

A Cretaceous *Pityoxylon* with Marginal Tracheides.¹

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With Plate XXVI.

IN their description of succiniferous *Pityoxyla* from the Cretaceous of Staten Island and Scituate, Jeffrey and Chrysler called attention to the fact that the wood of the pinelike Conifers of the Mesozoic, unlike that of the modern members of the genus, is characterized by the absence of ray tracheides. This condition was considered ancestral, inasmuch as among living pines ray tracheides do not occur in regions of phylogenetic significance, namely, the cone axis and the earliest formed wood of the stem. It was further inferred by the writers that the evolution of these structures, occurring in all probability in the Tertiary, explains the greater development of the genus in recent geological times.

In view of this well-marked peculiarity of the pines which antedate the Tertiary, the occurrence of ray tracheides in a *Pityoxylon* from the Upper Cretaceous of Morgans, New Jersey, specimens of which have been submitted to me for investigation, is of interest in affording a connecting link between modern pines and their Mesozoic ancestors.

ANATOMICAL STRUCTURE OF THE SPECIMEN.

The material in the form of lignite consisted of one large fragment, about 30 cm. long, 10 cm. wide, and 8 cm. thick, and several smaller pieces. The former, the core of a larger stem which had been flattened by lateral pressure, exhibited in selected areas an admirable state of preservation. A small lateral branch, which fortunately possessed a well-preserved medulla and brachyblasts or short shoots, was embedded in this fragment, and together with the other anatomical characters present in the lignite affords conclusive evidence of the affinities of the specimen.

Fig. 1, Pl. XXVI, shows the structural features of the larger fragment in transverse section. The annual rings are distinct and conspicuous, as is the

¹ Contributions from the Phanerogamic Laboratories of Harvard University, No. 41.

² Jeffrey, E. C., and Chrysler, M. A. : On Cretaceous *Pityoxyla*. Bot. Gaz., vol. xlii, July, 1906, pp. 1-15.

case in living pines. The abrupt transition from small thick-walled summer tracheides of one annual ring to the larger thin-walled spring tracheides of the succeeding ring is clearly shown at the base of the figure, and the more gradual transition from spring to summer tracheides which takes place during the year's growth may be seen in the annual ring in the central portion of the photomicrograph. The resin canals, which are occluded by numerous tyloses, are surrounded by large masses of thick-walled and highly resinous parenchyma cells, a feature which is without parallel among living pines, but which greatly resembles the condition found by Jeffrey and Chrysler in *Pityoxylon scituatense*.

Fig. 2 shows a resin canal under higher magnification, and illustrates more clearly the thick-walled character of the parenchyma cells and their dark resinous contents.

In these photomicrographs it may be noted that the wood rays contain the resinous substance, and that cells adjacent to them are frequently filled with it. The latter, however, are not wood parenchyma, since they possess bordered pits, but are tracheides into which a portion of the resinous contents of the adjacent ray parenchyma cells has been poured. That this is the case is clearly shown by longitudinal sections, in which the resinous matter may be found passing through the ray pits into the neighbouring tracheides. This appears to take place by means of tyloses more or less completely filled with resinous secretions. Chrysler¹ in his study of the occurrence of tyloses in the tracheides of Conifers came to the conclusion that they occurred only in *Pinus*, in the heartwood of the root and in the cone axis. Since these regions are often the seat of ancestral or primitive characters, the occurrence of tyloses in the stem of a Cretaceous *Pityoxylon* seems to indicate that these structures are ancestral, and occur only in primitive regions of modern pines. This conclusion, however, is not entirely substantiated by a study of the stem wood of living pines, as I have found indications of tyloses in the tracheides of several species. Fig. 5, a transverse section, illustrates the occurrence of tyloses in the stem wood of *Pinus Strobus*, L.

Fig. 3 shows the tangential section of the lignite under a low magnification. The rays are obviously of two kinds, linear and fusiform, which are characteristic of *Pityoxylon*, Kraus. The fusiform rays are seen to contain horizontal resin canals, occluded by numerous tyloses. The highly resinous character of the ray parenchyma is clearly shown in this section, and it may be noted that the walls of the tracheides have been crushed together by lateral pressure, whereas the ray parenchyma cells have retained their natural form. This condition is probably accounted for by the resinous contents of the rays.

¹ Chrysler, M. A.: Tyloses in the tracheides of Conifers. The New Phytologist, vol. vii, No. 8.

Fig. 4 shows the tangential section under higher magnification, and illustrates with greater distinctness a portion of the structures shown in Fig. 3. It may be noted that the marginal cells of the linear ray in the central portion of the figure are narrower and devoid of resinous contents. Similarly, two cells of the next ray to the left are of small size and without the dark-coloured substance which fills the ray parenchyma cells. This is in marked contrast to the other Cretaceous *Pityoxyla*, especially *Pityoxylon statenense* and *P. scituatense* of Jeffrey and Chrysler, in which the marginal cells are not noticeably narrower than the central cells of the ray. In radial section the cells are seen to be ray tracheides, *since bordered pits occur between adjoining cells of this form, and half-bordered pits between these cells and the succiniferous ray parenchyma cells.*

