important work on fossil woods that had yet been published. This is the "Commentatio de Psarolithis, Ligni Fossilis Genere," published at Halle by Anton Sprengel. After reviewing carefully the literature of the subject and discussing the various theories of the nature of these organisms he established their undoubted vegetable character and described six species which he called *Endogenites*. The work, which is in Latin, is illustrated by a single plate. Says Professor Ward:[5]

> The year 1828 is without question the most eventful one in the history of paleobotany, since it saw the issue of Brongniart's Prodrome and the commencement of his Histoire des végétaux fossiles, which, taken together as they belong, form the solid basis upon which the science has since been erected.

The year 1830 was remarkable for the appearance of two papers by Henry T. M. Witham which gave evidence of the high and permanent place this author was to occupy in the annals of paleobotany. These papers, although short, treated of some of the peculiarities of structure to be observed in the plants of the Carboniferous of England. These observations were supplemented and extended in his "Observations on Fossil Vegetables, accompanied by Representations of their Internal Structure as seen through the Microscope," which appeared in the following year. In this volume, which was quarto in size, he discusses at length the peculiarities of structure which he was able to make out by the study of thin sections of the silicified specimens under the micro-

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[1] Marcelli Maphigii opera ommia. Lugd. Bat., 1687.

[2] Über aufrecht im Gebirgsgestein eingeschlossene fossile Baumstämme und andere Vegetabilien. Bonn, 1819.

Fortgesetzte Bemerkungen über fossile Baumstämme und andere Vegetabilien. Bonn, 1821.

[3] J. G. Rhode. Beiträge zur Pflanzenkunde der Vorwelt. Breslau, 1820.

[4] Baron E. F. von Schlotheim. Die Petrifactenkunde auf ihrem jetzigen Standpunkte. Gotha, 1820; Nachträge, Gotha, 1822.

[5] Sketch of Paleobotany, in Fifth Annnual Report U. S. Geol. Survey, Washington, 1885, p. 406.

scope. In the preparation of these thin sections he acknowledges his indebtedness to the kindness of Mr. William Nicol, of Edinburgh, who first brought the method to his attention. This new method, which is the one in use at the present time, worked a complete revolution in the study of petrified trunks, and from the appearance of this book the study of the internal structure of fossil plants may be said to date. These sections were made by first grinding a smooth surface on the specimen and cementing it with Canada balsam to a small piece of glass. As much as possible of the specimen was cut away, leaving a thin layer adhering to the glass, and this was ground down until it was thin enough to allow the light to pass through, when it was mounted permanently in Canada balsam. Witham examined in this way fossil coniferous, monocotyledonous, and dicotyledonous woods, which he compared with living forms, but did not venture to give names to them. This was left for his last and greatest work, which appeared in 1833.[1] In this work, after describing the localities in Great Britain from which his specimens were obtained and giving other information concerning them, he established four genera of fossil conifers, the first that had ever been described from considerations of internal organization alone. The new genera were: Peuce and Pitus, each with two species; Pinites, with five species; and Anabathra, with one species. A single species of Lepidodendron was also characterized. The organization of these plants was illustrated by sixteen plates, two of which were, however, devoted to living species, and considering the time at which these figures appeared they are remarkably good.

A work had been published a year previous to this time which had also done much to stimulate the study of internal structure. This was C. Bernhard Cotta's "Die Dendrolithen in Beziehung auf ihren inneren Bau," in which he attempted to "classify systematically and describe scientifically the various kinds of fossil wood that had been discovered." He studied the internal structure of specimens in his collection and described several new genera and species. While the illustrations in his book are inferior to Witham's, they are nevertheless sufficiently characteristic to be readily recognized.

Besides several shorter papers that appeared about this time by Pattinson,[2] Parkinson,[3] and others, the year 1831 saw the beginning of Lindley and Hutton's great work, the "Fossil Flora of Great Britain." This work, which was not completed until 1837, was concerned principally with the superficial phase of the fossil flora, but contained never-

[1] The Internal Structure of Fossil Vegetables found in the Carboniferous and Oölite Deposits of Great Britain, Described and Illustrated. Edinburgh, 1833.

[2] H. L. Pattinson. On the Fossil Trees found in Jefferies Rake Vein at Derwent Lead Mine in the County of Durham. Phil. Mag. and Annals, vol. 7, London, 1830, pp. 185-189.

[3] James Parkinson. Outlines of Oryctology. An Introduction to the study of Fossil Organic Remains. London, 1830. Fossil wood, pp. 21-33.

theless illustrations and remarks on three of the species of Piuites (*P. Brandlingi*, *P. Withami*, and *P. medullaris*) mentioned by Witham.

In 1833 William Nicol published his valuable "Observations on the Structure of Recent and Fossil Coniferæ,"[1] which was the first systematic comparison of internal structure instituted between living and fossil species. He examined quite an extensive series of living conifers, which he illustrated in six plates accompanying the article, and pointed out some facts that must be observed in the study of fossil forms. He refers to the method of preparing thin sections, which was credited to him by Witham as his invention, and says that it was not original with himself, but derived from a Mr. Sanderson, a lapidary of Edinburgh. In the following year he published a second article,[2] in which he decribed fossil dicotyledonous wood from the island of Mull with conifers and dicotyledons from Egypt and Nubia, and conifers from the Cape of Good Hope. He did not, however, attempt to give names to anything examined from these localities.

We pass hastily over the period from 1835 to 1839, during which papers of some interest in this department appeared by Bronn,[3] Gazlay,[4] and others, and come to the publication of Brongniart's splendid memoir on *Sigillaria elegans*.[5] Having obtained from the environs of Autun, Aix-la-Chapelle, and Werden some perfectly silicified fragments which showed on the exterior the leaf scars characteristic of this species, Brongniart was enabled to examine for the first time the internal organization of this interesting group of plants. After describing carefully his specimens of *Sigillaria elegans* he compared them with all the other Carboniferous species of which the structure was known. These he divided into three groups, according to the distribution of the vascular elements. As *Sigillaria elegans* showed undoubted evidence of exogenous growth it was placed by Brongniart among the Gymnosperms, a position which was further insisted upon in 1849 in his "Tableau des genres de végétaux fossiles." Although the conclusion as to the systematic position of this species has since been shown by Williamson, Zeiller, and others to be incorrect, the publication of this memoir was a long step towards a solution of some of the most difficult problems of the relations between Cryptogams and Phæuogams.

Although Witham, Nicol, and others had described the structure of fossil dicotyledonous woods, no one had ventured to name genera or

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[1] Edinb. New Phil. Jour., vol. 16, 1833–'34, pp. 137–158, pl. II–IV, pp. 310–314, pl. V.

[2] On the structure of some fossil woods found in the Island of Mull, Northern Africa, and on the Karoo Ground to the northeast of the Cape of Good Hope. Edinb. New Phil. Jour., vol. 18, 1834–'35, pp. 335–338.

[3] Heinrich Georg Bronn. Lethæa geognostica. Stuttgart, 1835–'38.

[4] Rev. Sayrs Gazlay. Notices of Fossil Wood in Ohio. Am. Jour. Sci., vol. 25, 1834, pp. 104–107.

[5] Observations sur la structure intérieure du Sigillaria elegans comparée à celle des Lepidodendron et des Stigmaria et à celle des végétaux vivants. Mus. Hist. Nat., Paris, Archives, 1839, pp. 405–461, pls. XXV, XXXV.

species until Göppert,[1] in 1839, characterized his *Klœdenia quercoides*, a genus which is now included under Quercinium of Unger.

Several short papers appeared in 1841 by Unger,[2] Göppert,[3] and others.

During the year 1842 Kutorga, in a short paper on the paleontology of Russia,[4] described three new species of fossil wood, two of which are from the Kupfersandsteine of Perm, the other from the Kreidegebirge of Don. They were *Peuce biarmica*, *Peuce tanaitica*, and *Pinites biarmicus*. Göppert in this year contributed a paper[5] on the flora of the iron sands of Aachen, in which he made valuable suggestions in regard to the method of studying fossil wood. Recognizing the fact that little could be accomplished in the study of fossil forms without a thorough knowledge of the internal structure of living species, he made a very careful examination of more than one hundred living species, of conifers. These he arranged in four groups, viz: the Pinus, Araucaria, Taxus, and Ephedra forms, and briefly characterized each.

For the fossil Coniferæ of Aachen he adopted Witham's name Pinites, and described a single new species, *Pinites aquisgranensis*.

Another new species of Pinites (*P. gypsaceus*) was described in the Flora der Gypsformation in Oberschlesien.[6]

Göppert also published a paper[7] on the Cycadaceæ, in which, after reviewing what he had before written on the subject, he monographed the order. Of the seventy-eight species known at that time, nine were characterized from the trunks, sixty-five from the fronds, and four from the fruit.

The year 1845 was remarkable for the production of three great works, besides numerous smaller papers. These were Corda's "Beiträge zur Flora der Vorwelt,"[8] Göppert's Amber-Flora,[9] and Unger's

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[1] "Bemerkungen über die als Geschiebe im nördlichen Deutschland vorkommenden versteinerten Hölzer." Neues Jahrb., 1839, pp. 518–521, pl. VIII B.

[2] Franz Unger. Ueber die versteinerten Hölzer des National-Museums zu Lintz. Warte an der Donau, August, 1841, pp. 497–499.

[3] Taxites scalariformis, eine neue Art fossilen Hölzer. Karst. Archiv. für Mineral., etc., vol. 15, 1841, p. 727, plate XVII, figs. 1–7.

[4] Dr. S. Kutorga. Beitrag zur Palaeontologie Russlands. Russ. kais. mineral. Gesell., St. Petersburg., Verhandl., 1842, pp. 1–34, plates I–VI.

[5] Fossile Pflanzenreste des Eisensands von Aachen, als zweiter Beitrag zur Flora der Tertiärgebilde. Acad. Leop. car. Nat. cur. Acta, vol. 19, 1842, pp. 137–160, plate LIV.

[6] Ueber die fossile Flora der Gypsformation zu Dirschel in Oberschlesien, als dritter Beitrag zur Fl. d. Tertiärgebilde. Acad. Leop. Car. nat. cur. Acta, vol. 19, 1842, pp. 369–378, plates LXVI–LXVII.

[7] Ueber die fossilen Cykadeen überhaupt, mit Rücksicht auf die in Schlesien vorkommenden Arten. Schles. Gesell. f. vater. Kult., Uebersicht, 1842, pp. 114–142.

[8] August Joseph Corda. Beiträge zur Flora der Vorwelt. Prag, 1845, pp. 1–128, plates I–LX.

[9] G. C. Berendt. Die im Bernstein befindlichen organischen Reste der Vorwelt. Vol. I. Berlin, 1845. I. Abtheilung: Der Bernstein und die in ihm befindlichen Pflanzenreste der Vorwelt (by Dr. Göppert).

Synopsis plantarum fossilium.[1] Lack of space prevents a satisfactory analysis of these works, and I will simply say that the first in the list, by Corda, is a magnificent folio, illustrated by sixty plates, nearly all of which are devoted to internal structure. Göppert's Amber-Flora was a complete summary of the known facts relating to the origin of amber, and also an enumeration of all the plants detected in it. The amber he thinks was produced almost entirely by a single species of pine, which he called *Pinites succinifer.* Unger's Synopsis enumerated 1,648 species of plants, the total number known at that time.

In 1847 appeared Unger's "Chloris Protogæa,"[2] another magnificent work, containing characterizations of a considerable number of new genera of Dicotyledons. The genera that appear for the first time are Ulminium, Fegonium, Quercinium, Betulinium, Acerinium, and Plataninium, named for their resemblance to wood of Ulmus, Fagus, etc. Many fine figures illustrate the work.

Equally important was Endlicher's "Synopsis Coniferarum,"[3] which also appeared in 1847. Of the 177 species mentioned nearly 60 are characterized from internal structure.

This hasty review closes the period from the origin of definite ideas concerning petrifactions to the beginning of the year 1850, which is remarkable for the production of two of the most important works. These were "Monographie der fossilen Coniferen,"[4] by Göppert, and "Genera et species plantarum fossilium,"[5] by Unger.

Göppert's work was a most elaborate essay, filling 359 quarto pages and illustrated by 58 plates, more than half of which is devoted to internal structure. The first 67 pages of the work describe the living conifers, which he considers under the following heads: I. Historical review of our knowledge of the Coniferæ. II. Geographical distribution. III. Organography and anatomy. This last part is, for the student of internal structure, perhaps the most important, as here are passed in review all the terms used in the description of the external and internal parts, with special emphasis of those characters which are found to be of the most importance in the diagnosis of genera and species.

The part devoted to the fossil Coniferæ is likewise divided into several subdivisions. The first of these is a historic review of the study of fossil plants, particularly the conifers, from the first crude speculations of the ancients through the formative period of the Middle Ages to the scientific period of our own times. This part more

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[1] Lipsiæ, 1845.

[2] Chloris Protogæa. Beiträge zur Flora der Vorwelt. Leipzig, 1847.

[3] Stephen Endlicher. Synopsis coniferarum. Sangalli, 1847.

[4] Monographie der fossilen Coniferen. Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Tweede Verzameling, 6e Deel Leiden, 1850.

[5] Genera et species plantarum fossilium. Vindobonæ, 1850.

than any other shows the scholarly attainments of the illustrious author. He seems to have read everything that had even the most remote bearing upon the subject.

In the systematic part, which occupies pages 169–248, he follows the divisions of the fossil forms into four groups as proposed by himself in 1842. In the Cupressineæ he established the genus Cupressinoxylon and described under it 15 species. Of the Abietineæ he described 38 species of Pinites, 6 of which were new; 11 species of Araucarites; 2 of Pissadendron and 1 of Protopitys. Under the Taxineæ he enumerates 4 species of Taxites and 1 each of Physematopitys and Spiropitys. Of the Gnetaceæ none are characterized from internal structure.

In the last part are enumerated all the localities where fossil wood, beds of coal, etc., occur, with a statement of the geological horizon to which each belongs.

A careful analysis of Unger's "Genera et species" can not be attempted. It is sufficient to say that it contains descriptions of 2,421 species of plants, a great advance in knowledge over anything that had previously appeared.

Two interesting papers on the structure of palms were published by C. G. Stenzel[1] during the year.

For the next few years, while much material was published that was of general interest in paleobotany, nothing of special importance came out relating to the internal organization of plants. Most of the papers were systematic descriptions of the flora of various localities and contain only incidental mention of fossil wood. Of this character were the papers of Weber,[2] Göppert,[3] Massalongo,[4] and Mercklin.[5]

Göppert's "Beiträge zur Tertiärflora Schlesien's"[6] was of more importance, as it contains descriptions of several species of Cupressinoxylon, Pinites, Physematopitys, Taxites, and Spiropitys.

One of the first contributions to our knowledge of American deposits of lignite was that by Edward Hitchcock[7] on the brown coal deposit in Brandon, Vt. No attempt at identification of species from study of structure was made except that a pine cone in connection with "pine lignite" is mentioned. Many figures of dicotyledonous fruits, which

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[1] De trunco palmarum fossilium. Inaug. diss. Vratislaviæ, 1850, pp. 1–18, plates I, II. Zwei Beiträge zur Kenntniss der fossilen Palmen. Acad. Leop.-Carol. Nova Acta, vol. 22, Breslau, 1850, pp. 467–508, plates 51–53.

[2] C. Otto Weber. Die Tertiärflora der niederrheinischen Braunkohlenformation. Palaeontographica, vol. 2, Cassel, 1852, pp. 115–236, plates XVIII–XXV.

[3] Fossile Flora des Uebergangsgebirges. Acad. Leop.-Car. nat. cur. Nova Acta, vol. 22, Supplement, 1852, pp. 1–299, tab. I–XLIV.

