The Distribution of the 'Bars of Sanio' in the Coniferales.[1]

BY

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With Plate XIII.

THE 'bars' or 'folds' of cellulose, which, when stained with haematoxylin, are especially obvious as horizontal or more or less semicircular markings in the tracheide walls of a radial section from such a Conifer as *Pinus silvestris*, L., were described by Sanio in 1872. Although these structures were named the 'Bars of Sanio' from him, and in spite of the fact that he declares that 'diese scheibenförmige Verdickung der Scheidewand ist bisher übersehen',[2] we find that in 1849 Göppert had indicated their presence in two drawings, one of *Cryptomeria japonica*, and the other of *Cupressinoxylon aequale*, which he used to illustrate his 'Monographie der fossilen Coniferen'.[3]

Little attention, however, has been directed towards the bars of Sanio, although their presence in *Pinus silvestris*, L., is indicated in the chapter concerning coniferous woods in Zittel's 'Handbuch der Palaeontologie'.[4] Again, in 1898, Dippel mentions them in his chapter entitled 'Entstehung der behöften Poren'.[5] But here, as before, *Pinus silvestris*, L., is the only species cited.

It is the purpose of this paper to discuss their distribution from observations made upon all the genera of living Conifers, together with some fossil forms. For this study radial sections 5 μ in thickness were used. The bars, since they are composed of cellulose, take a blue stain with haemotoxylin, and therefore stand out clearly from the red background obtained by the general staining of the tracheide walls with safranin. In every case they appear most abundantly in the thin-walled tracheides in the spring-wood of the stem and in the root. Often when they are absent or difficult to discern in the stem they are found without difficulty in the root.

[1] Contributions from the Phanerogamic Laboratories of Harvard University, No. 21.

[2] Jahrbücher für wissenschaftliche Botanik, Bd. 9, S. 78, 1873–1874.

[3] Leiden, bei Arnz & Co., 1850.

[4] II. Abtheilung, München u. Leipzig.

[5] Das Mikroskop, zweiter Theil, Braunschweig, von F. Vieweg & Sohn.

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The description of the abundance and modification of the bars of Sanio in each genus of the living Conifers, taken in the order of classification of Engler and Prantl, is as follows. Beginning with the Abietineae, we find in *Pinus* numerous straight bars between pits which are, for the most part, in single uncompressed rows. In *Picea canadensis* the pitting, although mainly uniseriate, shows a few opposite pits. The greater part of the bars are straight, but instances of curved and, rarely, even of double bars appear. In *Pseudotsuga taxifolia* the general uniseriate pitting, with exceptional cases of opposite pitting, is obscured by tertiary thickening. Nevertheless the straight or occasionally slightly curved or double bars are visible in abundance. *Cedrus Libani* has a closely packed uniseriate and opposite pitting with straight bars. *Larix occidentalis* likewise clearly shows numerous bars of Sanio. In *Tsuga canadensis* (root) abundant straight or curved and double bars are present with the, for the most part, opposite pitting. In *Keteleeria* species (root) we find both opposite and uniseriate pitting with a notable crowding and increase in the number of pits between the bars ; here also the bars are straight, curved, and often double between the pits. In a similar way *Pseudolarix Kaempferi* has both uniseriate and opposite pitting with straight, as well as strongly curved, bars. *Abies balsamea*, the last of this group, with its generally uniseriate pitting and curved bars, is illustrated in Pl. XIII, Fig. 1.

In the Taxodineae also, the bars of Sanio are well developed. Although in the root of *Sciadopitys verticillata* pits without bars occur, yet, for the most part, curved bars, 'tilde' shaped bars, and even double bars are in good evidence. In *Cunninghamia sinensis* they are not so thick, but apparently have split and adhered to the edges of the pits. *Athrotaxus cupressoides* has single rows of pits and numerous bars. Likewise *Cryptomeria japonica* and *Glyptostrobus heterophyllus* show a sufficient number of bars to make their presence unquestionable. In *Sequoia washingtoniana* the pits are both uniseriate and opposite, often being somewhat oval in shape ; the bars are generally straight. *Taxodium distichum* is characterized by a crowded, flattened, and often irregular pitting. The bars are straight, curved, and slanting. There are, moreover, some indications between the opposite pits of vertical bars perpendicular to the horizontal bars of Sanio.