Fig. 6 shows in radial section a linear ray composed of succiniferous ray parenchyma and ray tracheides. The latter, which occur in the middle of the ray, are noticeably narrower than the ray parenchyma cells, and possess bordered pits between their end walls. The lateral pits of the ray parenchyma cells are seen with difficulty in this photomicrograph owing to the resinous character of the cells, but are narrow lenticular openings, with circular borders on the tracheide side. This type of pit, which occurs characteristically in all Abietineous Conifers with the exception of certain large pitted and highly specialized modern pines (see Figs. 11 and 12), has been conveniently called 'piciform'. In the *Pityoxylon* under consideration in this article, the pits, although variable in size and somewhat larger than the most primitive type (see Fig. 10), are uniformly distributed, one to each crossing field. Fig. 7, a radial section of the root wood of *Pinus Taeda*, L., illustrates pits of similar size, shape, and structure, and in the central portion of the photomicrograph the distribution, one pit to each crossing field, is also similar.

The sclerified condition of the pith is shown in Fig. 8, a longitudinal section of the small branch found embedded in the larger fragment of lignite. The clusters of sclerenchymatous cells are arranged in more or less well-defined horizontal bands.

Fig. 9 shows a cross section, cut near the base of one of the brachyblasts or short shoots. Clusters of sclerenchymatous cells, such as occur in the pith of the branch, are also present in the medullary tissue at the base of these structures. The short shoots are thicker and shorter than those of most species of living pines.

THE IDENTIFICATION OF CONIFEROUS WOODS.

With this consideration of the salient anatomical characters of the lignite, we may turn to a consideration of the affinities of the specimen. One of the earliest scientific classifications of coniferous woods, and one which in its main features has been adopted by most modern anatomists

and palaeobotanists, was advocated by Kraus,¹ and divides the Conifers into five distinct groups or 'genera', separated by marked structural differences. The 'genus' *Araucarioxylon*, framed to include the Araucarian Conifers, of which *Agathis* and *Araucaria* are living representatives, possesses closely approximated and mutually flattened bordered pits in the radial walls of the tracheides, pits which when in more than one row alternate with one another. The remaining Conifers in contrast to this possess unflattened and non-alternating or opposite pits. Of the four genera which occur in this general group, the most distinctive is *Pityoxylon*, which possesses resin canals and is represented among living Conifers by *Pinus*, *Picea*, *Larix*, and *Pseudotsuga*. *Taxoxylon*, with *Taxus* for its type, possesses throughout the year's growth tracheides with well-developed tertiary spiral thickenings. *Cedroxylon*, represented by *Cedrus* and allied forms, is separated less easily from *Cupressoxylon* (*Cupressinoxylon*), which includes the Cupressineae and Taxodineae, &c., but in contrast to the latter is characterized by the absence or feeble development of resin parenchyma.

According to the classification of Kraus, our lignite would undoubtedly be classified under *Pityoxylon* since it possesses well-developed resin canals.

The 'genera' of Kraus have been somewhat modified by Gothan² who points out that the distribution of resin parenchyma is not a satisfactory criterion upon which to separate *Cedroxylon* and *Cupressinoxylon*, since abundant resin parenchyma occurs in certain forms commonly referred to the former. He asserts that the Abietineae possess a distinctive type of pitting (*Abietineentüpfelung*) which he uses as a diagnostic character in separating the two 'genera'. The latter 'genus' is divided by him into five divisions upon the basis of differences in ray pitting. Similarly, *Pityoxylon* is divided into *Pinuxylon*, to which are assigned the ligneous characters of living pines, and *Piceoxylon*, which includes *Picea*, *Larix*, *Pseudotsuga*, and similar forms.

The classification of coniferous woods as originally framed by Kraus, and as modified by Gothan and others, affords from the point of view of the anatomy of modern representatives a satisfactory basis for dividing Conifers into natural groups of closely related forms. In addition it has been customary in the past to study the affinities of the ligneous remains of primitive Conifers by similarity of structure with the genera of Kraus. Thus the absence of so-called Araucarian pitting has been considered a sufficient criterion for excluding relationship with the Araucarian Conifers. The occurrence of heavily pitted ray parenchyma and resin canals has been taken as conclusive evidence of relationship with the Abietineae, &c.

¹ Kraus, G., in Schimper's *Traité de paléontologie végétale*, Bd. v, pp. 363-85.

² Gothan, W.: *Zur Anatomie lebender und fossiler Gymnospermen-Hölzer*. *Abhandl. der königl. preussisch. geolog. Landesanstalt, Neue Folge*, Heft 44, Berlin, 1905, pp. 101-103.

However, a review of recent investigation upon the coniferous remains of the American Cretaceous, and a study of the comparative anatomy and phylogeny of modern and fossil Conifers, leads to the conclusion that in the identification of the fossil remains of primitive Conifers, the structural characters which separate the 'genera' of Kraus are not of constant diagnostic value, and may be utilized only in connexion with numerous other anatomical features in the study of the affinities of ancestral forms.