[4] Synopsis palmarum fossilium. Natur.-Wiss. Verein Lotos, vol. 2, 1852, pp. 193–208.

[5] C. von Mercklin. Ueber fossiles Holz und Bernstein in Braunkohle aus Gishiginsk. Acad. Imp. Sc. St.-Pétersbourg. Bull. Classe Phys. Math., vol. 11, pp. 81–93, pl. I.

[6] Palaeontographica, vol. 2, Cassel, 1852, pp. 257–282, plates XXXIII–XXXVIII.

[7] Description of a brown coal deposit in Brandon, Vermont, with an attempt to determine the geological age of the principal hematite ore beds in the United States. Am. Jour. Sc., 2d ser., vol. 15, 185 pp. 95–104.

were afterwards identified and named by Lesquereux,[1] accompany the article.

The first American investigations of the internal organization of fossil wood seem to have been made in 1854 by Dr. (now Sir) J. W. Dawson, who mentions[2] specimens from Prince Edward Island which exhibited on the wood cells the hexagonal disks characteristic of the Araucarian type. The specimens are described as being perfectly silicified trunks of trees, in some cases three feet in diameter; they are prostrate and slightly flattened. These were subsequently described by Dawson as species of Dadoxylon, but no identification is made in this paper.

In the same year, but of less importance, was a note[3] by Dr. A. T. King on fossil trees in the coal rocks of Pennsylvania.

The year 1854 was particularly remarkable for the European activity manifested. C. G. Stenzel, in his "Staarsteine,"[4] monographed the genus Psaronius, enumerating 18 species, and gave much valuable information regarding the structure and synonomy. The six plates all illustrate the internal structure. Göppert, in his Tertiary Flora of Java,[5] described the deposit of fossil wood of that country and established three new genera (Junghuhnites, Bradæa, and Miquelites), each with a single species.

Unger, in his Flora of Gleichenberg,[6] described several conifers and three species of dicotyledons, and Balfour[7] wrote of the vegetable structure detected in the coal of Fordel, a subject which had since the time of Witham attracted great attention.

The most important publication during 1855 was that of Schmid and Schleiden, "Ueber die Natur der Kieselhölzer."[8] It is divided into two parts: the first treats of the average chemical composition of silicified wood and the second is a systematic description of the fossil wood in the Grand Ducal Museum of Jena. Twelve species are enumer-

[1] Am. Jour. Sc., 2d ser., vol. 32, 1861, pp. 355-363. Also see Hitchcock's Geology of Vermont, vol. 2, pp. 712-718.

[2] On fossil coniferous wood from Prince Edward Island. Acad. Sc. Phil., Proc., vol. 7, 1854, pp. 62-64.

[3] Description of fossil trees in the coal rocks near Greensburgh, Westmoreland County, Pennsylvania. Acad. Sc., Phil., Proc., vol. 7, 1854, pp. 64-65.

[4] Ueber die Staarsteine. Acad. Leop. Car. Nova Acta, vol. 24, Jena, 1854, pp. 753-896, plates 34-40.

[5] Die Tertiärflora auf der Insel Java, nach den Entdeckungen des Herrn Fr. Junghuhn beschrieben u. erörtert in ihrem Verhältnisse zur Gesammtflora der Tertiärperiode. 's Gravenhage, 1854.

[6] Die fossile Flora von Gleichenberg. K. Acad. wiss. Wein, Denkschriften, vol. 7, 1854, pp. 157-184, pl. I-VIII.

[7] J. H. Balfour. On certain vegetable organisms found in the coal of Fordel. Roy. Soc. Edinb., Trans., vol. 21, 1854, pp. 187-193, pl. II.

[8] E. E. Schmid und M. J. Schleiden. Ueber die Natur der Kieselhölzer. Jena, 1855, pp. 1-42, plates I-III.

ated, of which four are new conifers and four new dicotyledons, and three new genera established, each with a single species.

In the next year several notices appeared by American authors. One by George C. Schaeffer described[1] the structure of two specimens of wood from the Colorado Desert. The specimens were very well preserved and are undoubtedly dicotyledonous, as is also the specimen from Posuncula River described by Prof. W. J. Bailey.[2] No names are given in either case, but the specimens from Colorado are compared with figures of dicotyledons from Antigua given by Witham in his "Internal Structure of Fossil Vegetables."

Dawson also described and figured[3] the internal structure of wood from the Devonian of Gaspé, Canada East. The specimens, he says, were collected by Sir W. E. Logan in 1844, and placed in the collection of the Canadian Geological Survey. No attempt is made by Dawson to name these fossils, but they were without doubt coniferous.

Richter and Unger contributed a valuable paper, "Beitrag zur Palæontologie des Thüringer Waldes,"[4] in which the structure of Calamopteris, Calamopitys, Stigmaria, Lepidodendron, Cladoxylon, Aporoxylon, etc., is illustrated.

From 1856 to 1860 many interesting papers were published, of which, limited space will allow only the briefest mention. Goldenberg[5] monographed the Selagineæ and the Sigillarieæ; Göppert[6] describes briefly the fossil forests discovered by Möllhausen in New Mexico and named a single new species (*Araucarites Mœllhausianus*). Unger also contributed two valuable articles. In one of these he describes[7] the petrified forests near Cairo and in other parts of Egypt. Several new species are characterized, among them *Nicolia Ægyptiaca*, which was named in honor of William Nicol, who will be remembered as the contemporary of Witham. The other paper, "Ueber fossile Pflanzen des Süsswasser-Kalkes und Quartzes,"[8] describes and figures the internal

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[1] Description of the structure of the fossil wood from the Colorado Desert. U. S. Pac. R. R. Rep., vol. 5, 1856, pp. 338, 339, plate XII, figs. 3, 4.

[2] Letter from Prof. J. W. Bailey, describing the structure of the fossil plant from Posuncula River. U. S. Pac. R. R. Rep., vol. 5, 1856, p. 337, pl. XII, figs. 1, 2.

[3] J. W. Dawson. Remarks on a specimen of fossil wood from the Devonian rocks (Gaspé sandstones) of Gaspé, Canada East. Am. Assoc. Adv. Sc. Proc., vol. 10, 1856, pp. 174–176, figs. 1–4.

[4] R. Richter und F. Unger. K. Acad. Wiss. Wien, Denkschr., vol. 11, 1856, pp. 1–100, plates I–XIII.

[5] Friedrich Goldenberg. Flora Saræpontana Fossilis. Die Pflanzenversteinerungen des Steinkohlengebirges von Saarbrücken. Saarbrücken, 1855–'57.

[6] Ueber die von Möllhausen mitgebrachten Fragmente des Holzes aus dem versteinerten Walde. In Möllhausen's Tagebuch einer Reise vom Mississippi nach den Küsten der Südsee. Leipzig, 1858, p. 492.

[7] Der versteinerte Wald bei Cairo und einige andere Lager verkieselten Holzes in Agypten. Sitz. K. Acad. Wiss. Wien, math.-nat. hist. Kl. vol. 33, 1858, pp. 209–233, plates I–III.

[8] F. Unger. K. Acad. Wiss. Wien, Denkschr., vol. 14, 1858, pp. 1–38, plates I–V.

structure of species of Arundo, Nymphæa, Thuioxylon, Betulinium, Klippsteinia, Peuce, and Hauera. The species are all European, with the exception of *Hauera Americana*, which is from Papantla, Mexico.

In 1859 Dawson again returned to the study of the plants of the Peninsula of Gaspé, Lower Canada, and for the first time made positive determinations of them.[1] He visited Gaspé in person and collected an extensive series of specimens, upon which he founded several new genera and species. The first of these is Psilophyton, a genus of lycopodiaceous plants, "which is characterized by slender, bifurcating, ridged stems, proceeding from a horizontal rhizoma, which sends forth numerous rootlets." The internal structure had in most cases disappeared; yet it could be traced in a few instances. It is described as consisting "of a slender axis of scalariform vessels, surrounded by a space now occupied by calcspar, but showing in parts the remains of a loose, cellular tissue. Externally to this is a cylinder of well preserved, elongated, woody cells, without distinguishable pores, but with traces of very delicate spiral fibers." Two species are established.

Prototaxites is described as a new genus of conifers in the following manner: "Woody trunks, with concentric rings of growth and medullary rays. Cells of pleurenchyma scarcely in regular series, thick walled and cylindrical, with a double row of spiral fibers. Disk structure indistinct." Coming, as this plant does, from the Devonian, it was regarded as one of the oldest forms of coniferous structure known, and yet it was highly differentiated even then, as is shown by the fact that its nearest living representatives were thought by Dawson to be Taxus and Torreya. Other remains of tissues, doubtfully referred to Unger's Aporoxylon, may represent a still more primitive phase.

In the same year was published a further contribution by the same author on the vegetable structures in coal,[2] the observations applying to the bituminous coal of Nova Scotia. He divides the coal into two classes: mineral charcoal and compact coal. In the mineral charcoal he detected both cryptogamous and gymnospermous tissue. In the former were abundant remains of scalariform tissues belonging apparently to Lepidodendron, Ulodendron, Stigmaria, and even Sigillaria. Of the gymnospermous tissues the identifications were less positive, although they were unquestionably coniferous and probably belonged to the Araucarian type.

Of the structure observed in compact coal comparatively little could be satisfactorily made out, although fragments apparently of both cryptogams and conifers were detected in exceptionally well-preserved specimens.

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[1] On Fossil plants from Devonian Rocks of Canada. Quart. Jour. Geol. Soc., vol. 15, 1859, pp. 477–478, figs. 1–6; also, Can. Nat. and Geol., vol. 5, 1860, pp. 1 14, figs. 1–6.

[2] On the Vegetable Structures in Coal. Quart. Jour. Geol. Soc., London, vol. 15, 1859, pp. 626–641, pl. XVII.

In 1861 there appeared an important work by Dr. F. Hildebrand,[1] in which he discusses in a very exhaustive manner the distribution of both living and fossil Coniferæ. The geological, as well as the geographical, distribution of the fossil species was given and has been of great aid to the student of stratigraphy. Several maps and tables illustrate the paper.

Curious remains of plant structure, identified as *Araucarites Schrollianus*, were detected by Bornemann[2] in quartz crystals.

The study of American material was carried on with great vigor by Dawson, who contributed numerous articles touching more or less upon the internal organization of the plants of Devonian and Carboniferous ages in Canada, Nova Scotia, and other regions. One, in 1861, "On the Pre-Carboniferous flora of New Brunswick, Maine, and Eastern Canada,[3] contains descriptions of species of Dadoxylon, Prototaxites, Sternbergia, Aporoxylon, etc., but a more elaborate and systematic paper than he had published up to this time was that on the "Flora of the Devonian Period in Northeastern America,"[4] which appeared in 1862. In this he first discusses the localities in New York, Maine, Canada, and New Brunswick from which Devonian fossils have been obtained. In the systematic portion which follows, no less than 69 species belonging to 32 genera are described, of which number 36 species are regarded as new. Most of these are, of course, described from stem, leaf, or fruit impressions; but a few are characterized from internal structure, among them Syringoxylon, a new dicotyledonous genus. The single species known is from the upper part of the Hamilton Group, on Lake Erie. A new Dadoxylon, also from the same group, in Ontario County, New York, is described.

Among some of the shorter papers of this time may be mentioned one by Schimper,[5] in which *Dadoxylon vogesiacum* is described as new, and one by Unger on some fossil plants from New Zealand.[6] Two species of wood, *Podocarpium dacrydioides* and *Nicolia zelandica*, are mentioned by Unger. The first species of Nicolia it will be remembered was from the Egyptian Desert, and the occurrence of another species in New Zealand is of interest.

Göppert's "Flora of the Permian Formation,"[7] which appeared at Cassel in 1864–'65, was another of the many valuable works produced by

[1] Die Verbreitung der Coniferen in der Jetztzeit und in den früheren geologischen Perioden. Bonn, 1861, 8°.

[2] J. G. Bornemann. Ueber Pflanzenreste in Quarzkrystallen. Deutsch. geol. Gesell., Zeitschr., vol. 13, Berlin, 1861, pp. 675–681, plate XVI.

[3] Can. Nat. and Geol., vol. 6, 1861, pp. 161–180.

[4] Quart. Jour. Geol. Soc., vol. 18, 1862, pp. 296–330, pl. XII–XVII.

[5] Le Terrain de Transition des Vosges. Partie Paléontologique, par Wm. Ph. Schimper. Strasbourg, 1862, p. 342, plate XXX.

[6] Fossile Pflanzen aus Neu-Seeland. In Hochstetter's Geologie von Neu-Seeland, Wien, 1864, pp. 1–13, plates I–V.

[7] Die fossile Flora der permischen Formation. Cassel, 1864–'65.

this author. It contains 316 pages and 64 plates, not a few of the latter being devoted to internal structure. It is a systematic work, and describes and discusses with great fullness the 272 species that had at that time been collected from the Permian. Without attempting an exhaustive analysis, an idea of its magnitude and of the value to the student of the internal structure of fossil plants may be obtained by noting the number of species described from internal structure. There are 43 species of fern stems and rhizomes, of which number 25 belong to the genus Psaronius alone. The Cycadaceæ are represented by three species of Zamites, two species of Medullosa, and one species each of Stenzelia, Myelopitys, and Colpoxylon. The Coniferæ are represented by 16 species of Araucarites and a single species of Pinites. The work closes with a discussion of the origin and distribution of the Permian flora.

Another work of great value, also published in 1864, was the microscopical examination made by Kraus of the structure of living and fossil Coniferæ.[1] Wishing to ascertain, for use in the elucidation of fossil forms, what marks were of the most diagnostic value, he examined upwards of one hundred living species and obtained results which have been generally accepted. Without giving a full exposition an example will suffice. He investigated the width of the annual ring and found that it had no value as a distinctive mark, as it varied in different parts of the same individual and also widely from year to year, this latter variation being the result of changes in temperature and in moisture. In composition the ring consists of an inner, a middle, and an outer layer. The inner layer, or spring wood, consists of thin-walled, mostly four-sided cells, with bordered pits only on the radial walls; the middle ayer, of thicker, mostly polygonal, cells, which have a decreasing radial diameter; the outer layer, or fall wood, is of thick-walled, compressed cells, with bordered pits on the tangential as well as on the radial walls. The predominance of certain layers may help to distinguish stem from root wood. Thus in the stem the cells of the inner layer predominate; in the root, the cells of the middle layer.

In similar manner were taken up the wood cells, resin cells and ducts, and medullary rays, and more or less valuable characters were drawn from them.

Equally useful observations were made on the fossil forms studied and several species new to science were diagnosed.

In 1863 Dawson described four new species of Dadoxylon from the coal formation in Nova Scotia.[2]

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[1] Gregor Kraus. "Mikroskopische Untersuchungen über den Bau lebender und vorweltlicher Nadelhölzer." Würzburger naturwiss. Zeitschr., vol. 5, 1864, pp. 144–200, plate v.

[2] Synopsis of the Flora of the Carboniferous Period in Nova Scotia. Montreal, 1864, pp. 1–27. Reprint from Can. Nat., 1863, vol. 8.

In the same year E. W. Binney published[1] a continuation of his observations on the structure of the coal plants of England. The specimens, eight in number, upon which these observations were made, were from the lower division of the coal measures of Lancashire and Yorkshire, and were embedded in calcareous nodules which occur in seams of coal. They were very perfectly preserved and yielded valuable results; but, as the author says in the conclusion, the memoir "was intended to be more of a descriptive character than an attempt to trace the analogy of the plants." They are, however, referred to Diploxylon and Sigillaria.

Several short but valuable contributions appeared about this time from the pens of Unger,[2] Kraus, and others.