Further evidence is derived from the Cupressineae. In *Chamaecyparis thuyoides* the pitting is uniseriate, and the straight, often double, bars are very abundant. *Callitris arborea* and *Biota orientalis* have uniserial pitting and numerous bars. In *Thuyopsis dolabrata* the uniseriate pits are not crowded, and the bars are not so numerous. *Libocedrus decurrens* has uniserial, rarely opposite, pits with both straight and curved bars. *Cupressus Goveniana*, with its single-rowed, open pitting, shows scattered bars—straight, curved, or double. *Fitzroya patagonica*, too, has uniseriate pitting

with curved, double bars. A photograph of a characteristic region of the stem of *Thuja plicata* is shown in Fig. 5.

The Podocarpineae are an especially interesting group, for, although bars are present in all the members, there exists at the same time cases of a markedly compressed and crowded pitting without bars. In *Dacrydium cupressinum* (root) there are both uniseriate and opposite rows of pits; the bars—curved, straight, or double—are numerous. A photograph of a section of *Microcachrys tetragona* with its uniseriate pitting and numerous bars is shown in Fig. 3. *Saxegothea conspicua* (root), showing, from a characteristic region, its well-developed and unmistakable, although rather scattered, distribution of bars, appears in Fig. 4. *Podocarpus polystachya*, which has opposite as well as uniseriate pitting, manifests its prominently developed bars in the photograph shown in Fig. 2.

Lastly, the Taxineae give the concluding cases where bars of Sanio are present. Although in many cases the tertiary thickening obscures the bars, yet they are found as follows. In *Phyllocladus hymenophylloides* there are uniseriate and opposite pits, and curved, double bars. *Cephalotaxus drupacea* and *Taxus canadensis*, where the tertiary thickening is most highly developed, show, between the uniseriate pits, bars of Sanio, which, though not numerous, are unmistakable. *Torreya taxifolia*, with its opposite and uniseriate pits, shows a very marked development of straight, curved, and double bars.[1]

In definite contrast with the preceding are representatives of the two remaining genera of living Conifers, *Araucaria imbricata* and *Agathis australis*, which do not possess the bars of Sanio. *Araucaria imbricata* (stem) is shown in Fig. 6. Compressed pitting with a tendency to clusters of alternating pits is characteristic of the stems of both genera. In the root, on the other hand, the presence of uniseriate compressed rows of pits is rare in comparison with the general alternating and closely packed arrangement. The root appears to be one of the centres of the preservation of ancestral traits and is, in the preceding genera, the place of persistence and greatest development of bars, but in the roots of the Araucarineae even vestigial traces of bars are completely absent.

The conditions found in all the available fossil Conifers confirm this segregation of the genera with Araucarian affinities from the remaining tribes of Conifers which, as has been shown, all manifest the bars of Sanio. *Geinitzia Reichenbachi* with its uniseriate, open pitting shows no indication of bars. Neither does *Brachyoxylon*, which is shown in Fig. 7, nor a new undescribed genus closely related to it and very abundant in Mesozoic deposits. *Araucaryopitys americana*, illustrated in Fig. 8, with its rather compressed uniseriate pitting, also gives no evidence of bars. Even after special treatment such as bleaching with chlorine water fol-

[1] The bars of Sanio also appear in *Ginkgo biloba*, the only living member of the Ginkgoales.

lowed by staining with haematoxylin, although the pit membranes are stained blue, there is not the slightest indication of bars in any of the above-mentioned genera.

On the other hand, in *Prepinus statenensis*, where they were observed by Jeffrey,[1] they appear, as shown in Fig. 9, as prominent light bands. In an undescribed *Pityoxylon* from Martha's Vineyard the characteristic double bars are well illustrated by Fig. 10. In *Pityoxylon scituatense* they appear unmistakably as shown in Fig. 11. Again we find them in a fossil *Picea*, dug up with a mammoth in Alaska, where they stand out almost as well, after the usual staining, as they do in the living material. In *Sequoia Penhallowii*, Jeffrey, of the California Gold Gravels the bars are strikingly present as appears in Fig. 12. The fine state of preservation of all these fossil woods makes the presence of the bars perfectly obvious even in unstained sections such as those of *Prepinus statenensis*, Fig. 9, and of *Pityoxylon scituatense*, Fig. 11, or even in spite of the fact that, being cellulose, the bars have sometimes become decomposed and left transparent spaces such as appear in *Sequoia Penhallowii*, Fig. 12, and in *Prepinus statenensis*, Fig. 9.

Conclusions.