Thus, for example, the Araucarineae, which have been considered an isolated group of Conifers,¹ are represented in the American Mesozoic by forms which possess well-developed Abietineous structures. *Brachyoxylon*, described by Hollick and Jeffrey,² from the Cretaceous deposits of Kreiserville, comprises several genera of Araucarian Conifers which differ from modern members of the family in the scarcity of alternating pitting and in the presence of numerous traumatic resin canals. *Araucariopitys*,³ although an undoubted Araucarian Conifer, approaches even more closely to the structures of the Abietineae, since it possesses short shoots, thick-walled and heavily pitted ray parenchyma (*Abietineentüpfelung*), scarcity of alternate pitting, and traumatic resin canals. More recently Sinnott has described⁴ an Araucarian Conifer from the Cretaceous of Scituate, Mass., in which the bordered pits of the radial walls of the tracheides occur in a single row, and only infrequently are the pits flattened somewhat by mutual contact. Evidently there exists then a strong similarity between the ligneous characters of the older Araucarian Conifers and the Abietineae.

The difficulty in separating the wood of living forms included under *Cedroxylon* and *Cupressinoxylon* has been referred to above. We are not able to follow Gothan, who separates the genera upon the basis of ray pitting, since his so-called 'Abietineentüpfelung', which occurs in the primitive Araucarians, is nearly identical to the ray pitting which exists in certain specimens of *Juniperus*, *Libocedrus*, and *Cupressus* which have recently come under my observation. Furthermore, there is strong evidence for believing that the older Abietae, Taxodineae, and Cupressineae possessed ligneous characters which resembled those of *Pityoxylon*. The well-known occurrence of resin canals in *Sequoia* and the Abietae, in regions which reflect ancestral characters, points strongly in this direction. Similarly, the

¹ Seward, A. C., and Ford, S. O.: The Araucarineae, recent and extinct. Phil. Trans. Roy. Soc., London, B. 198, 305-411, 1900, pp. 23, 24.

² Hollick, A., and Jeffrey, E. C.: Affinities of certain plant remains commonly referred to the genera *Dammara* and *Brachyphyllum*. Am. Nat., vol. xl, 1906, pp. 189-215. Studies of Cretaceous Coniferous remains from Kreiserville, New York. Mem. of the N. Y. Bot. Gardens, vol. iii, 1909.

³ Jeffrey, E. C.: *Araucariopitys*, a new genus of Araucarians. Bot. Gaz., vol. xlv, 1907, pp. 435-44.

⁴ Sinnott, E. W.: *Paracedroxylon*, a new type of Araucarian wood. Rhodora, vol. ii, No. 129, Sept., 1909.

sporadic occurrence of ray tracheides which has been noted by De Bary, Penhallow, and Gothan in certain Taxodineae and Cupressineae leads to the same conclusion as does the traumatic occurrence of ray tracheides which Jeffrey has described in *Cunninghamia sinensis*.

From this we see that a careful consideration of the comparative anatomy and phylogeny of living and ancestral Conifers is necessary in studying the affinities of the remains of primitive Conifers; that the anatomical features which characterize the genera of Kraus are not of constant diagnostic value in separating Conifers into natural groups of closely related species, and that in many cases a large number of anatomical characters must be considered in order to make an accurate identification of the remains of primitive forms.

Before attempting to classify our fossil, therefore, it seems to be necessary to point out certain anatomical lines of evolution which are very significant and have been made clear by recent researches in the comparative anatomy of living Conifers. Primitive Araucarian and Abietineous Conifers, which strongly resembled one another, were characterized by the entire absence of wood parenchyma except where associated with resin canals, and by the presence of resin canals. In these forms the rays were characterized by the absence of ray tracheides, by thick, usually heavily pitted, ray parenchyma walls, and by small lateral ray pits with distinct borders upon the tracheide side. The disappearance of resin canals, the development of wood parenchyma, the reduction in the thickness of the ray parenchyma walls, the development of 'Eiporen' or non-piciform lateral ray pits, and the development and subsequent loss of ray tracheides are all lines of evolutionary modification in the development of modern Conifers.

Lines of evolution which appear significant in the Araucarian Conifers are—the disappearance of resin canals and thick-walled, heavily pitted ray parenchyma, and the development of wood parenchyma.¹ In the case of the Taxodineae and Cupressineae similar lines of phylogenetic interest exist—the disappearance of resin canals, the development of wood parenchyma, and the reduction in thickness of the ray parenchyma walls; but to these must be added the loss of ray tracheides, structures which have never been observed in Araucarian Conifers.

The woody structure of modern Abietineous Conifers has been evolved from that of their Mesozoic ancestors by the development of ray tracheides, by the development of wood parenchyma, except in *Pinus*, and by the disappearance in the Abietae of resin canals.