In one of these papers Unger reports the occurrence of *Nicolia Ægyptiaca* from the highlands of Abyssinia. In another[3] he characterizes two new genera of dicotyledons (Constantinium and Tchihatcheffites) from Thrace in Asia Minor.

Kraus, in his paper "Ueber einige bayerische Tertiarhölzer,"[4] enumerates several well-known conifers and a new species of birch (*Betula lignitum*, and in his "Zur Kenntniss der Araucarien des Rothliegenden und der Steinkohlenformation,"[5] he combined and characterized several species of Araucarites.

The year 1868 saw the completion of Eichwald's great work on the paleontology of Russia.[6] This work, which was begun as early as 1859, consists of two parts, Ancienne Période and Période Moyenne, each accompanied by a folio atlas of plates, many of which are devoted to internal structure. It is impossible to give even an approximate analysis of the work, and we can simply say that it placed at the disposal of savants all the facts then known of the paleontology, animal as well as vegetable, of this vast empire.

This year was noteworthy also for the production of important papers by Cramer, Carruthers, Binney, Hooker, and others.

The "Fossile Hölzer der arctischen Zone,"[7] by Cramer, deserves special mention. He describes and figures wood from Greenland, Banks Land, and Spitzbergen, which, with one exception, was found to be all coniferous. From Greenland came two species of Cupressinoxylon (*C.*

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[1] A description of some fossil plants, showing structure, found in the Lower Coal seams of Lancashire and Yorkshire. Roy. Soc. London, Phil. Trans., 1865, pp. 579–604, pls. XXX–XXXV.

[2] Notiz über fossile Hölzer aus Abyssinien. Wien, 1866, pp. 289–297, plate I.

[3] Flore tertiaire moyenne. In Tchihatcheff's Asie Mineure. Paris, 1866–'69, 4° partie, pp. 319–325, pl. XVII, figs. 1–4.

[4] Würzburger naturwiss. Zeit., vol. 6, 1866–'67, pp. 45–48.

[5] Op. cit., pp. 70–73.

[6] Édouard D'Eichwald. Lethæa Rossica, ou Paléontologie de la Russie. Stuttgart, 1853–'68.

[7] Cramer. In Flora fossilis arctica. Oswald Heer. Vol. 1. Zürich, 1868, pp. 167–180, plates XXXIV–XLIII

Breverni Merekl. and *C. ucranicum* Göpp.); from Banks Land, a single species of Pinus (*P. MacClurii* Heer), three species of Cupressinoxylon (*C. pulchrum* Cramer, *C. dubium* Cramer, and *C. polyommatum* Cramer), and the now well known *Betula MacClintockii;* from Spitzbergen came three species, all new, of Pinites (*P. latiporosus*, *P. pauciporosus*, and *P. cavernosus*).

Carruthers's paper on the Cycadean stems of Britain[1] was a valuable contribution to our knowledge of this poorly understood family. So, also, were Hooker's papers on the structure of Stigmaria[2] and on the structure and affinities of some Lepidostrobi.[3]

Binney issued in this year the first part of his "Observations on the Structure of Fossil Plants found in the Carboniferous Strata," a consideration of which is deferred.

The most systematic contribution to our knowledge of the fossil Coniferæ published since Göppert's Monographie was that of Dr. Kraus, in Schimper's "Traité de Paléontologie Végétale."[4] Ever since the publication of Göppert's work, "De Coniferarum structura anatomica," in 1841, the opinion had been growing among students that the genera must be regarded as comprehensive; that is, that a genus established upon fossil remains may include what might be regarded as several distinct genera, provided they were living and in possession of other organs which are of taxonomic value. With this point settled, Kraus divided the Coniferæ into the five following types, which, it will be observed is one more than Göppert admitted:

I. Type of Cupressineæ (Cupressoxylon), comprising all the Cupressineæ, the Podocarpeæ, and a part of the Taxeæ.

II. Type of the Abietineæ (Cedroxylon), including the genera Abies, Picea, Larix, and Cedrus.

III. Type of the Pinaceæ (Pityoxylon), which includes the genus Pinus and its subgenera

IV. Type of the Araucarieæ (Araucarioxylon), which will include Araucaria, Agathis, etc.

V. Type of the Taxeæ (Taxoxylon), comprising all the genera not included under Cupressoxylon.

Aporoxylon Unger is still retained as a genus incertæ sedis.

To these six generic types all the other names in use were reduced as synonyms. Thus Cupressoxylon Kraus included Thuioxylon of Unger and Endlicher and Physematopitys of Göppert; Araucaroxylon Kraus was made to include Araucarites Göpp., Pissadendron Endl., and Palæoxylon Brongn. Other changes it is unnecessary to mention.

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[1] William Carruthers. On Fossil Cycadean Stems from the Secondary Rocks of Britain. Linn. Soc. Lond., Trans., vol. 26, 1868, pp. 675–708, pls. LIV–LXIII.

[2] On some peculiarities in the structure of Stigmaria. Geol. Surv., Gt. Brit. Mem., vol. 2, pt. 2, 1848, pp. 431-439, pls. I, II.

[3] Remarks on the Structure and Affininities of some Lepidostrobi. *Op. cit.*, pp. 440–456, figs. 1-5 in text.

[4] Bois fossiles des conifères. In Traité de paléontologie végétale, W. P. Schimper, vol. 2, Paris, 1870–'72, pp. 363-385, Atlas, pl. LXXIX.

This systematic arrangement was followed by a detailed enumeration without description of all the known species.

The period between 1870 and 1880 was a remarkably active one, as is shown by the fact that more than fifty papers, of greater or less value, appeared during this time. As it will be impossible to notice all these works fully a few only of the more important will be selected and the others given by title only.

Caruthers contributed an article on the fossil forests near Cairo,[1] in which he described and figured yet another species of Nicolia, named in honor of the collector, *N. Owenii.*

The wonderful fossil forests of California and the Yellowstone National Park were treated of in short articles, the former by Marsh[2] and the latter by Holmes.[3] The structure of the specimens from California was investigated by Dr. M. C. White, of New Haven, and pronounced by him to resemble the wood of Sequoia, but no further attempt was made to determine it.

Specimens of the wood from Californian forests were later sent to Dr. H. Conwentz,[4] in Breslau, who made a thorough examination, which resulted in determining them all to be coniferous and to belong to a single species, which he called *Cupressinoxylon taxodioides.*

The year 1871 saw the beginning of Professor Williamson's great work "On the Organization of the Fossil Plants of the Coal Measures." This work, published in the Transactions of the Royal Society of London, already (1889) numbers fifteen parts, and is, it is safe to say, the most valuable contribution that has been made to our knowledge of the organization of the plants of the Carboniferous age. A consideration of it is deferred.

This work by Professor Williamson is by no means his first, as he entered the field of paleontological science in 1833 as a contributor to the Fossil Flora of Great Britain, by Lindley and Hutton. From that time many able articles on the plants of the Coal Measures have appeared from his pen. They are mostly short and directly to the point. A chronological list of most of them is given below.[5]

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[1] On the Petrified Forest near Cairo. Geol. Mag., vol. 7, 1870, pp. 306–310, pl. XIV.

[2] Notice of a Fossil Forest in the Tertiary of California. Am. Jour. Sci., 3d ser., vol. 1, 1871, pp. 266–268.

[3] Fossil Forests of the Volcanic Tertiary Formations of the Yellowstone National Park. U. S. Geol. and Geog. Surv. Terr., Bull., vol. 5, No. 1, 1879, pp. 125–132.

[4] Ueber ein tertiäre Vorkommen cypressinartiger Hölzer bei Calistoga in Californien. Neues Jahrb., 1879, pp. 800–813, plates XIII–XIV.

[5] On the origin of coal. Brit. Assoc. Adv., Sc. Rep. 1842, Notices and abstracts, pp. 48–49.

On the structure and affinities of the plants hitherto known as Sternbergiæ. Lit. and Phil. Soc. Machester, Mem., 2d ser., vol. 9, 1851, pp. 340–347.

Additional notes on the structure of Calamites. Lit. and Phil. Soc. Manchester, Proc. vol. 8, 1869, pp. 153–155.

On the structure of an undescribed type of Calamodendron from the upper

This period was one of greatest activity for Dr. J. W. Dawson, who published at least a dozen papers relating more or less to the organization of the fossil plants of Canada, Nova Scotia, etc. The most important are the following: "On the structure and affinities of Sigillaria, Calamites, and Calamodendron,"[1] in which he describes and figures very perfect examples of these forms, and presents a scheme of relationship; a paper on Prince Edward Island,[2] in which he mentioned two species of Dadoxylon (*D. materiarium* and *D. Edvardianum*), and characterized and illustrated them; and a note on the plants collected by Mr. G. M. Dawson near the forty-ninth parallel,[3] in which is reported the occurrence of Cedroxylon, Pityoxylon, Cupressoxylon, Taxoxylon, and Populus.

In a collection of wood from the Mesozoic, British Columbia,[4] made by Mr. Richardson, Dawson detected Cupressoxylon and Taxoxylon among the gymnosperms, and species of Quercus, Betula, and Populus among the angiosperms. Specific names are omitted in all instances.

In 1875 appeared the fourth and last part of Binney's "Observations on the Structure of the Fossil Plants found in the Carboniferous Strata,"[5] a work which was begun, it will be remembered, in 1868. Each

Coal-Measures of Lancashire." Lit. and Phil. Soc. Manchester, Proc., vol. 8, 1869, pp. 26–37.

On the structure and affinities of some exogenous stems from the Coal-Measures. Monthly Mic. Jour., vol. 2, 1869, pp. 66–72.

On the structure of the woody zone of an undescribed Calamite (? Calamopitus). Lit. and Phil. Soc. Manchester, Mem., vol. 4, 1869, pp. 155–183.

On the organizations of the stems of Calamites. Brit. Assoc. Adv. Sc., Rep. 1870, Notices and abstracts, pp. 89–90.

Exogenous structures amongst the stems of the Coal Measures. Nature, vol. 4, 1871, pp. 490–492.

On the organization of an undescribed verticillate Strobilus from the lower Coal Measures of Lancashire. Lit. and Phil. Soc. Manchester, Proc., vol. 10, 1871, pp. 105–106.

On the structure of some specimens of Stigmaria. Lit. and Phil. Soc. Manchester, Proc., vol. 10, 1871, pp. 116–118.

On the structure of the woody zone of an undescribed form of Calamite. Lit. and Phil. Soc. Manchester, Mem., vol. 10, 1871, pp. 155–183.

On the structure of the Dictyoxylons of the Coal Measures. Brit. Assoc. Adv. Sc., Rep. 1871, Notices and abstracts, pp. 111–112.

On the fern-stems and their petioles, of the Coal Measures. Brit. Assoc. Adv. Sc., Rep. 1873, Notices and abstracts, p. 106.

[1] Quart. Jour. Geol. Soc., vol. 1871, pp. 147–161, pls. VII–X.

[2] Report on the Geological Structure and Mineral Resources of Prince Edward Island. Montreal, 1871, pp. 1–51, pls. I–III.

[3] Note on the plants collected by Mr. G. M. Dawson, from the lignite tertiary deposits near the forty-ninth parallel. Report by G. M. Dawson, Montreal, 1875. Appendix, pp. 327–331, pls. XV–XVI.

[4] Note on Fossil Woods from British Columbia, collected by Mr. Richardson. Am. Jour. Sc., 3d ser., vol. 7, 1874, pp. 47–51.

[5] E. W. Binney. Palæontographical Society, London. Observations on the Structure of Fossil Plants found in the Carboniferous Strata. Part I, vol. 21, 1868, pp. 1–32, pl. I–VI; Part II, vol. 24, 1871, pp. 33–62, pl. VII–XII; Part III, vol. 25, 1872, pp. 73–96, pl. XIII–XVIII; Part IV, vol. 29, 1875, pp. 97–147; pl. XIX–XXIV.

part is complete in itself and deals with one or more of the characteristic types of the Carboniferous flora. Thus the first part takes up Calamites and Calamodendron. After giving the bibliography, synonomy, and geological position of these types, a detailed and careful description is given of the specimens upon which the memoir is founded, and in conclusion the resemblances and the distinctions between Sigillaria and Calamodendron are pointed out. In a similar manner the other parts describe the structure and discuss, more or less, the affinity of Lepidostrobus and some allied cones, Lepidodendron and Sigillaria, and Stigmaria. This work was a most valuable contribution to our knowledge of some of the intricate problems connected with the origin and development of vegetation.

In 1876 Conwentz[1] published his first contribution to the study of fossil wood, in the form of an inaugural dissertation presented to the faculty of the University of Breslau. This work, which gave an earnest of his future position as a thorough worker, dealt with the wood of the North German Diluvium. He found both conifers and dicotyledons. Of the former he mentions three species, one new, for which he restores the generic name of Pinites. Of the Dicotyledons he obtained three species of oak, for which he adopts the name of Quercites of Göppert in place of the generally accepted Quercinium of Unger.

In the United States, Claypole[2] described a new fossil tree from the Clinton Limestone of Ohio, for which he proposed the name of Glyptodendron.

Renault published two elaborate memoirs[3] on the structure of the plants of the Carboniferous, with the mention of which I close the enumeration of the publications of this decade.

In the next decade, beginning in 1880, a glance at the literature suffices to show that there is an ever increasing activity and interest in this branch of paleontological science. Discarding older and cruder ideas regarding the constitution of genera and species, a knowledge of what can and what can not be made out by a study of the preserved remains is accepted, and "hair-splitting subtleties" give place to deductions made on a firmer scientific basis.

Among such a wealth of publications it is difficult to select any for special mention, as all are, in one way or another, of so much value, but a brief enumeration of such as possess undoubted superiority or interest will be attempted.

Schroeter's[4] examination of the fossil wood of the Arctic zone, made

[1] Über die versteinten Hölzer aus dem norddeutschen Diluvium. Breslau, 1876.

[2] E. W. Claypole. On the occurrence of a fossil tree (Glyptodendron) in the Clinton Limestone (base of Upper Silurian) of Ohio, U. S. Geol. Mag., vol. 5, 1878.

[3] B. Renault et C. Grand 'Eury. Études sur le Sigillaria spinulosa et sur le genre Myelopteris. Paris, 1875. Structure comparée de quelques tiges de la flore carbonifère. Mus. Paris, Nouvell. Archiv., pp. 313–348, pl. x–xvii, 1879. 2d Ser., vol. ii.

[4] Untersuchung über fossile Hölzer aus der arctischen Zone. In Flora fossilis arctica. Oswald Heer., vol. 6, Zürich, 1880, pp. 1–36, plates i–iii.

in 1880, is more than a mere description of species; it is a valuable discussion of important structural points, particularly in the Coniferæ. He accepts the classification of Kraus and gives an analysis of the five groups in seeking to identify a specimen from King Charles's Land, which is afterwards described as new, under the name of *Pinus Johnseni*. From the Mackenzie River three species are described, of which two are new, viz., *Sequoia Canadensis*, *Ginkgo* spec., and *Platanus àceroides* Göpp.

In this year also Conwentz contributed an article on the wood of Karlsdorf,[1] in which he speaks at some length of the various collectors and writers who have worked upon material from this locality, which he regards as one of the richest deposits of fossil wood known.

After an examination of a large series of specimens the conclusion is reached that they all belong to a single form, for which the new generic name Rhizocupressinoxylon is proposed, since they are all considered as representing the wood of the roots. Conwentz thinks three specimens to be the roots of *Cupressinoxylon uniradiatum* of Göppert, and refers them to this species under his new genus. By this process, which has been justly condemned, we may have a single species known under two accepted, but totally different, generic names, depending upon whether the specimens examined be regarded as stem or root wood. This idea, if carried out, would create untold confusion, and make nomenclature an end rather than a means.