The distribution of the bars of Sanio as above described establishes a constant and useful diagnostic character in the determination of fossil woods. In woods with Abietineous affinities we always find bars of Sanio even though at the same time we may find more or less Araucarian-like pitting. But in the Araucarineae we never find bars, although in fossil forms such as the Araucariopityoideae and the Brachyphylloideae, we find Abietineous as well as Araucarian pitting.[2]

The presence of bars of Sanio in the Podocarpineae points with other evidence to the probability that they are more closely related to the Abietineae than to the Araucarineae. At least they may have sprung from a common branch, for the apparent relationship is strengthened by the presence of the tendency towards recapitulation and preservation in the root which indicates the primitive, rather than the recently acquired, character of the bars. The ancient character of the bars of Sanio is further emphasized by the fact that they occur in *Prepinus statenensis*, which lays an undoubted claim to primitiveness on the ground of its double foliar transfusion sheaths and centripetal wood. Therefore, judging from the fossil evidence and from the well-developed distribution at the present time, the bars of Sanio appear to be a definite and constant anatomical characteristic of all the Coniferales except the Araucarians.

[1] On the Structure of the Leaf in Cretaceous Pines. Ann. Bot., vol. xxii, April, 1908.

[2] Hollick and Jeffrey: Studies of Cretaceous Coniferous Remains from Kreischersville, N.Y., p. 75. Mem. N. Y. Bot. Garden, No. III, May, 1909.

SUMMARY.

1. Bars of Sanio occur in thirty-five of the living genera of the Coniferales.

2. They do not occur in two genera of the living Conifers, namely, *Agathis* and *Araucaria*.

3. This distribution is confirmed by fossil evidence which shows the bars to be absent in Conifers of Araucarian affinities.

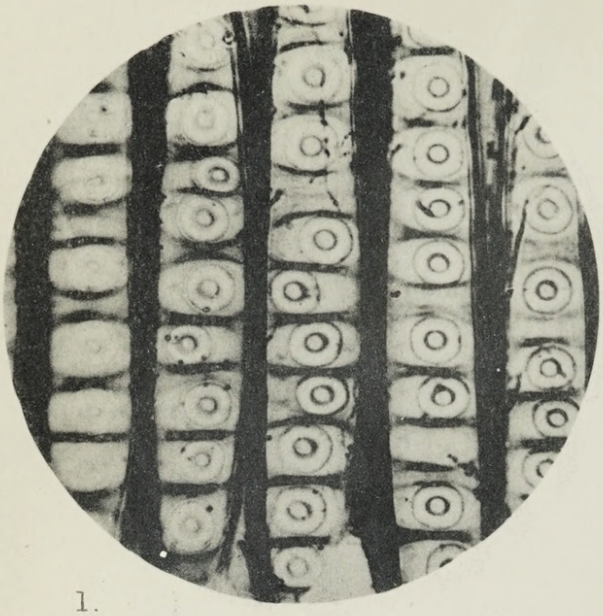
4. The presence of bars of Sanio is of practical use as a diagnostic character for fossil woods.

In closing the writer wishes to express her thanks to Prof. E. C. Jeffrey for his helpful advice, guidance, and generous provision of material.

DESCRIPTION OF PLATE XIII.

Illustrating Miss Gerry's paper on the 'Bars of Sanio'.

Fig. 1. Radial section of the wood of *Abies balsamea*. × 180.
Fig. 2. Radial section of the wood of *Podocarpus polystachya*. × 500.
Fig. 3. Radial section of the wood of *Microcachrys tetragona*. × 500.
Fig. 4. Radial section of the root of *Saxegothea conspicua*. × 500.
Fig. 5. Radial section of the wood of *Thuja plicata*. × 180.
Fig. 6. Radial section of the wood of *Araucaria imbricata*. × 180.
Fig. 7. Radial section of the wood of *Brachyoxylon*. × 180.
Fig. 8. Radial section of the wood of *Araucaryopitys americana*. × 180.
Fig. 9. Radial section of the wood of *Prepinus statenensis*. × 500.
Fig. 10. Radial section of the wood of *Pityoxylon* (undescribed). × 180.
Fig. 11. Radial section of the wood of *Pityoxylon scituatense*. × 500.
Fig. 12. Radial section of the wood of *Sequoia Penhallowii*. × 500.