In the evolution of modern White and Hard Pines certain highly

¹ In regard to the alternate and flattened bordered pits of modern Araucarians which are strongly contrasted to the more Abietineous type of pitting which occurs in Cretaceous genera, it seems to be impossible to determine in the light of present investigation whether this type of pitting is really homologous or merely analogous to that of the *Cordaites*.

specialized structures have been evolved. Thus modern Hard Pines are characterized by the absence of tangential pitting in the summer tracheides, and by possessing ray tracheides with dentate and reticulate thickenings, structures which occur only in these pines. Recently the writer has called attention¹ to the evolution in modern Hard and White Pines of large irregular lateral ray pits or 'Grosseiporen' (see Figs. 11 and 12) from piciform pits (see Fig. 10) such as occur in certain primitive living pines (the Nut and Foxtail Pines of the south-western United States, *Pinus Bungeana*, Zucc., and *P. Gerardiana*, Wallich, of Asia) and Cretaceous pines. The 'Grosseiporen' were shown to be formed by the fusion of several small piciform pits into a single large pit. This fusion takes place either by the enlargement of the lenticular openings of the piciform pits and their subsequent fusion as is shown in Figs. 7 and 11, or by the gradual reduction in thickness of a large portion of the tracheide and parenchyma walls. In the latter case the lignified secondary wall of the tracheide often falls away first, leaving the ghost-like pit partition intact on the parenchyma side. This condition is illustrated in Fig. 12, a radial section of *Pinus flexilis*, James. The development of 'Grosseiporen' or fusion pits does not appear to the writer a character of great diagnostic importance, since it is a character which is likely to be evolved in all Conifers in which there is a reduction in the thickness of the ray parenchyma walls. In defence of this statement it is only necessary to call attention to the occurrence of fusion pits or 'Eiporen' in certain Podocarpaceae, notably in *Dacrydium* and in certain ligneous remains referred to *Araucarioxylon latisporosum* by Kraus and Conwentz,² to *Cupressinoxylon Barberi* by Seward,³ and to *Xenoxylon phyllocladoïdes* by Gothan.⁴

If we now turn to the lignite under consideration in this article we see that the mere presence of resin canals, of thick-walled, heavily pitted ray parenchyma (*Abietineentiüpfelung*), of piciform lateral ray pits, and the absence of wood parenchyma and so-called Araucarian pitting are not in themselves sufficient evidence for inferring that we have not to deal with a primitive member of the Araucarineae, Abietae, Taxodineae, or Cupressineae. The occurrence of ray tracheides appears, however, to exclude the Araucarineae, since these structures have never been observed in living or fossil forms of this family. Furthermore, the occurrence of bars of Sanio between the radial bordered pits in the tracheides of our Conifer confirms this supposition. Miss Gerry has made a careful study of the distribution

¹ Bailey, I. W.: Anatomical characters in the evolution of *Pinus*. Am. Nat., vol. xlv., May, 1910.

² Fossile Hölzer aus der Sammlung der königl. preuss. geolog. Landesanstalt, 1882, p. 170.

³ Jurassic Flora, pt. ii, 1904, p. 61, t. vii, Figs. 1, 4, 6.

⁴ Fossile Hölzer aus dem Bathonien Russ. Polens. Verhandl. kais. russ. mineral. Gesellsch., 1906, p. 454. Die fossilen Hölzer von König Karls Land. Kungl. Svenska Vetenskapsakademiens Handl., Bd. 42, No. 10, 1907.

of these structures¹ in the Coniferales, and although unable to discover their presence in living or fossil Araucarians, noted their presence in all other genera of living Conifers, and in a number of fossil Abietineous forms, including *Prepinus*.

The short shoots, which are a very characteristic feature of our lignite, indicate that the material is the stem of a pine-like Conifer, since these structures occur in Conifers only among pine-like forms and primitive Araucarians. Furthermore, the distribution, structure, and general appearance of the ligneous characters strongly resembles that of living and Cretaceous pines, and is quite unlike that of other Abietineous genera. It appears to be quite evident that we have to deal with a primitive pine-like Conifer, and it is therefore necessary that we should compare in greater detail the structures of the lignite with those which occur in other living and Cretaceous pines. As has been pointed out earlier in this article, this pine possesses the highly resinous ray parenchyma which is characteristic of *Pityoxylon statenense* and *P. scituatense*, and resembles the latter in possessing large masses of resinous parenchyma associated with the resin canals. It likewise possesses the primitive thick-walled ray parenchyma and piciform pits which are present in Cretaceous pines, including the very primitive *Prepinus*, and in the living Nut and Foxtail Pines of the southwestern United States. It is, however, distinct from other Mesozoic pines in possessing well-developed ray tracheides, which are present, however, in all living pines. Thus we see that in its anatomical characters our lignite appears to occupy an intermediate position between *Pityoxylon scituatense* and *Pinus edulis*, Engelm., since it possesses the highly resinous parenchyma and abundant epithelium of the former, combined with the ray tracheides of the latter, and resembles both species in possessing numerous tangential bordered pits in the summer wood, and thick-walled ray parenchyma with piciform lateral ray pits.

Owing to the strong similarity between the woody structure of the *Pityoxylon* and that of certain primitive living pines, the American Nut and Foxtail Pines, we propose to follow the precedent set by Conwentz² in naming the succiniferous remains of Baltic *Pityoxyla*, and refer the lignite to the genus *Pinus*. We appear to be justified in this course, particularly as the foliar structure of the pines of the Upper Cretaceous, as shown by Stopes and Kershaw,³ is similar to that of living pines. The leaves of pines in the Lower Cretaceous, as has been shown by Jeffrey,⁴ differed from modern pines in the probable absence of an endoderm and in possessing a double transfusionary sheath. We therefore suggest for our fossil the

¹ Gerry, E. : Bars of Sanio in Coniferales. *Annals of Bot.*, vol. xxiv, No. 93, Jan., 1910.