Numerous other smaller roots were found penetrating the tissues of Rhizocupressinoxylon, some of which were analogous to the roots of cypress, others to the roots of the alder. For these latter the name Rhizoalnoxylon is proposed, and one species is characterized.

The mycelium of a fungus was also found in the tissues of many of the specimens.

In the following year Dr. Conwentz worked up the fossil wood in the collection of the Royal Geological Land Office Department of Berlin.[2] Most of it was identified as coniferous, although a few dicotyledonous species were detected, among them a new genus, Cornoxylon, with two species. Two new species of Fasciculites are also characterized by Dr. Stenzel, of Breslau.

In the same year Göppert and Stenzel[3] published their paper on the Meduloseæ, a new group in the Cycadaceæ, which they propose to take the place of the group to which the species of Meduloseæ were usually referred.

Undoubtedly one of the most important papers in 1882 was the "Studien über fossile Hölzer," by Johannes Felix, presented as an inaugural

[1] Die fossilen Hölzer von Karlsdorf am Zobten. Danzig, 1880, pp. 1-47, plates I-VIII.

[2] Fossile Hölzer aus der Sammlung der königlichen geologischen Landesanstalt zu Berlin. Jahrb. d. k. preuss. geol. Landesanstalt, 1881, Abhand., pp. 144-171.

[3] Die Medulloseæ. Eine neue Gruppe der fossilen Cycadeen. Cassell, 1881, pp. 1-17, plates I-IV.

dissertation to the philosophical faculty of the University of Leipzig. It is a pamphlet of 81 pages and has one plate. The first part is a discussion of the characters found to be of most importance in distinguishing fossil genera and species. In dicotyledons and monocotyledons he considers that the genera must be in a measure comprehensive, while for the conifers he follows Kraus in adopting five types. In describing conifers, however, he falls into the grave error initiated by Conwentz (supra, p. 32) of using the prefixes rhizo-, cormo-, and clado-, to distinguish wood of the root, stem, and branch. In this way a single species may come to have three totally different generic appellations, and in anything but a systematic arrangement would be as widely separated as the initial letters will permit. Its absurdity is well shown on pages 46 and 47, when *Cupressoxylon Protolarix* of Kraus *Pinites Protolarix G.*) is given under the names of *Cormocupressoxylon Protolarix*, *Cladocupressoxylon Protolarix*, and *Rhizocupressoxylon Protolarix!*

In the systematic part are described woods from Europe, India, Java, Japan, the Islands of Cuba and Antigua in the West Indies, from Brazil, and from Australia. About forty species are enumerated, nearly all of which are new.

Two short papers by Schenk also appeared in 1882. The first of these treats of the wood collected in India by the brothers Schlagintweit,[1] and the other is a discussion of Cotta's species of the genus Perfossus.[2] Cotta described two species (*P. angularis* and *P. punctatus*), the originals of which Dr. Schenk had opportunity of examining in the Dresden Museum. He found them to be unquestionably palm-like in structure and proposed the name Palmoxylon for them, a name which has been since adopted for all palm wood.

In a paper on the plants of the Erian (Devonian) and Upper Silurian formations of Canada,[3] Dawson again defends his Prototaxites and affirms as his opinion that it is "a cotemporary of that prototype of gymnosperms *Aporoxylon* and similar plants of the Devonian," and has a decided likeness to the modern Taxus in structure. Of the genus Dadoxylon he describes one new species, which is the fifth reported from the Middle Erian of America, "an interesting confirmation," as he says, "of the facts otherwise known as to the great richness and variety of this ancient flora."

Other papers during this year were published by Felix,[4] Beck,[5] and others.

[1] Dr. A. Schenk. Die von den Gebrüdern Schlagintweit gesammelten fossilen Hölzer. Engler's bot. Jahrb, vol. 3, 1882, pp. 353–358.

[2] Die Perfossus-Arten Cotta's op. cit., pp. 483–486.

[3] Geol. Surv. Canada, pt. 2. Montreal, 1882. Pp. 95–142, pls. XXI–XXIV.

[4] J. Felix. Beiträge zur Kenntniss fossilen Coniferenhölzer. Engler's bot. Jahrb., vol. 3, 1882.

[5] Richard Beck. Das Oligocän von Mittweida mit besonderer Berücksichtigung seiner Flora. Deut. geol. Gesell., Zeitschr., vol. 34, 1882, pp. 735–770, plates XXXI, XXXII.

The year 1883 witnessed the production of a goodly number of valuable contributions, mostly from well known authors.

Two by Felix are deserving of special notice. Under the modest title of "Untersuchungen über fossile Hölzer,"[1] he gives much useful information concerning Tertiary dicotyledonous woods. The genera mentioned are Laurinoxylon, Lillia, Helictoxylon, Sapotoxylon, Quercinium, and Ficoxylon. The discussion of the genus Quercinium is particularly interesting. In the second part of this paper material from other horizons is described, among which are roots of plants found penetrating other tissues. The name Rhizonium of Corda is adopted for these intruding roots except in one case, where it was clearly of the nature of a cypress, when it was called Rhizocupressoxylon, after Conwentz.

The other work by Felix is a monograph of the fossil wood of the West Indies.[2] In the introduction he again speaks of the difficulty attending a satisfactory determination of angiospermous wood as compared with that of gymnospermous wood, and concludes, after having examined over 400 living species, that the genera founded on fossil forms must be regarded as comprehensive. Salicinium, for example, will include wood of Populus as well as that of Salix.

Most of the material was from the Island of Antigua, from which fossil wood had been known since the time of Scheuchzer. The following genera of dicotyledons were identified: Tænioxylon, Zittelia, Cassioxylon, Schmideliopsis, Anacardioxylon, Ebenoxylon, and Helictoxylon. The monocotyledons all belong to the genus Palmoxylon, of which ten species are described and figured.

In 1883 also appeared the first volume of Göppert and Menge's magnificent "Flora des Bernsteins,"[3] a work which neither of the illustrious authors lived to complete. The second volume was written by Dr. H. Conwentz, and appeared in 1886. The first volume is the most valuable to the student of internal structure, since it contains the results of the examination of the internal structure of such fragments of wood as were preserved in connection with the amber. Göppert first reviewed the work that had been done by Kraus on the structure of living conifers. Many species were described, some from characters taken from the wood, others from leaves, flowers, and fruits, all being illustrated by beautiful colored plates. In conclusion, an elaborate account is given of the origin and relations of the amber flora.

The fossil wood of the Libyan Desert, by Schenk,[4] is a valuable

[1] Deut. geol. Gesell., Zeitschr., vol. 35, 1883, pp. 59-91, plates II-IV.

[2] Die fossilen Hölzer Westindiens. Sammlung palaeontologischer Abhandl., Ser. I, part I. Cassel, 1883, pp. 1-32, plates I-V.

[3] H. R. Göppert und A. Menge. Die Flora des Bernsteins und ihre Beziehungen zur Flora der Tertiärformation und der Gegenwart. Erster Band, Danzig, 1883; Zweiter Band, Danzig, 1886.

[4] Fossile Hölzer. In Beiträge z. Geol. u. Palaeont. d. libyschen Wüste und der angrenzenden Gebiete von Aegypten. Palaeontographica, vol. XXX, 1883, pp. 1-20, plates I-V.

systematic paper. In it the conifers are represented by one species of Araucarioxylon; the monocotyledons by two species of Palmoxylon; the dicotyledons by the following genera, each, except the first, with a single species: *Nicolia*, *Acacioxylon*, *Rohlfsia*, *Jordania*, *Laurinoxylon*, *Capparidoxylon*, *Dombeyoxylon*, and *Ficoxylon*. These last, it will be seen, are mostly named from some living dicotyledon which they most nearly resemble.

In 1884 the most important contribution was that of Beust,[1] in which he describes and figures several species from the Lower Miocene of Greenland.

One of the new species *Araucarioxylon Heerii* is the first of the genus found in Greenland, while the other, *Libocedrus Sabiniana*, is referred to a species already described by Heer from twig impressions.

By far the most valuable part of this paper is the elaborate discussion entered into in seeking a name for the Libocedrus. He examined critically many living conifers to ascertain, if possible, whether the characters considered of most importance in describing fossil forms had any value in distinguishing living genera or species. The result was in the main negative for single or special characters, such as thickening of the cell walls, pits, or markings on the medullary rays, etc., but a combination of all possible characters was found to be of diagnostic worth. Thus the number and the size of the cells in the medullary rays he considers unreliable, but the relative volume of the ray cells as compared with the wood cells, among which they are placed, he considers of the highest value.

He also gives four elaborate tables, in which are presented systematized accounts of a microscopical examination of all recent and fossil species belonging to the groups Araucarioxylon and Cupressinoxylon. These tables, which are invaluable to the general student, represent hundreds of careful observations.

Felix also published an excellent paper in 1884, "Die Holzopale Ungarns in palaeontologischer Hinsicht,"[2] in which he established the new dicotyledonous genera Alnoxylon, Liquidambaroxylon, and Staubia, and described many new species belonging to well known genera. The most important part is his admission of the incongruity of the use of the prefixes rhizo, cormo, and clado to indicate wood of different parts of the plant. It works, as he admits, the greatest confusion in nomenclature, and he wisely concludes to abandon it. In the description of species, if one is fortunate enough to obtain material from all parts of the plant, it is best indicated by simple headings "root wood," "stem wood," or "branch wood," as the case may be. We have not three distinct genera, but simply a very perfect representation of a species of one genus.

Another important work which appeared during this year was J.

[1] Fritz Beust. Untersuchung über fossile Hölzer aus Grönland. Allgem. schweiz. Gesell., neue Denkschr., vol. XXIX, 1884, pp. 1-43, mit. 4 Tabellen u. 6 Tafeln.

[2] Jahrb. d. k. ung. geol. Anstalt, vol. 7, 1884, pp. 1-43, plates I-IV.

Schmalhausen's paper on the Tertiary flora of the southwestern part of Russia.[1] The paper is divided into four parts, the first three of which are devoted to descriptions of leaves, fruits, etc. The fossil wood described in the fourth part is from the Spondylus (Eocene) zone of Russia.

In regard to naming fossil wood, Schmalhausen concludes that the generic as well as the specific names must be comprehensive and possibly include several forms that would be regarded as distinct if we were provided with all the essential parts. Following out this line of argument he refers nearly all his specimens to the genus Cupressinoxylon, which, according to Mercklin, Schroeter and others, he considers may probably represent the wood of Sequoia. The well known structural resemblances between the wood of living Sequoias and the wood of the fossil genus, together with the marked abundance of species of Sequoia during Tertiary times make this seem very probable.

Six species are then described, three of which are considered to be new to science (*Cupressinoxylon glyptostrobinum*, *C. Mercklini*, and *Pityoxylon microporosum*). Three finely executed plates illustrate the structure of the wood.

Other papers were published during 1884 by Vater,[2] Solms-Laubach,[3] Hofmann,[4] and others.

In 1885 Dr. Conwentz described a collection of wood from the Rio Negro, in Patagonia,[5] which possesses features of interest. The species are mostly coniferous and are all new to science. They are distributed as follows: Cupressinoxylon, four species; Araucarioxylon, one species and Glyptostroboxylon, the latter a new genus. The single angiosperm is called Betuloxylon, under which it is proposed to include the genus Betulinium of Unger. A list of all the known species is given.

Renault contributed, also in 1885, a valuable paper on the structure and position of the genus Astromyelon.[6] It is illustrated by several fine plates.

In 1886 Dr. Felix published a continuation of his "Untersuchungen,"[7]

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[1] J. Schmalhausen. Beiträge zur Tertiärflora Südwest-Russlands. Palæontologische Abhandl. von Dames u. Kayser, vol. 1, Berlin, 1884, pp. 285-336, plates XXVIII-XLI.

[2] H. Vater. Die fossilen Hölzer der Phosphoritenlager des Herzogthums Braunschweig. Deutsch. geol. Gesell., Zeitschr., vol. 36, 1884, pp. 783-857.

[3] H. Graf zu Solms-Laubach. Die Coniferenformen des deutschen Kupferschiefers und Zechsteins. Palæontologische Abhandl. von Dames u. Kayser, vol. 2, Berlin, 1884, pp. 81-116, plates XII-XIV.

[4] Hermann L. Hofmann. Untersuchungen über fossile Hölzer. Inaug.-Diss. an d. Univ. Leipzig. Halle a S., 1884, pp. 1-44.

[5] Dr. H. Conwentz. Sobre algunos, árboles fósiles del Rio Negro. Academia Nacional de Ciencias en Córdoba (República Argentina), Boletin, vol. 7, Buenos Aires, 1885, pp. 435-456.

[6] B. Renault. Recherches sur les végétaux fossiles du genre Astromyelon. Annales des Sciences Géologiques, vol. 16, 1885, pp. 1-34, pl. 7-9.

[7] Dr. J. Felix. Untersuchungen über fossile Hölzer. Zweites Stück, Deut. geol. Gesell., Zeitschr., vol. 38, 1886, pp. 483-492, plate XII.

in which he describes six species, distributed as follows: *Pityoxylon inæquale*, from Alaska; *Pityoxylon Krausei*, from the Little Missouri, in Dakota; *Cupressoxylon erraticum*, Mercklin, from Copper Island, in Behring Strait; *Cupressoxylon*, cf. *sylvestre*, Mercklin, from Little Missouri, Dakota; *Laurinium Meyeri*, from New Guinea, and *Tænioxylon eperuoïdes*, from Negro Island, in the Philippines.

In a short paper[1] read before the American Association at the Buffalo meeting (August, 1886), Prof. E. W. Claypole reports the occurrence of *Dadoxylon antiquius* and *D. Newberryi* in the Carboniferous of Ohio. Other wood was found, but so poorly preserved as to be useless for purposes of determination.

Papers which were of less value were published by Blanckenhorn,[2] Beck,[3] and others.

To treat in anything like an exhaustive or satisfactory manner the elaborate memoir of Professor Williamson on the organization of the fossil plants of the coal measures, of which mention was made above, would require much more space than is at my disposal, and an analysis of the contents and value of one of them must be taken as a sample of all. These papers have appeared from time to time, since 1871, in the Philosophical Transactions of the Royal Society of London. The first is on the Calamites, a group of Carboniferous plants that has been in confusion from time immemorial. In the beginning Professor Williamson propounds four questions concerning this group, as follows:

1. Do all the well known plants hitherto designated Calamites belong to one natural family, or there are two groups of these objects—the one cryptogamic, represented by the true *Calamites*, and the other phanerogamic, and represented by the *Calamodendron* of Brongniart?

2. Are there several genera, divisible into numerous species, with well marked internal characteristics, or are there but few specific types, each of which, though they are all constructed upon one common plan, exhibits a wide range of variability in the details of its internal organization.

3. What are the casts commonly known as Calamites, and what parts of the plants do their varied superficial markings represent?

4. To what living plants are these fossil forms most closely related?

To all these questions the specimens in hand suffice to give answers, according to Williamson, who, after describing minutely the structure of his specimens, proceeds to draw the conclusions from them.

To the first question he replies that the Calamites are undoubtedly cryptogamic, but that they possess a much higher organization than is seen in any of the living cryptogams, and there is proof that they have an undoubted exogenous mode of growth.

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[1] E. W. Claypole. Preliminary note on some fossil wood from the Carboniferous of Ohio. Am. Assoc. Adv. Sc., Proc., vol. 35, 1886, pp. 219-220.

[2] Dr. Max Blanckenhorn. Die fossile Flora des Buntsandsteins und des Muschelkalkes der Umgegend von Commern. Palaeontographica, vol. 32, 1886, pp. 117-154, plates XV-XXI.

[3] Richard Beck. Beiträge zur Kenntniss der Flora des sächsischen Oligocäns. Deut. geol. Gesell., Zeitschr., vol. 38, 1886, pp. 342-352, plate VII.

To the second question he replies that we have two very distinct types of calamites clearly distinguished from one another by presence or absence of certain structural peculiarities.

The casts called Calamites he regards not as the result of filling up of cavities formed by decay, but by filling of cavities formed naturally by a process of absorbtion during the life of the plant.

That the modern Equisetaceæ are the only living representatives with which the Calamites can be compared he does not doubt.

Many elegant illustrations accompany the article.

In a similarly exhaustive manner are taken up the Lepidoendra, Sigillariæ, Asterophyllites, etc.

GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF THE POTOMAC FORMATION.

It is now necessary to discuss briefly the geological position and geographical distribution of the formation from which the wood herein described was obtained. This formation was described at length by Prof. W. B. Rogers in the annual report of the geological survey of Virginia for 1840,[1] where it was designated as the *Jurasso-Cretaceous* or Upper Secondary Sandstone. It is laid down upon the primary rocks along their eastern boundary in the State of Virginia and is in its turn overspread by undoubted Tertiary strata. The Potomac formation, the name by which it is now more generally known, is the one proposed by the U. S. Geological Survey to distinguish it as a local formation and to fix more definitely its position in the geological scale. From the palæobotanical evidence available in 1885 Mr. W. J. McGee considered it to be "Lower Cretaceous in age—the American equivalent of the European Neocomian."[2] Prof. William M. Fontaine, on the other hand, from an exhaustive study of the leaf and cone impressions, is inclined to regard it as belonging to the Wealden, while Prof. O. C. Marsh, who has studied the animal remains, regards it as Jurassic.

As to the nature of the material comprising this formation Rogers says:[3] "These strata consist of sandstones, slates, shales, and conglomerates, and, as might be anticipated, display much variety as to color, texture, and solidity." In and about the District of Columbia, Mr. McGee describes it as being composed of "mottled clays, gravels, and laminated sands and clays." It is thus observed to present considerable diversity of character and, as might be expected, offers in the different members very unequal conditions for preservation of organic remains. It attains in some instances, as along Potomac Creek, an observed thickness of from sixty to seventy feet, but in general the expos-

[1] See Geology of the Virginias, pp. 437–449. New York, 1884.

[2] The Geology of the District. The Evening Star, Washington, July 11, 1885.

[3] Op. cit., p. 442.

ures are much less than this, being rarely over thirty or forty feet. Its total thickness must be two hundred or three hundred feet, or even more.

The geographical distribution, both on the north and on the south, has been extended considerably beyond the points indicated by Professor Rogers. Thus the southernmost point at which the Potomac formation has been detected is Weldon, North Carolina, where it was observed by Messrs. McGee, Fontaine, and Ward, in July, 1885. From this point it extends almost directly north, occurring in irregular and scattered outcrops, to the Nottoway River, which was indicated as the southern limit by Rogers. From Petersburgh it extends northward in a narrow belt, offering good exposures on the Appomattox, James, South Anna, North Anna, Rappahannock, and Potomac Rivers. It touches the Potomac at Acquia Creek, and, extending up past Mount Vernon, which Rogers considered as the northern terminus, embraces a large portion of the District of Columbia. Thence it extends to Baltimore, where extensive outcrops containing abundant plant remains have been observed by Mr. McGee. The most northern point at which this formation has been identified by fossils is near Havre de Grace, at the head of Chesapeake Bay. This outcrop was visited by Messrs. McGee and Ward in 1885, and a few plant remains were obtained, but a more extended exploration is necessary to complete our knowledge of this locality. Quite recently gravelly deposits, evidently representing this formation, have been observed by McGee on the highlands of northeastern Maryland, northern Delaware, and southeastern Pennsylvania, overlooking Chesapeake and Delaware Bays, as far north as the Schuylkill River. It may yet be found that the Raritan clays of New Jersey rest conformably upon the Potomac formation, but of the truth of this we can only conjecture at present.

THE ORGANIC REMAINS AND THEIR MODE OF OCCURRENCE.

The organic remains of the Potomac formation occur principally in lenticular pockets of a hard, bluish clay, which bear evidence of having been transported in mass from the original bed in which they were laid down. These pockets vary in their dimensions, some being only a few feet in length and one or two feet in thickness, while others are two or three rods long and from three to ten feet thick. It is more than probable that originally this material was deposited in shallow water, which was fresh, or at most but slightly brackish. An unknown thickness, filled with the débris of vegetable growth, was here accumulated, after which there was a gradual uplifting of the land. This newly emerged land was now subjected to the powerful action of moving water, which cut down and transported a large portion of it, leaving now and then these irregular or lenticular masses, which were eventually surrounded and covered by a lighter material, and the whole was finally buried under the Tertiary.

Good exposures of this formation, containing lignite and silicified wood, occur at Fort Washington, White House Landing, and Acquia Creek on the Potomac; at Dutch Gap and vicinity, on the James River; and also in the cities of Washington and Baltimore, where excavations have been made. Cuts along the lines of railways which pass through this formation often give good sections. Most of the specimens described in the following pages came from these localities.

The wood of this formation occurs under two widely different conditions, viz: as lignite and as silicified wood. There seems to be almost no transition between the two forms, although in one instance, in a silicified specimen from the new reservoir, Washington, a few small lignitized areas were detected. There is reason for supposing, however, that some of the silicified forms are also represented in a lignitized state, that is, owing to different conditions of fossilization some specimens of a species were silicified, while others were turned to lignite.

The lignite is much more abundant than the silicified form, occurring in the above mentioned lenticular masses in pieces of considerable size and in the loose surrounding material as minute fragments, which shows that this latter is the result of the wearing away of a large part of the original deposit. One of the largest specimens noted was found at Fort Washington. This was a log about five feet in length, eight inches in width, and four in thickness. A cross-section of this specimen of course would have been lenticular, showing that it had been subjected to great pressure. A transverse section, as seen under the microscope, (Pl. I, Fig. 2), shows the cells completely collapsed and distorted by the pressure.

In color this lignite is almost uniformly jet black, in a few cases being of a slightly brownish cast. It has a specific gravity of about 1.333.[1] and breaks with a true conchoidal fracture like ordinary anthracite. When thus broken it does not exhibit superficially the slightest trace of organic structure (see Pl. I, Fig. 5 *c*), although careful microscopic examination of thin sections shows it to be generally present. It may, however, be split along certain lines, notably in a direction parallel to the medullary rays, where very plain structure shows superficially. Viewed as an opaque oөject (Pl. I, Fig. 5), the outlines only of the wood cells and medullary rays are detected.

Supposing a priori that all parts of this lignite must exhibit traces, at least, of organization, its intense blackness naturally becomes a serious obstacle in the way of a satisfactory examination, since, in order to make a successful study with the higher powers of the microscope the specimen must be thin enough to be viewed by transmitted light. An attempt was made to grind down sections, after the usual manner of cutting rock sections; but, even when the sections were so thin as to begin to break in fragments and be torn from the slide, they still remained too opaque for even a ray of light to pass through. Other

[1] Kindly determined for me by Mr. George P. Merrill, of the U. S. National Museum.

methods, as incineration, boiling in acids, etc., were equally unsuccessful. The method finally adopted, and which proved eminently successful, was that recommended by Griffith and Henfrey in their Micrographic Dictionary, second edition (p. 178), for the examination of coal. The specimens are macerated for a week or more in a strong solution of carbonate of potash, "at the end of which time it is possible to cut tolerably thin slices with a razor. These slices are then placed in a watch glass with strong nitric acid, covered, and gently heated; they soon turn brownish, then yellow, when the process must be arrested by dropping the whole into cold water, or else the specimen would be dissolved. The slices thus treated appear of a darkish amber color, very transparent, and exhibit the structure, where existing, most clearly." The specimens are then carefully washed in pure water and are best examined in glycerine, and may be mounted permanently in cells of this fluid.

The translucency obtained by this process is brought about by the dissolving out of the hydrocarbons by the potash. This shows that there can be little or no free carbon present, else it could not be dissolved by the liquids used. The intense yellow color produced is probably due to the presence of picric acid, of which, owing to its great coloring power, only a trace would be necessary.

The silicified wood occurs in situations similar to the lignite, but generally in larger pieces. One trunk seen by Messrs. McGee and Ward at the new reservoir, Washington, was about twenty feet below the surface and was reported to have been between thirty and forty feet long. It had a diameter of nearly two feet and was but slightly flattened. Other smaller specimens from the same locality were more flattened, and a transverse section as seen under the microscope shows the cells to be distorted by pressure. Generally, however, the tissue is very perfectly preserved in the silicified specimens and admits of careful dissection and study.

In color the specimens vary from almost white to jet black, sometimes showing a transition between the two colors in the same specimen. The only examples of a decided yellow were collected by W. J. McGee in a cut on the Baltimore and Ohio Railroad half way between Montello and Rives Station, D. C. These were small fragments; yet they have the structure very perfectly preserved in places.

The method employed in preparing these woods for study is that commonly followed in the preparation of petrographic specimens, viz: slicing and grinding to the requisite thinness and mounting in Canada balsam.

SYSTEMATIC DESCRIPTION OF LIGNITE.

A great many specimens of lignite have been examined by the process mentioned above—from Baltimore, from the new reservoir and vicinity, Washington, from Fort Washington on the Potomac, from the Dutch Gap on the James River, and from other localities throughout the area covered by this formation—and the result, although not as satisfactory as could be wished, is probably all that could be expected under the circumstances. The most casual examination shows that this material has been subjected to great pressure, which has so entirely crushed and distorted the cellular elements that it is difficult in many cases to recognize the original form. The examination of a large series of sections serves, however, to give a pretty correct general idea of it.

A transverse section like that given in Plate I, Fig. 2, shows the lumen of the cells to be almost entirely closed up by lateral pressure. This specimen, which was collected in the new reservoir, Washington, by Mr. McGee, is one of the best obtained. In most of those studied the pressure had seemingly been greater, and consequently the original outlines of the cells were more difficult of determination, as they had been crushed and crowded upon one another in great confusion.

A radial section shows the medullary rays to be in great abundance (Plate I, Fig. 3), and, like the wood cells, to have been considerably distorted by pressure. In a few cases some of the cells of the rays were filled, before being subjected to this pressure, with a hard substance, which was more resistant to pressure, and consequently they retain nearly their original form. The infiltration of this substance must have been quite accidental and without any regularity of action, since not one cell in twenty is thus preserved. The irregular distribution of these ray cells is shown by a glance at the tangential section (Plate I, Fig. 1). The number of cells entering into the composition of each ray varies considerably, ranging in vertical section from as few as two or three to as many as fifty or more. By this is to be understood the average of all the specimens examined. In some of the specimens, as for example those from the new reservoir, the rays are rarely ever more than twenty cells high, while in others there may be as many as forty or fifty. In most cases the rays are but one cell broad, although in a few instances sections have been obtained with the rays two cells broad. In one poorly preserved example there seemed to be several cells, perhaps as many as four, with a larger one in the center. This appearance may have been the result of pressure, and, if so, would of course have no value, but if natural it would indicate that the specimen belonged to the genus Pityoxylon. It was, however, too indefinite to be more than suggestive.

As for pits or markings on the rays, they seem to have been pretty generally wanting, or, at most, rarely to have been preserved in a satisfactory manner. They have been observed only in one instance (Plate I, Fig. 3 b), where only two pits or circular markings were noted. In radial sections the cells that have been filled with the harder substance present a slightly different appearance, being granular. I at first mistook this granulation for evidence of markings on the walls, but a more careful study convinced me that it was due to the above cause.

In tangential sections the medullary rays are seen to be very numerous, but this appearance is due partly to the collapsing of the wood-cells by pressure, by which they are made to occupy nearly one-third less space than when in a turgid condition, thus bringing a greater number of rays into the field at once. Most of the cells are crushed flat, only those above mentioned escaping.

In regard to the identification of this lignite it is manifestly impossible to attempt more than an indication of its general character and position. That it is coniferous is beyond question. The absence of wood elements other than tracheïds, which were provided in some cases at least with bordered pits, and the number and arrangement of medullary rays, make the coniferous nature clear. From the abundance of the genus Cupressinoxylon in the Potomac Formation, as shown by the silicified examples, it is probable that most of the lignite may be also of this genus, particularly as there is in many cases a marked resemblance, so far as I am able to interpret the distorted structure, between it and some of the species described from silicified specimens. This is, however, little more than conjecture.

The variation in height and in breadth of the medullary rays, as described above, indicates that several species, as species of fossil wood are understood, entered into the formation of this lignite. Whether these characters are of sufficient importance to merit specific distinction is a question still undecided.

SYSTEMATIC DESCRIPTION OF SILICIFIED SPECIES.

CUPRESSINOXYLON Göppert.

Cupressinoxylon[1] Göppert, Mon. foss. Conif., 1850, p. 196.

This genus, as it is now emended, is a somewhat comprehensive one, including, according to Kraus, what were regarded at one time as several distinct genera. Thus we have Thuioxylon of Unger and Endlicher, Physematopitys of Göppert, a part of Pinites of Göppert, and Peuce of Witham, all embraced under Cupressinoxylon. This modern extension of the generic characters in the study of fossil wood is the direct result of our more extensive and exact knowledge respecting the internal structure of living forms, for in this department, as in all the departments of paleontology, our knowledge of the fossil types is derived almost entirely from comparison with their most nearly related living representatives. As our knowledge of the internal organization of living conifers has been gradually worked out by Göppert, Kraus, Beust, and others, the fact has become more and more apparent that types founded upon these characters alone must be regarded in a measure as comprehensive; that is, species founded upon external characters may so much resemble one another in internal structure that it will be impossible to distinguish them; and in like manner what are regarded as genera may resemble one another to such an extent that, if we had

[1] There is a considerable diversity among authors as to the way this word is to be spelled, but I prefer to follow Göppert, not only because his name has the claim of priority, but because it is etymologically correct. The root is from the tribal name Cupressineæ, and not simply the generic word Cupressus.

them only in a fossil state, we should be obliged to refer them to a single type. We are able in all cases, however, to recognize families and tribes, and, as the above example is an extreme case, we are able to distinguish genera in many instances.

This looseness, or expansiveness, of structural characters does not by any means invalidate the results obtained from their study, for, as Williamson truly says, nothing can have the value that a study of internal organization has; "it is the basis upon which all recent botany should rest," and through it and by it must we seek for the explanation of many of the otherwise inexplicable problems of the origin of various types of vegetation and of the line of development that has been followed by them. If it can be shown that a number of species or genera have an identical or but slightly dissimilar cellular structure, then we have an argument that can not be controverted of their community of origin, for the characters drawn from leaves, flowers, or fruits, upon which recent species are founded, are the most plastic and those most readily modified by change of environment. The structural elements, on the other hand, are more permanent, and undergo change and modification much more slowly. As proof of the value of this method may be cited the now very generally acknowledged systematic position of the Coniferæ. Botanists have generally placed the Coniferæ between the monocotyledons and dicotyledons on account of their exogenous mode of growth, but paleobotanists have all along insisted that their true position was between the cryptogams and the phanerogams, and have substantiated their arguments by showing that there is a gradual transition from some of the higher cryptogams, which are only known in a fossil state, to undoubted conifers. So indistinct is this line of demarkation that many eminent paleobotanists have placed the Sigillariæ, which are now believed to be true cryptogams, among the Coniferæ.

The genus Cupressinoxylon is characterized by Kraus as follows:[1]

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 various specimens that I have examined from the Potomac Formation belong, with one exception, to this genus, which is the largest one founded upon internal structure. Most of the specimens are rather small, although a few, as for example, those from the new reservoir, Washington, are from trunks that were of very large size. In their structural details these specimens exhibit affinities with some described species, but as they differ in one or more of the characters that are considered of importance I have described them all as new. The view of this specific distinctness is still further strengthened by the fact that the species most nearly related to them come from different horizons and also from distant localities. The question of relationship will be discussed under each species.