² Conwentz, H. : Monog. d. balt. Bernsteinbäume. Danzig, 1890.

³ Stopes, M. C., and Kershaw, E. M. *Annals of Bot.*, vol. xxix, No. 94, April, 1910.

⁴ Jeffrey, E. C. : On the structure of the leaf in Cretaceous pines. *Annals of Bot.*, vol. xxii, No. 86, April, 1908.

name *Pinus scituatensisiformis*, since it possesses highly resinous ray parenchyma and abundant epithelium about its resin canals, characters which occur in *Pityoxylon scituatense*.

CONCLUSIONS.

The occurrence of ray tracheides in this Mesozoic Conifer throws interesting light upon the origin and phylogeny of these structures. As has been mentioned above, Jeffrey and Chrysler have pointed out that ray tracheides do not occur in Lower Cretaceous pines, nor in the primitive regions of modern pines, namely, the cone axis and the first-formed wood of the stem. From this they inferred that ray tracheides are of comparatively modern origin, and that in all probability they were evolved early in the Tertiary. The distribution of ray tracheides in our lignite confirms these writers in their conclusion that the absence of ray tracheides is a primitive condition, but shows that these structures were evolved during the latter part of the Cretaceous rather than at the beginning of the Tertiary. This is shown by the fact that ray tracheides are feebly developed even in the older wood of the stem, and do not occur during the first ten to fifteen annual rings. Among modern pines ray tracheides are often absent or feebly developed in the first few years' growth of the stem, but the condition which we have described is a more primitive one and indicates the recent origin of ray tracheides in the plant under consideration in this article.

There are two theories which have been advanced recently to explain the origin of ray tracheides. Penhallow¹ holds the view that these structures, at least in *Pinus*, have been formed from ray parenchyma cells by the thickening of their walls. The transition from thin- to thick-walled parenchyma, which occurs in certain pines, culminates according to this writer in the formation of ray tracheides. We are not able to follow Professor Penhallow in this supposition, since, as has been shown by the writer, thick-walled ray parenchyma is the primitive condition in *Pinus*, and the gradations from thick-walled to thin-walled parenchyma occur in pines which are becoming specialized by the reduction in thickness of the parenchyma walls and by the formation of 'Eiporen', which is a natural concomitant of the process.

Thompson² has more recently advocated the theory that ray tracheides were originally derived from short tracheides which have assumed a horizontal position parallel to the axis of the ray. His investigations, however, have been confined to *Pinus resinosa*, Sol., and *P. Strobus*, two perhaps of the most highly specialized and most modern pines. Among the more

¹ Penhallow, D. P.: A manual of the North American Gymnosperms, ch. vi. Ginn & Co., Boston, 1907.

² Thompson, W. P.: The origin of ray tracheides in the Coniferae. Bot. Gaz., vol. 50, No. 2, Aug., 1910, pp. 101-16.

primitive Hard and White Pines, and the American Nut and Foxtail Pines, and the very primitive pine under consideration in this article the writer has been unable to find conclusive evidence in support of this theory. In many specimens of stem wood, conditions similar to those figured by Thompson were observed, but occurred invariably where the wood was of slow growth and twisted grain, and the tracheides in consequence of irregular shape. Root wood, as is well known, possesses an extremely short and twisted 'fibre' which may account for the irregularly shaped tracheides found by Thompson in the root of *Pinus Strobus* and *P. resinosa*.

SUMMARY.

1. In the identification of the remains of primitive Conifers the absence of alternate pitting, wood parenchyma, or 'Eiporen', or the presence of resin canals or 'Abietineentüpfelung' are insufficient data in determining whether we have to deal with a primitive member of the Araucarineae, Abietineae, or Cupressineae.

2. The fact that bars of Sanio and ray tracheides are well-developed features of the lignite under consideration in this article indicates that we are not concerned with an Araucarian Conifer.

3. The presence of short shoots and the general pine-like appearance of the fossil indicate strongly that the specimen is a primitive member of the genus *Pinus*.

4. It is intermediate in structure between the older Cretaceous pines and the most primitive of living pines.

5. It affords additional evidence that primitive pines possessed thick-walled ray parenchyma with piciform lateral ray pits, abundant tangential pitting in the summer tracheides, and highly resinous ray parenchyma.

6. The somewhat infrequent occurrence of ray tracheides in the older portions of the stem and their entire absence from the younger wood indicate that these structures are of recent origin and are not strongly fixed upon the plant.

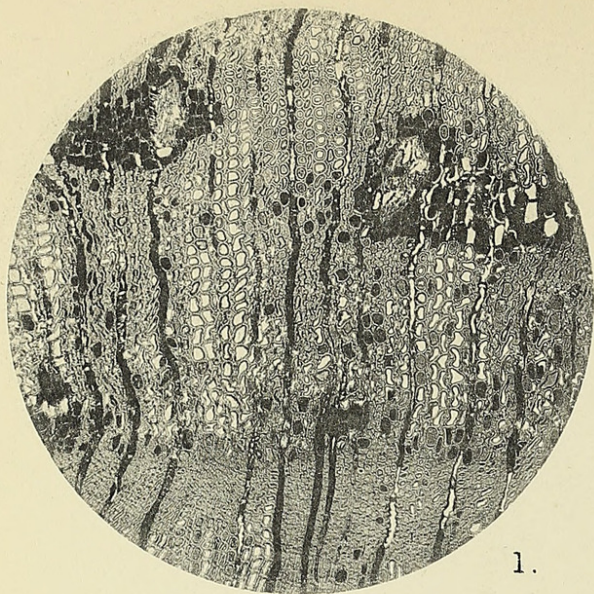
7. The occurrence of ray tracheides in this Cretaceous pine indicates that the development of these structures occurred in the Upper Cretaceous, and not, as has been supposed, in the Tertiary.