[1] In Schimper: Traité, Pal. Vég. Vol. II, p. 374.

CUPRESSINOXYLON PULCHELLUM, n. sp.

Plate II, Figs. 1-4.

Description.—Annual ring moderately distinct, 1.25 to 3^{mm} broad; tracheïds small, rather thick walled, with bordered pits only on radial walls, these in a single row; medullary rays numerous, simple, 1 to 15 cells high; resin ducts numerous, of a chain of short thin walled cells.

The specimen upon which the above species is founded was collected by Mr. Ira Sayles, of the U. S. Geological Survey, at Spring Hill, on the bank of the Appomattox River, half way between Petersburg and City Point, Va. It is a perfectly silicified fragment about 12^{cm} in length and 8^{cm} in diameter. In transverse section the pith is very clearly observable, being a little to one side of the exact center of the specimen. The medullary rays show very distinctly even to the naked eye. The annual rings are much less distinct than the rays, but may be observed with a small hand-glass. The general color of the specimen is yellowish-gray, discolored in places by patches of black, due to the infiltration of iron.

Microscopic analysis.—Transverse section: As above stated, the pith is well preserved and is found to consist, when viewed under the microscope, of numerous large, rather thick walled cells, with an elliptic or nearly circular outline. The larger cells, which have a diameter of from $.05^{mm}$ to $.08^{mm}$, occupy the center, from which they decrease in size and pass more or less gradually into the medullary rays. The rays are very numerous and pass in nearly a straight line to the circumference. Unfortunately no trace of the bark remains. The tracheïds are arranged with great regularity in radial rows, and are remarkable for their small size, particularly where they are in contact with the pith. As the medullary rays diverge, new layers of tracheïds are intercalated to fill up the space, as shown in Plate II, Fig. 2. The line of demarkation between the annual layers is generally well defined, the fall wood (Herbstholz of the Germans) consisting of from five to eight compressed cells in each radial row. The spring wood (Frühlingsholz) consists of much larger cells, which have a diameter of from $.025^{mm}$ to $.035^{mm}$. These cells are more nearly hexagonal than the others, and decreasing gradually in size, pass into the next ring of fall wood.

Radial section: In this section the tracheïds are seen to be long and provided with a single longitudinal row of bordered pits, which have an average outer diameter of from $.017^{mm}$ to $.021^{mm}$. The inner circle of the pits is rather small, with a diameter of from $.005^{mm}$ to $.006^{mm}$. The medullary rays are cut up into comparatively short cells, each one covering the space of five or six of the tracheïds; markings seem to be absent from the walls of the rays, but the real state of affairs may be masked by the petrifying material, which has evidently somewhat disorganized the original structure. The resin ducts are numerous, as is shown by the presence of two in the section figured. (Pl. II, Fig. 1), These ducts (Harzzellen of the Germans; conduits résineux simples of the French) consist of a chain of short, regular cells, which are slightly constricted at the ends. The individual cells are from .08^{mm} to .15^{mm} in length, and are usually filled with minute globules of darker matter, represented by dots in the drawing.

Tangential section: In this section the medullary rays are seen to be very abundant. They are always simple and consist of a single layer, which ranges from 1 to 15 cells in height, the average number being about seven or eight. The tracheïds do not show bordered pits on the tangential walls, a fact of considerable importance.

There are points of resemblance between the Potomac form and the following described species: *Cupressinoxylon sylvestre* Mercklin (Palæodendrol. ross. p. 58, pl. xiii, figs. 1–6), *Cupressinoxylon Breverni* Mercklin (op. cit., p. 71), *Cupressinoxylon pachyderma* Göppert (Mon. foss. Conif., p. 199, pl. xxv, figs. 1–2), *Cupressinoxylon juniperinum* Göppert, *Thuyoxylum juniperinum* Nug., (Chlor. prot., p. 31), and *Cladocupressinoxylon Protolarix* Felix (Stud. üb. foss. Hölz., p. 46). These species all differ, however, in one or more characters, which are considered of taxonomic value, from the Potomac species, which I have consequently ventured to describe as new. More complete and perfect material may show the relationships to be closer than is now suspected; but even in that case it would be doubtful whether the species were identical, coming as they do from such widely different geological and geographical positions.

CUPRESSINOXYLON MCGEEI, n. sp.

Plate II, Fig. 5; Plate III, Figs. 1–5.

Description.—Annual ring very distinct, from 2^{mm} to 4.5^{mm} broad; tracheïds remarkably large, thick walled, closely covered with from one to three rows of large bordered pits on the radial walls and a few scattered ones on the tangential walls; medullary rays simple, from 2 to 49 cells high, covered on the lateral walls with numerous oblong pores; resin ducts simple, numerous, composed of a chain of thin walled cells.

The type of this species was collected by W. J. McGee, of the U. S. Geological Survey, from excavations made for the new reservoir of the water-works extension, Washington, D. C. It had originally a length of nearly forty feet and a diameter of almost two feet. It was somewhat flattened by pressure, the shorter diameter being considerably less than the longer. The trunk was exposed at a depth of about twenty feet below the surface, and must have belonged originally to a tree of large size. To the naked eye the annual rings are very indistinct. The medullary rays, however, are easily observed and are seen to pursue a very tortuous course, due, in part at least, to the dislocation caused by the pressure to which it had been subjected. The bark was not preserved in any of the pieces examined.

Microscopic analysis.—Transverse section: This section shows the tracheïds to be arranged in strict radial rows, and also indicates their great size. The annual ring, as above stated, is broad, consisting in some cases of as many as fifty or sixty of the larger and from ten to sixteen of the smaller thick-walled cells. The larger cells are mostly quadrangular in outline and have a diameter in some instances of .080^{mm}, the average being about .068^{mm}. The cells of the fall wood have very thick walls and are much flattened. Intercellular spaces are frequently observed, particularly where additional rows of tracheïds have been intercalated (Pl. III, Fig. 1. *c*). The medullary rays are moderately numerous.

Radial section: The large size of the tracheïds is very clearly shown in this section; most of which is made up of summer wood. The tracheïds in the fall wood are, of course, much smaller and are covered with but a single row of pits. The bordered pits are very close together on the summer wood and are always in two and in some exceptionally large cells in three rows. They are also very large, the outer circle having a diameter of from .020^{mm} to .025^{mm}, and the inner of from .005^{mm} to .008^{mm}. The walls of the medullary rays are marked by large oval pores, from one to three of which occupy the width of a single wood cell. These pores are about .015^{mm} in length and .010^{mm} in the short diameter. The resin ducts consist of a chain of short, small, thin walled cells, which now contain a small quantity of granular matter, representing probably the drops of resin. The individual cells have a length of from .12^{mm} to .25^{mm} and a diameter of about .05^{mm}, slightly less, it will be observed, than the tracheïds among which they run.

Tangential section: The medullary rays are always simple; that is, they consist of but a single row of cells, which varies from 2 to 49 cells in height. The tracheïds are provided on the tangential walls with a few scattered bordered pits. These have a diameter of from .016^{mm} to .021^{mm}.

This species, which I take pleasure in naming in honor of the collector, shows remarkable affinities with several species that have been described by Mercklin from the Tertiary of Russia. So close, indeed, is the resemblance that I was at first inclined to describe it under one of Mercklin's names, but a more careful examination has shown points of difference which seem to entitle it to specific rank. Thus *C. sequoianum* Mercklin, which has been reduced to a synonym of *C. pannonicum* by Felix (Die Holzopale Ungarns, 1884, p. 36), differs in size of the tracheïds and in the size and shape of the pits on the radial walls. The ray cells are also unlike in shape, and they differ in the number of cells that compose them. In *C. erraticum* and its variety *Teredinum* of Mercklin (Palæodendrol. ross., pp. 60–63, pl. xiv and xv) the individual resin cells are much larger and not at all constricted at the ends. The tracheïds are smaller and mostly provided with one and more than two rows of bordered pits. The pits on the walls of the medullary rays also differ in size and shape. There are also points of resemblance with *C. nodosum* Göppert (Mon. foss. Conif., p. 203, pl. xxviii, figs. 1-4) and *Peuce* (*Cupressinoxylon?*) *affinis* Unger (Chlor. prot., p. 36), but they are more remote and hardly worth consideration. Besides these variations in anatomic features there still remains the greater one of the difference in geologic horizon. *C. McGeei* comes from the Jurassic or the very lowest Cretaceous, while all of the above species are found in the Tertiary, and Kraus has given as his opinion that species can be very rarely traced from one formation to another without changes in form.[1]

CUPRESSINOXYLON WARDI, n. sp.

Pl. IV, Figs. 1-4; Pl. V, Figs. 1, 2.

Description.—Annual ring distinct, moderately broad; tracheïds medium in size, the radial walls bearing one, rarely two, rows of bordered pits; medullary rays two cells broad and from one to thirty-five cells high; resin ducts simple, not numerous.

This species is represented by specimens from the localities which have been designated by the letters A and B, respectively.

A. Several small fragments collected by W. J. McGee in a cut on the Washington Branch of the Baltimore and Ohio Railroad about half way between Montello and Rives Station, D. C. The largest piece is only 8^{cm} long, 6^{cm} wide, and 1^{cm} thick, and the others are much smaller. They are all very poorly preserved, and the structure can be made out only in a few favored spots.

B. A small piece, hardly 5^{cm} square, collected by Lester F. Ward from Freestone Cut, on the Neabsco Creek, Virginia. Like the other specimens, this is very badly preserved, and the structure has entirely disappeared in many places.

The specimens from both localities are yellow in color, and have the cavities in them filled with minute quartz crystals.

Microscopic analysis.—Transverse section: The fragments are all too small and too poorly preserved to show the annual rings to the naked eye, but under the microscope they are observed to be tolerably distinct. The ring of fall wood consists of from three to six or eight compressed cells in each radial row. The spring wood contains some very large cells, with a diameter in some instances of $.062^{mm}$. The number of cells in each row of tracheïds varies according to the width of the annual ring, there being frequently as many as one hundred. Large intercellular spaces occur particularly where additional rows of tracheïds have been introduced.

Radial section: In this section the tracheïds are shown to be provided with one row, or, in some rare instances, with two longitudinal rows of bordered pits. They occupy the center of the cell and are close together, almost touching in some cases. The larger have a diameter

[1] Kraus in Traité Pal. Vég., W. P. Schimper, Vol. 2, p. 368.

of .020^{mm}, and the smaller a diameter of .015^{mm}. The medullary rays consist of typical parenchymatous tissue. The individual cells are short, covering the width of from four to eight tracheïds. I have not been able to detect markings on the walls of the rays, but this may be on account of the poor state of preservation of the specimens. The resin ducts are not numerous. They are of nearly the same size and shape as the tracheïds, and in fact look very much like tracheïds with transverse partitions. They are almost always empty.

Tangential section: The tracheïds are not provided with pits on the tangential walls, or at least none have been detected. The medullary rays in many cases are two cells broad, and, as above indicated, from one to thirty-five cells high. The individual cells of the rays have a diameter of from .017^{mm} to .030^{mm}.

This species I take pleasure in naming in honor of Prof. Lester F. Ward, who collected the specimen from Neabsco Creek. It has, like the others, affinities with several described species, but the resemblances are too vague to suggest specific identity.

CUPRESSINOXYLON COLUMBIANUM, n. sp.

Pl. IV, Fig. 5; Pl. V, Figs. 3, 4; Pl. VI, Figs. 1-5; Pl. VII, Fig. 1.

Description.—Annual ring very broad, indistinct; tracheïds very thick walled, provided with one or two rolls of small pits; medullary rays consisting of one layer of small, thick walled cells, ranging from three to forty cells in height; resin ducts numerous, of a chain of short but thick walled cells.

This species is also represented by specimens from two localities.

C. A piece 15^{cm} long, 10^{cm} wide, and 5^{cm} thick, collected by W. J. McGee at the Dutch Gap Canal on the James River, about twenty miles below Richmond, Va.

D. Several larger pieces, some of them 25^{cm} long, collected by Prof. William M. Fontaine, of the University of Virginia, from "sandy clay, a little north of Mr. Kankey's house, near Neabsco Creek, Virginia." The specimens from both localities have been severely crushed by pressure and in places are much distorted. They are grayish in color, marked in places by streaks of black.

Microscopic analysis.—Transverse section: The annual ring is very indistinct, although not entirely absent, as I have observed slight traces of it among a mass of crushed cells. The tracheïds are arranged in very regular radial rows, and are remarkable for their nearly uniform size and thick walls. The larger cells are about .050^{mm} in diameter, the smaller from .030^{mm} to .040^{mm} in diameter. The medullary rays are not abundant and appear very narrow as seen in this section.

Radial section: The tracheïds are here seen to be thick walled and to be covered with one or rarely two rows of bordered pits, which are rather small. The larger pits have a diameter of .015^{mm} and the smaller a diameter of only .010^{mm}. The rays consist of long cells, in some cases provided with minute round punctations. Thus the specimen from Dutch Gap exhibits them in places, but the Neabsco Creek specimens show but slight traces of them. The resin ducts are numerous, two of them appearing side by side in a single figure (Pl. VI, Fig. 2). In most cases they consist of a regular chain of short cells constricted at the joints. The cells of the specimen from Dutch Gap are filled with a multitude of minute round globules. In the other specimen they are nearly empty.

Tangential section: The medullary rays are shown to have very small cells which have a long diameter of from .015^{mm} to .017^{mm} and a short diameter of only .010^{mm}; the walls of the tracheïds are so thick and the rays so small that the walls between which they appear are but slightly "bulged." The tracheïds do not exhibit pits on the tangential walls.

There are resemblances between this species and several other described species, but they are not of sufficient importance to require extended consideration, particularly as they occur in widely separated geologic and geographic positions.

ARAUCARIOXYLON Kraus.

Araucarioxylon Kraus, 1870–'72. In Traité Pal. Vég., W. P. Schimper, vol. 2, p. 380.
Araucarites Presl., 1820–'38. In Sternberg's Vers., vol. 2, p. 203.
Pinites Witham, 1833. Int. Struct., Foss. Veg., etc., p. 72.
Dadoxylon Endlicher, 1847. Synop. Conif., p. 298.
Pissadendron Endlicher, 1842. Gen. Plant. Suppl., vol. 2, p. 27.
Palæoxylon Brongniart, 1849. Tableau des genres de végétaux fossiles, p. 77.

ARAUCARIOXYLON VIRGINIANUM n. sp.

Plate VII, Figs. 2–5.

Description.—Annual ring very indistinct, about 2^{mm} broad; tracheïds bearing one or two rows of hexagonal pits on the radial walls; medullary rays simple, of from 1 to 27 superimposed cells; resin ducts none.

This species, the only one of the genus that has been found in the Potomac formation, was collected by W. J. McGee, at Taylorsville, Va. It is a small piece, only about 10^{cm} long and 6^{cm} square, and is grayish in color. The structure is very well preserved, although somewhat disorganized in places by the process of silicification.

Microscopic analysis.—Transverse section: The annual ring is not perceptible to the naked eye, but when a thin section is examined under the microscope it is observed to be present. The actual ring or line of demarkation between the layers consists of only three or four rows of slightly smaller and thicker walled cells. In the living species of Araucaria the annual ring is usually indistinct and not infrequently entirely absent, both conditions sometimes obtaining in different parts of the same plant.

The tracheïds are prominent and have rather thick walls. The individual cells have a diameter in some instances of .051^{mm}, the average being perhaps .0375^{mm}. They are arranged in radial rows, which are most pronounced in proximity to the medullary rays. In places when additional layers of cells have been intercalated, considerable intercellular spaces have been left that are now filled with nearly transparent silica.

Radial section: The radial walls are the only ones observed to bear bordered pits. The number of rows vary, even on the same cell, from one to two. When there is but one row they occupy the center of the cell and are in contact. They are then nearly circular in outline, and have a diameter of from .017^{mm} to .020^{mm}. When there are two rows they are in contact and alternate with each other, and have a nearly regular hexagonal outline. These hexagonal pits have a diameter of from .016^{mm} to .021^{mm}. The inner pore is very small, being only about .0025^{mm} to .0030^{mm} in diameter.

Tangential section: The rays as seen in transverse section are shown to be single and to range from one to twenty-seven cells in height, the average number being about ten or twelve.

There have been thus far about forty species characterized from the wood which are now referred to the genus Araucarioxylon. This genus, as now emended, is of very great antiquity, having had its origin in the Middle Devonian, from which Dawson has described five species in this country, and has continued uninterruptedly to the Lower Miocene, from which several species are known. The living species, which show remarkable affinities with some of the fossil forms, are undoubtedly the lineal descendants of the ancient line. The antiquity is further confirmed by the number of species that have been described from leaf or cone impressions. According to Zincken, thirty-eight species have been reported from below the Carboniferous, forty-two from the Carboniferous proper, ten from the Triassic, eighteen from the Jurassic, ten from the Cretaceous, and one from the Tertiary. Some of these latter species may represent the branches or cones of some of the forms described from the wood alone, but we are at present unable to correlate them, and probably shall always remain so. It would be very satisfactory if we could correlate many of these supposed identical forms, for by so doing the number of paleontologic criteria would be reduced, and their value as stratigraphic marks proportionately enhanced. However, we must take them as they are and look to more careful research in the future to supply, if possible, the links.

In indicating that the above species is new to science I have followed the method of exclusion adopted by Beust in his admirable paper on the Fossil wood of Greenland.

Taking the markings on the wood cells and the height and the breadth of the medullary rays as the most important diagnostic characters, an examination of the described species gives the following results;

Species which have but one longitudinal row of bordered pits:

Araucarites Edwardianus Göpp.
Araucarites Keuperianus Göpp.
Araucarites stellaris Göpp.
Araucarites Schrollianus Göpp.
Araucarites orientalis Göpp.
Araucarites biarmicus Kut.
Araucarioxylon Schmidianum Fel.
Dadoxylon subrhodeanum Grand'Eury.

Species bearing from two to three rows:

Araucarites Rollei Göpp.
Araucarites Valdejolensis Mougeot.
Araucarites subtilis Mercklin.
Araucarites materiarum Göpp.
Araucarites Brandlingi Göpp.
Araucarites carbonaceus Göpp.
Araucarites argillicola Eichw.
Dadoxylon annulatum Dawson.
Dadoxylon antiquius Dawson.

Species having one to three or more rows:

Araucarites Ægyptiacus Göpp.
Araucarites Saxonicus Göpp.
Araucarites medullaris Göpp.
Araucarites cupreus Göpp.
Araucarites permicus Mercklin.
Araucarites Beinertianus Göpp.
Araucarites Tchihatcheffianus Göpp.
Araucarites acadianus Göpp [*Dadoxylon* Dawson].
Araucarites ambiguus Göpp.
Araucarites Richteri Göpp.
Araucarites pachytichus Göpp.
Araucarites Stigmolithos Göpp.
Dadoxylon intermedium Grand'Eury.
Pitys With. et Lindl.

It now remains to examine such as have from one to two rows of bordered pits, and to show the points of variation between them and the Potomac species:

Araucarites Kutorgæ Mercklin From the Permian of Russia. The medullary rays consist of from 4 to 15 cells.

Araucarites vogesiacus Göpp. From the Lower Carboniferous of Niederburbach. Cells of the ray from 1 to 20.

Araucarites stephanense Grand 'Eury. From the Carboniferous of France. This species has the rays only 1 to 3 cells high.

Araucarioxylon Heerii Beust. From the Lower Miocene of Greenland. Ray cells from 1 to 82 in number.

Araucarioxylon Rhodeanum Göpp. From the Permian of Silesia. The rays are composed of two rows of cells.

It will be observed from this list that the species with which our plant shows the greatest affinity are all from the Carboniferous or the Permian of Europe; but it would be unreasonable to suppose, provided the identity was close, that any of them had continued unchanged from the Carboniferous to the Potomac formation, for, as before stated, species rarely pass unchanged from one formation to another.

These considerations teach us that the species under discussion differs in essential points from any that have heretofore been described. I have named it *Araucarioxylon Virginianum*, from the State in which it was obtained.

PLATES.

PLATE I.

PLATE I.

FIGS. 1–5. Lignite.

FIG. 1. From the new reservoir, Washington.

Tangential section. *a*, *a*, *a*, cells of medullary rays filled with hard, black substance. × 67.

FIG. 2. From the new reservoir, Washington.

Transverse section. *a*, distorted medullary ray. × 242.

FIG. 3. From the new reservoir, Washington.

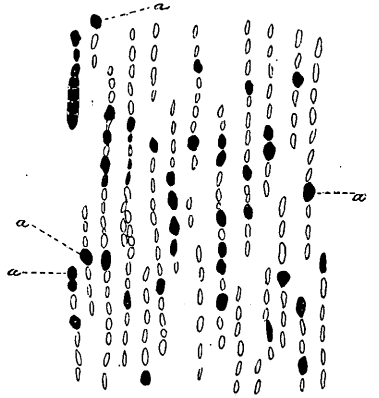
Radial section. *a*, bordered pit on well-preserved tracheïd; *b*, two small pits on medullary ray. × 242.

FIG. 4. Source unknown.

Tangential section, showing two badly crushed and distorted medullary rays. × 242.

FIG. 5. From Neabsco Creek, Va.

Natural size. *a*, annual rings; *b*, traces of medullary rays; *c*, surface exhibiting conchoidal fracture and no trace of structure.



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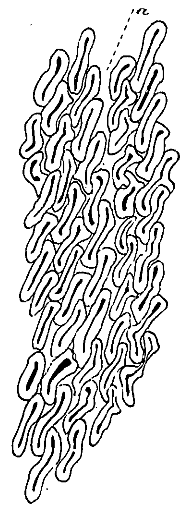

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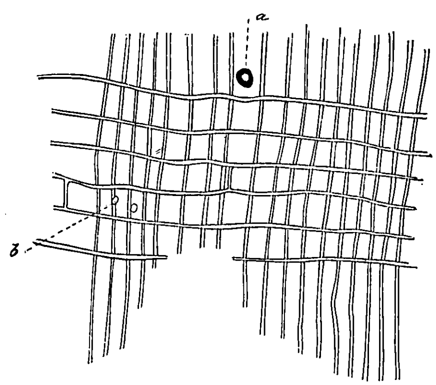

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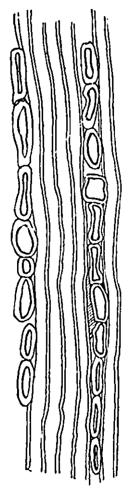

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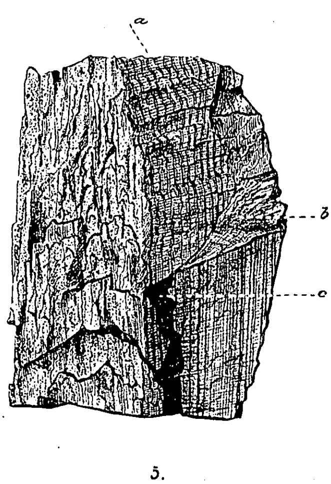

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PLATE II.

PLATE II.

FIGS. 1–4. *Cupressinoxylon pulchellum*, n. sp. From Spring Hill, on Appomattox River Va.

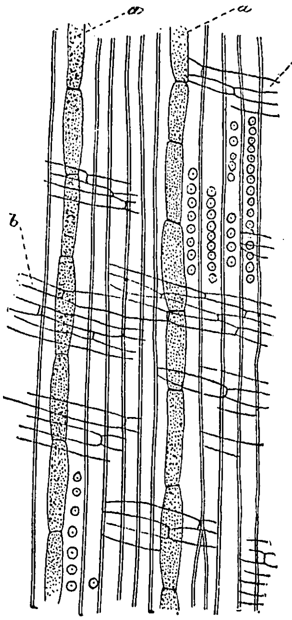
FIG. 1. Radial section. *a*, *a*, resin-ducts; *b*, *b*, medullary rays. × 67.

FIG. 2. Transverse section. *a*, *a*, medullary rays; *b*, fall wood; *c*, spring wood. × 67.

FIG. 3. Transverse section of pith. *a*, *a*, cells of pith; *b*, *b*, medullary rays; *c*, tracheïds in contact with pith. × 67.

FIG. 4. Tangential section. *a*, medullary ray of single cell. × 67.

FIG. 5. *Cupressinoxylon McGeei*, n. sp. From the new reservoir, Washington, D. C. Radial section. *a*, point at which the structure has disappeared; *b*, *b*, medullary rays, mostly showing oblong pores. × 67.



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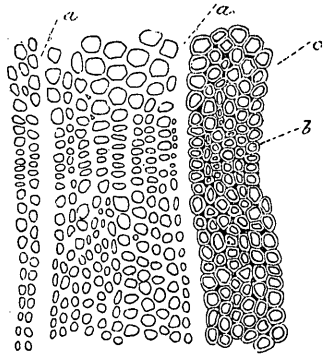

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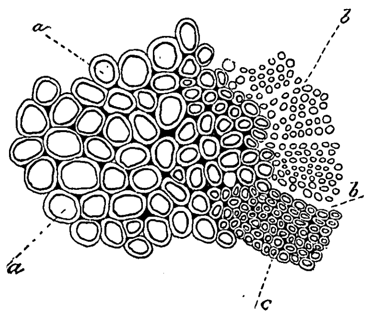

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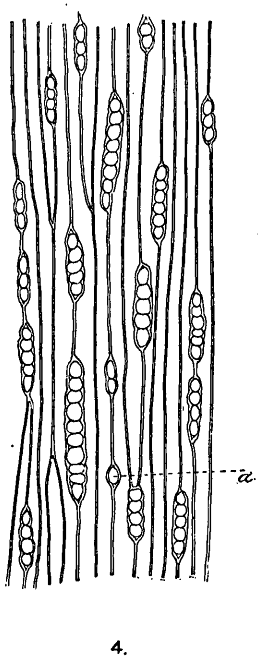

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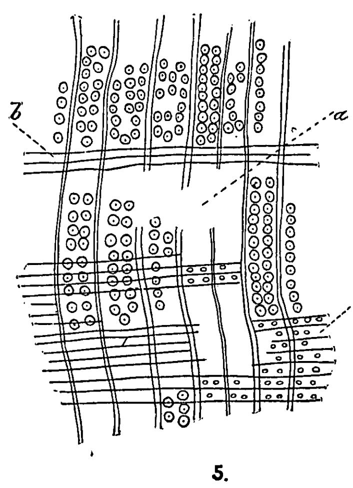


5.

PLATE III.

PLATE III.

FIGS. 1–5. *Cupressinoxylon McGeei*, n. sp. From the new reservoir, Washington, D. C.

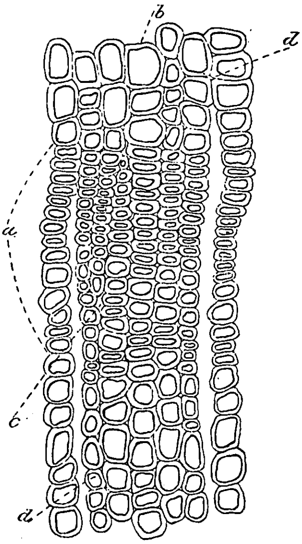
FIG. 1. Transverse section showing annual ring. *a*, cells of fall wood; *b*, typical cell of spring wood; *c*, large intercellular space; *d*, *d*, smaller intercellular spaces. × 67.

FIG. 2. Tangential section. *a*, resin-duct; *b*, *b*, bordered pits on tangential walls; *c*, sections of pits on radial walls. × 67.

FIG. 3. Radial section. Same section as Fig. 5, Pl. II. × 242. *a*, *a*, pits on walls of medullary rays; *b*, *b*, pits on walls of tracheïds.

FIG. 4. Transverse section further enlarged. *a*, medullary ray; *b*, *b*, cells of spring wood; *c*, section of pits on radial walls; *d*, section of pits on tangential wall. × 242.

FIG. 5. Tangential section. *a*, resin-duct; *b*, *b*, bordered pits on tracheïds; *c*, *c*, bordered pits on resin-duct connected by spiral lines.



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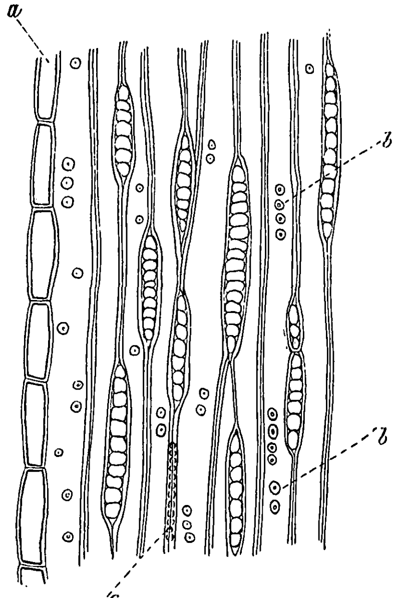

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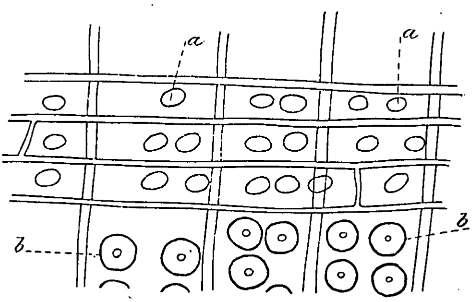

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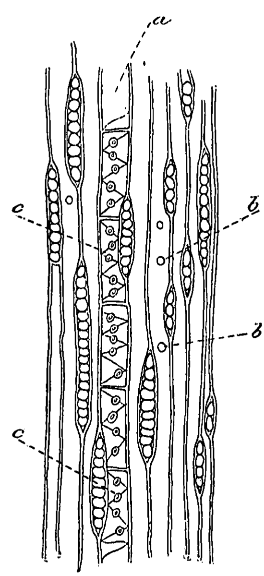

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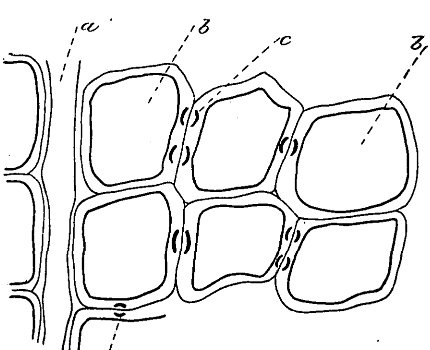


4.

PLATE IV.

PLATE IV.

FIGS. 1–4. *Cupressinoxylon Wardi*, n. sp.

FIG. 1. From Neabsco Creek, Va. Transverse section through annual ring. *a*, cells of fall wood; *b*, cells of spring wood; *c*, *c*, *c*, large intercellular spaces. × 67.

FIG. 2. From cut on B. & O. R. R. Tangential section. *a*, resin-duct; *b*, medullary two cells broad. × 67.

FIG. 3. From cut on B. & O. R. R. Radial section. *a*, *a*, medullary rays; *b*, single row of pits on tracheïds. × 67.

FIG. 4. From cut on B. & O. R. R. Transverse section further enlarged. *a*, cells of small annual ring; *b*, medullary ray; *c*, hexagonal cavity in the silica which fills the cell. × 242.