This investigation has been conducted in the Phanerogamic Laboratories of Harvard University, and to Professor Jeffrey the writer is indebted for material and kind assistance in the course of the work. To Professor Conwentz the writer is much indebted for his kindness in sending valuable material of the Baltic *Pinus succinifera*, and to Professor Jack of the Arnold Arboretum for material of Asiatic pines.

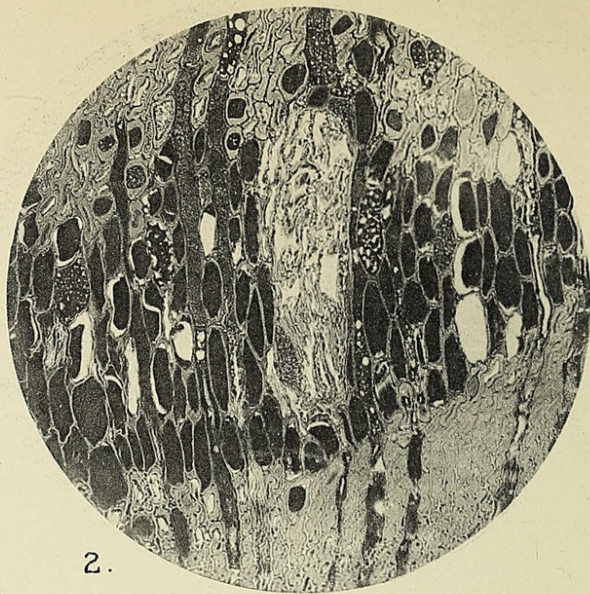
DESCRIPTION OF PLATE XXVI.

Illustrating Mr. Bailey's paper on a Cretaceous *Pityoxylon*.

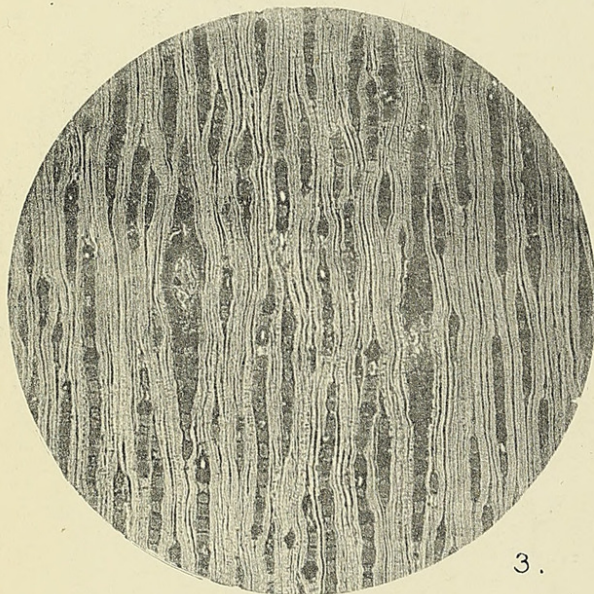
- Fig. 1. *Pinus scituatensiformis* : transverse section of stem wood. $\times 60$.
- Fig. 2. The same : higher magnification. $\times 100$.
- Fig. 3. The same : tangential longitudinal section of stem wood. $\times 60$.
- Fig. 4. The same : higher magnification. $\times 100$.
- Fig. 5. *Pinus Strobis* : transverse section of the stem wood. $\times 300$.
- Fig. 6. *Pinus scituatensiformis* : radial section of stem wood. $\times 500$.
- Fig. 7. *Pinus Taeda* : radial section of root wood. $\times 300$.
- Fig. 8. *Pinus scituatensiformis* : longitudinal section of the pith. $\times 60$.
- Fig. 9. The same : transverse section of the base of a short shoot. $\times 40$.
- Fig. 10. *Pinus Balfouriana* : radial section of stem wood. $\times 500$.
- Fig. 11. *Pinus palustris* : radial section of stem wood. $\times 500$.
- Fig. 12. *Pinus flexilis* : radial section of stem wood. $\times 300$.