FIG. 5. *Cupressinoxylon Columbianum*, n. sp.

From Neabsco Creek, Va. Transverse section showing resin-duct, *a*. × 242.

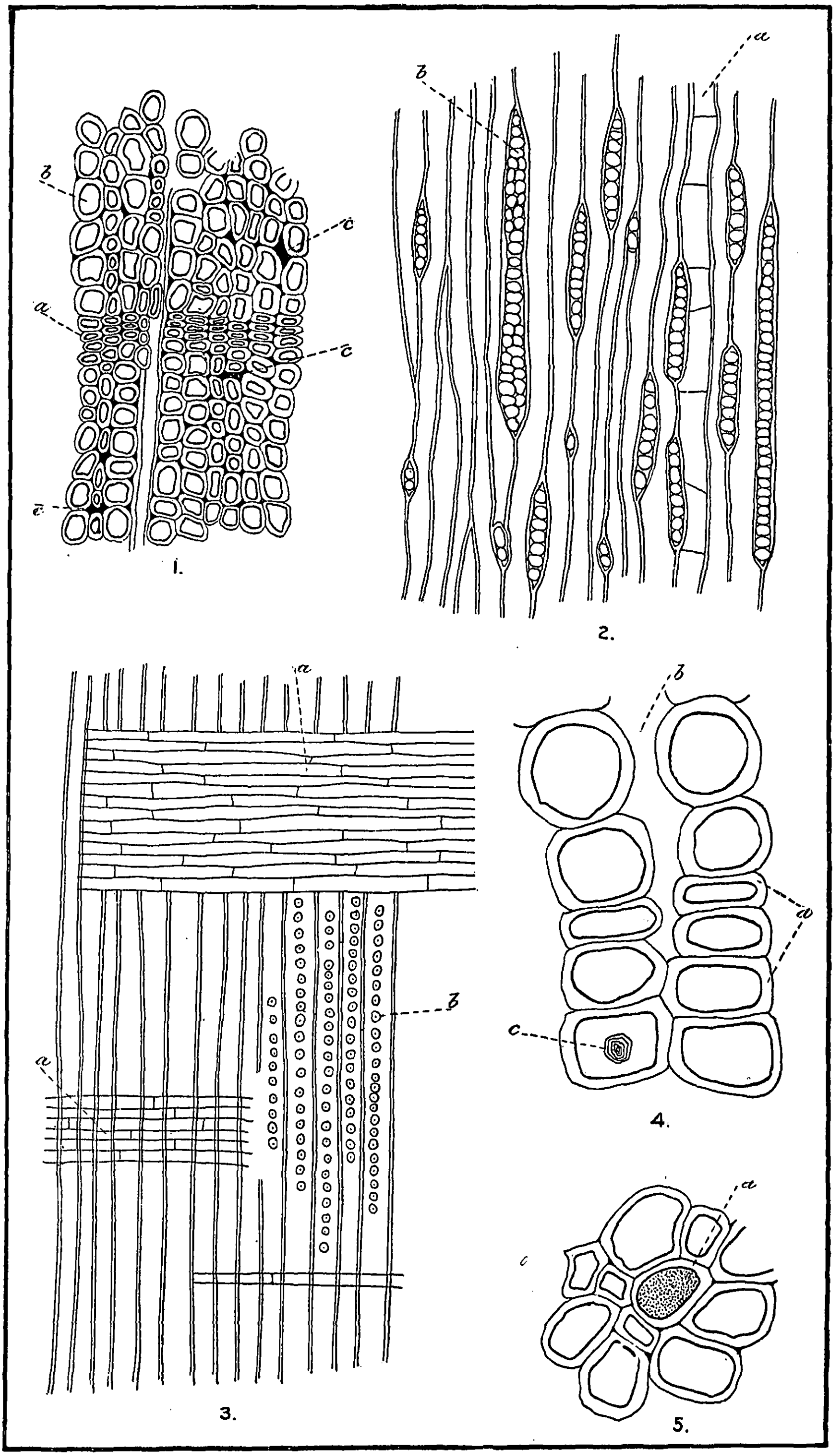

b
a
c
c
c
1.
a
b
2.
a
a
b
3.
b
a
c
4.
a
5.

PLATE V.

PLATE V.

FIGS. 1, 2. *Cupressinoxylon Wardi*, n. sp.

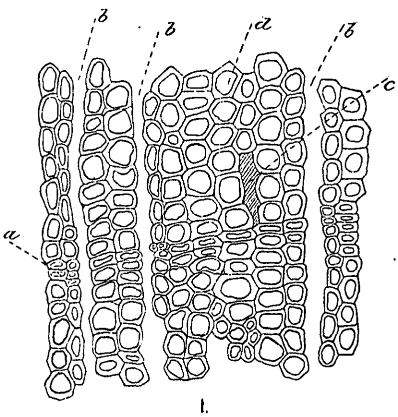
FIG. 1. From cut on B. & O. R. R. Transverse section through annual ring. *a*, cells of fall wood; *b*, *b*, *b*, medullary rays; *c*, very large intercellular space. × 67.

FIG. 2. From Neabsco Creek, Va. Radial section. *a*, medullary ray; *b*, tracheïd with two rows of bordered pits. × 67.

FIGS. 3, 4. *Cupressinoxylon Columbianum*, n. sp.

FIG. 3. From Neabsco Creek, Va. Radial section. *a*, resin-duct; *b*, *b*, medullary rays. × 67.

FIG. 4. From Dutch Gap Canal, Va. Tangential section. × 67.



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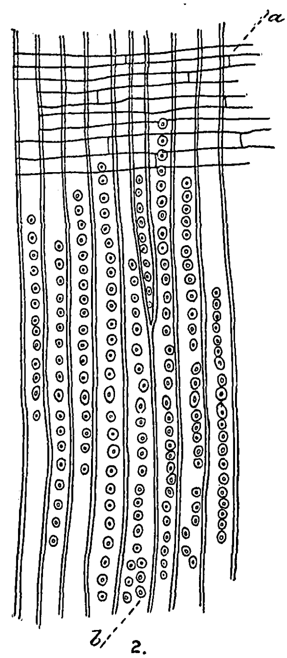

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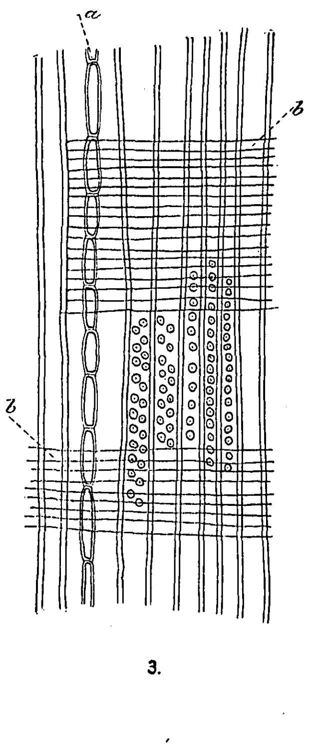

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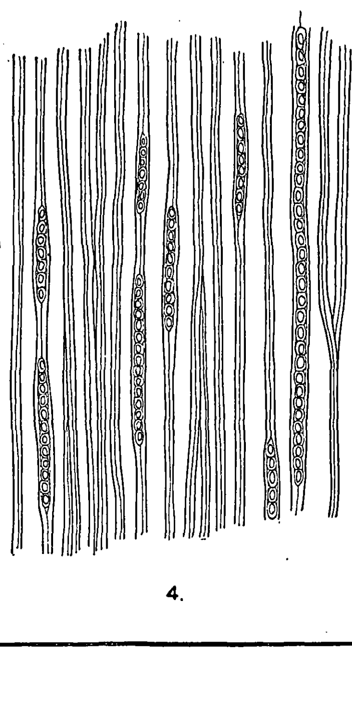


4.

PLATE VI.

PLATE VI.

FIGS. 1–5. *Cupressinoxylon Columbianum*, n. sp. **From Dutch Gap Canal, Va.**

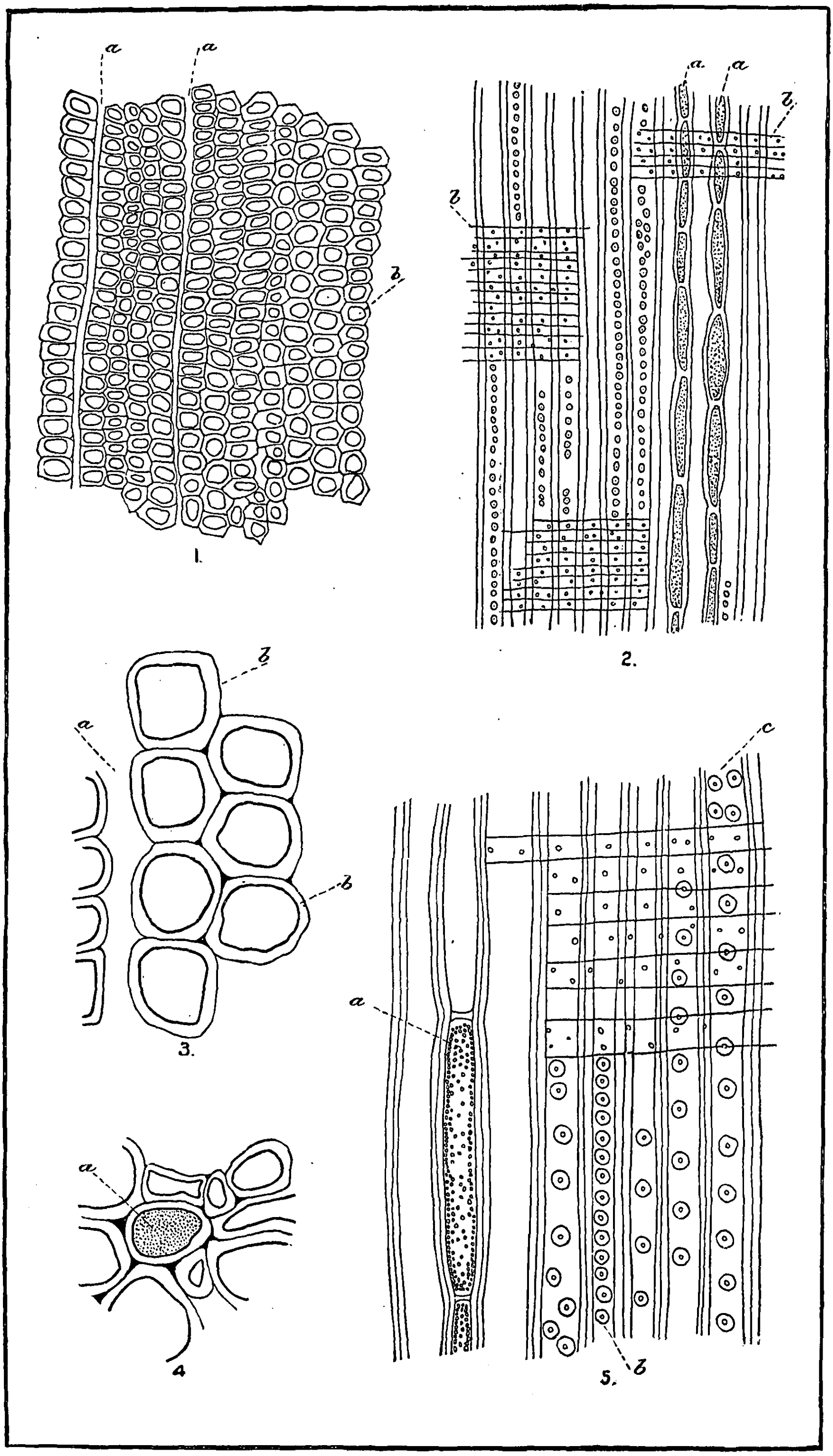
FIG. 1. Transverse section. *a*, *a*, medullary rays; *b*, typical tracheïds. × 67.

FIG. 2. Radial section. *a*, *a*, resin-ducts; *b*, *b*, medullary rays. × 67.

FIG. 3. Transverse section further enlarged. *a*, medullary ray; *b*, *b*, typical cells of spring wood. × 242.

FIG. 4. Transverse section of resin-duct, *a*. × 242.

FIG. 5. Radial section further enlarged. *a*, cell of resin-duct filled with minute globules of resin; *b*, tracheïd with a single row of bordered pits; *c*, tracheïd with two rows of bordered pits. × 242.


a
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b
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b
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b
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b
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c
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b

PLATE VII.

PLATE VII.

FIG. 1. *Cupressinoxylon Columbianum*, n. sp. From Neabsco Creek, Va. Tangential section. × 67.

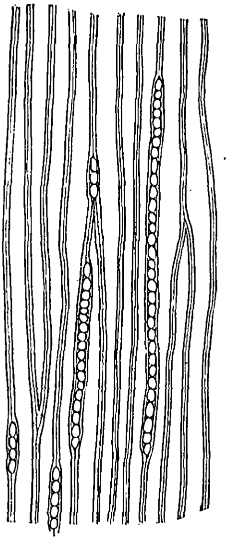
FIGS. 2–5. *Araucarioxylon Virginianum*, n. sp. From Taylorsville, Va.

FIG. 2. Radial section. *a, a*, medullary rays; *b*, tracheïds with two rows of hexagonal pits; *c*, walls of tracheïds dislocated by pressure. × 67.

FIG. 3. Transverse section. *a, a, a*, medullary rays; *b, b*, intercellular spaces. × 67.

FIG. 4. Tangential section. *a*, sections of bordered pits on radial walls. × 67.

FIG. 5. Radial section further enlarged. *a*, single row of rounded pits; *b*, double row of hexagonal pits. × 242.



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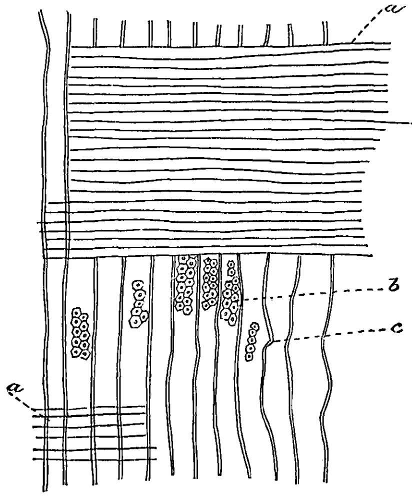

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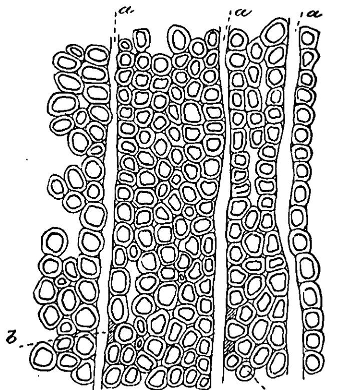

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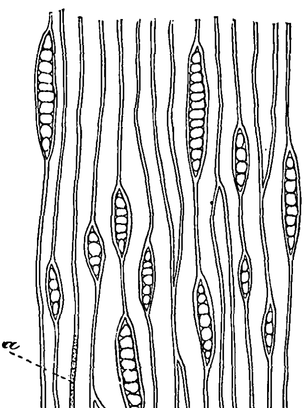

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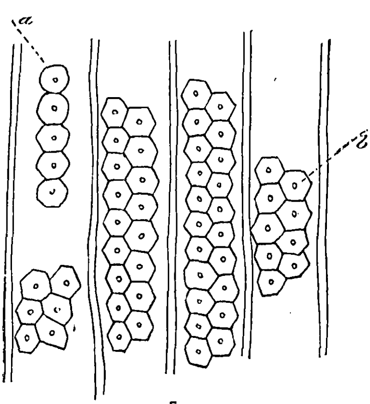

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