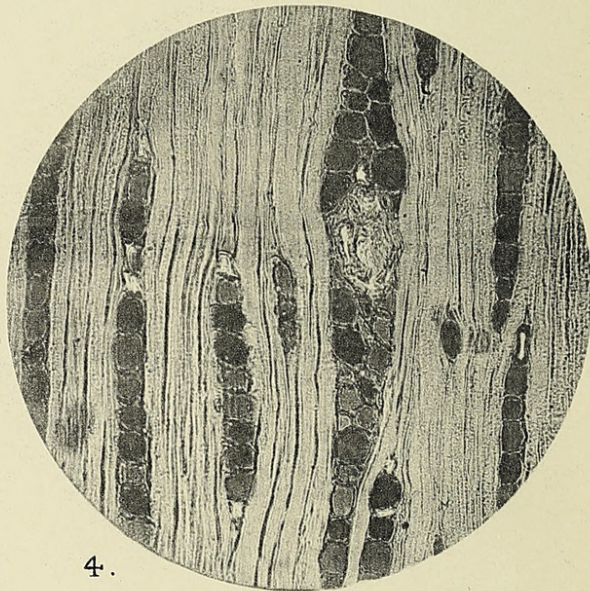
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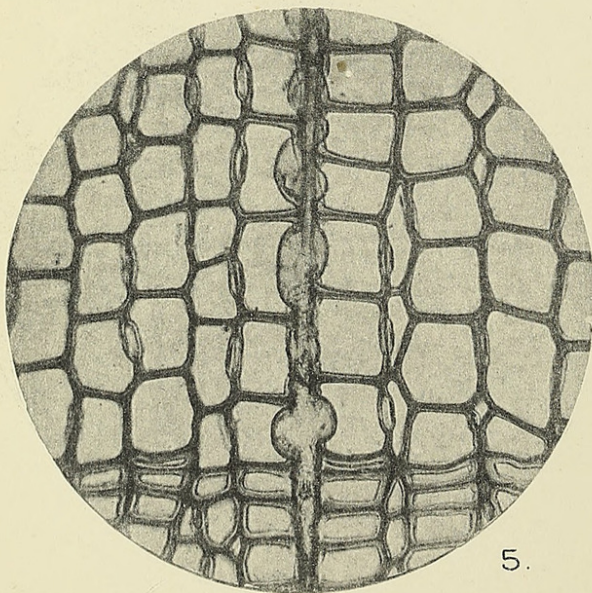
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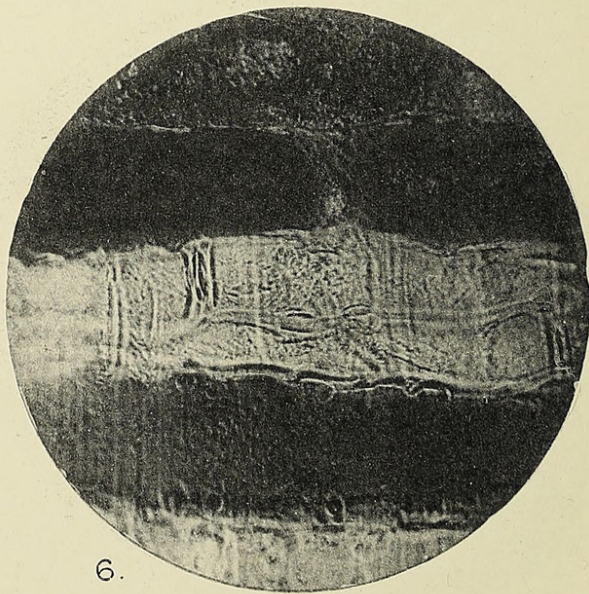
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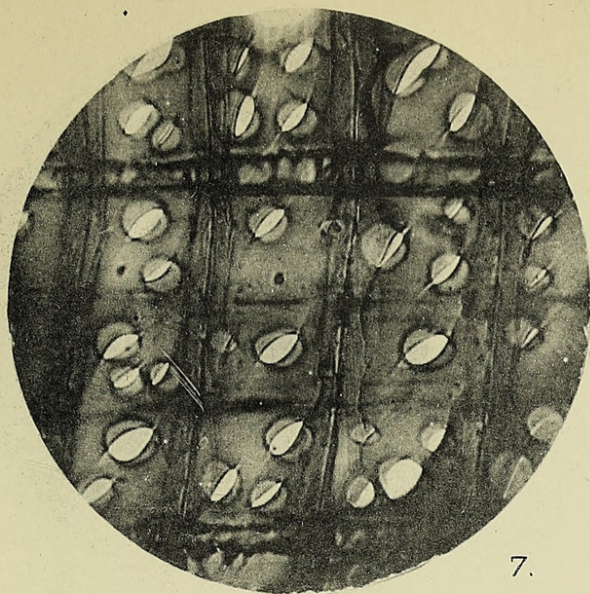
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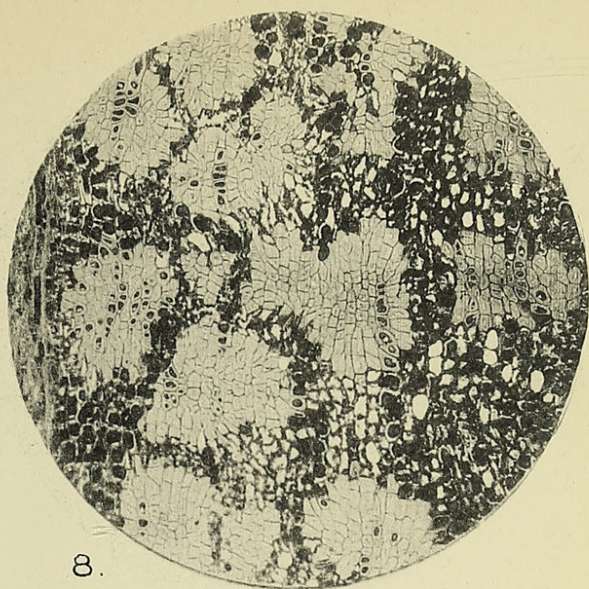
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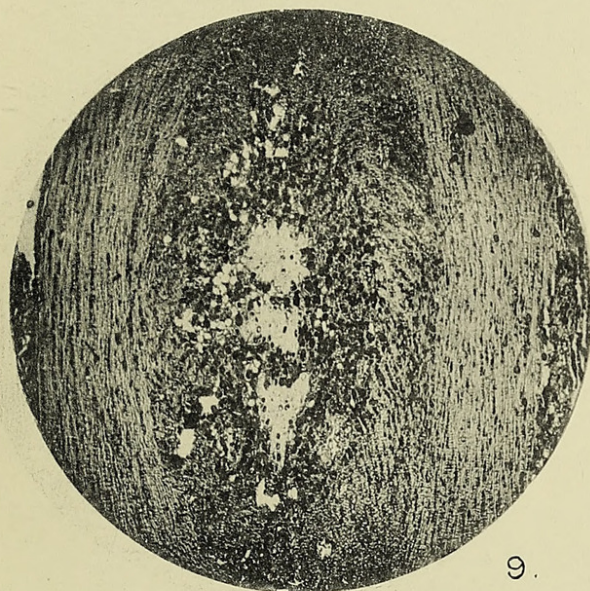
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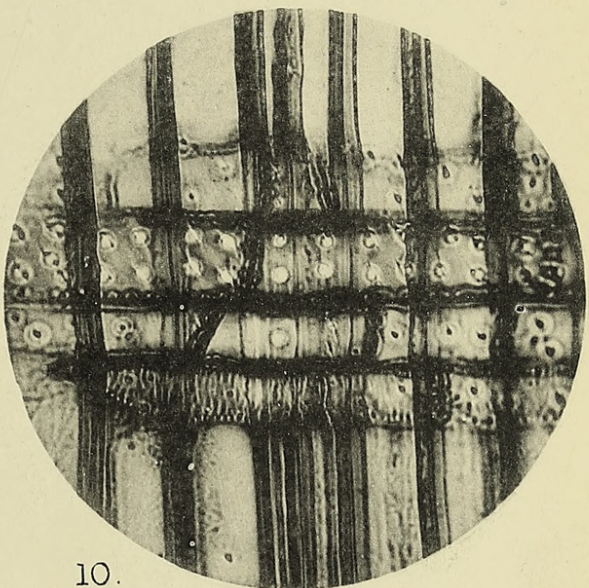
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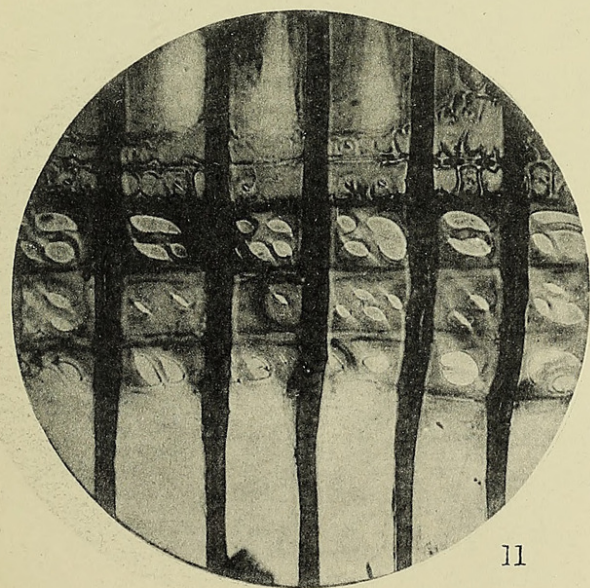
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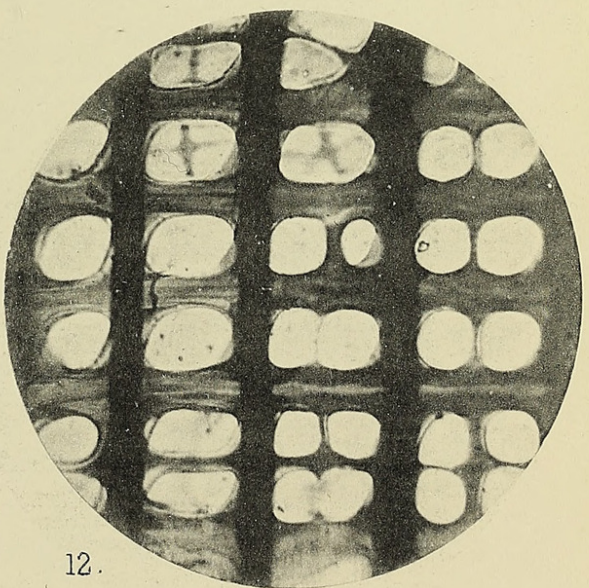
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12.



Bailey, Irving W. 1911. "A Cretaceous Pityoxylon with marginal tracheides."
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