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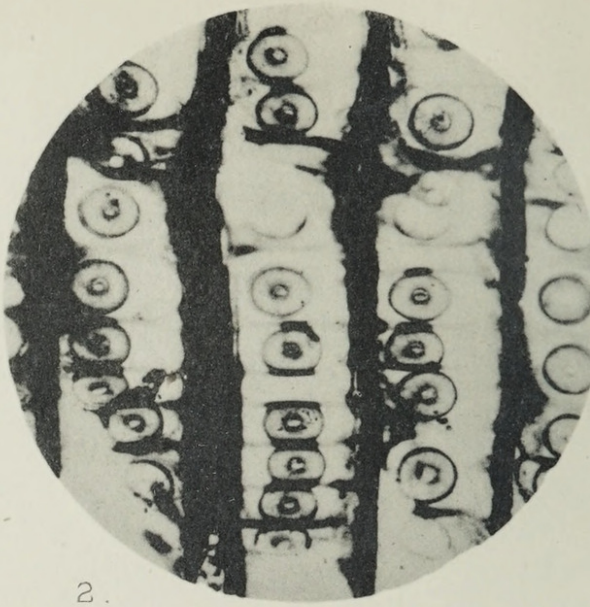

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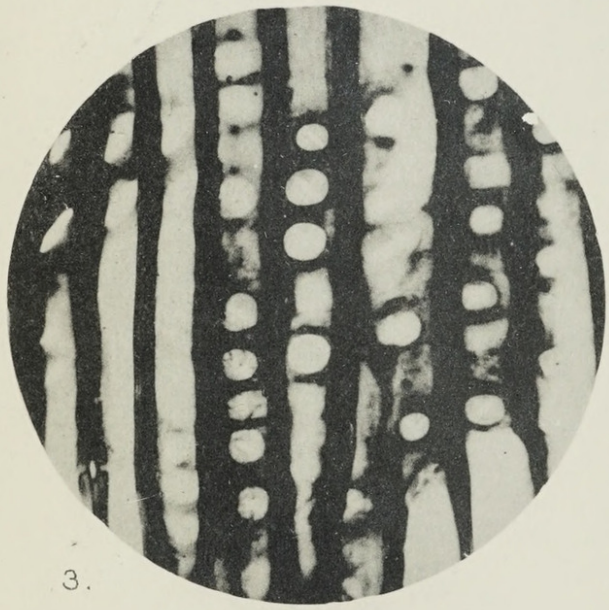

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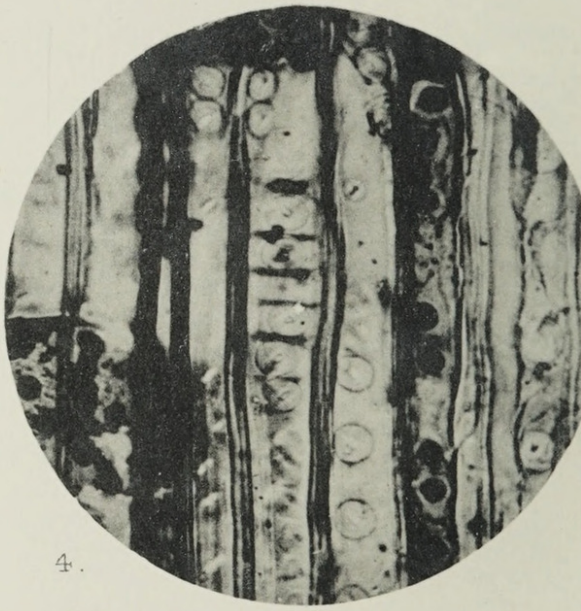

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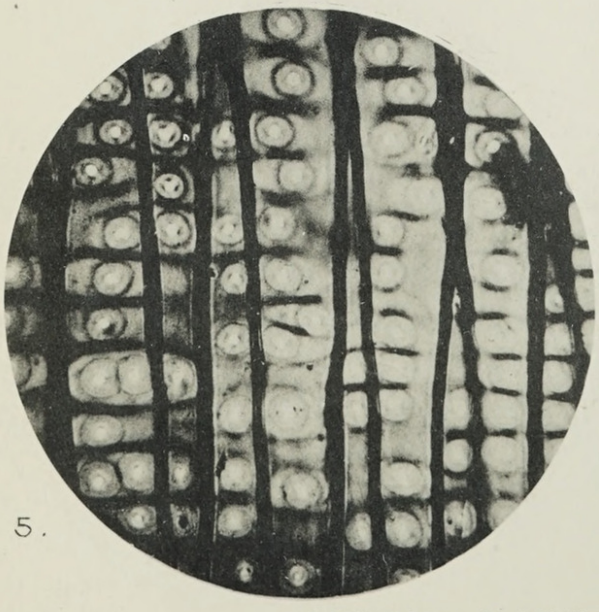

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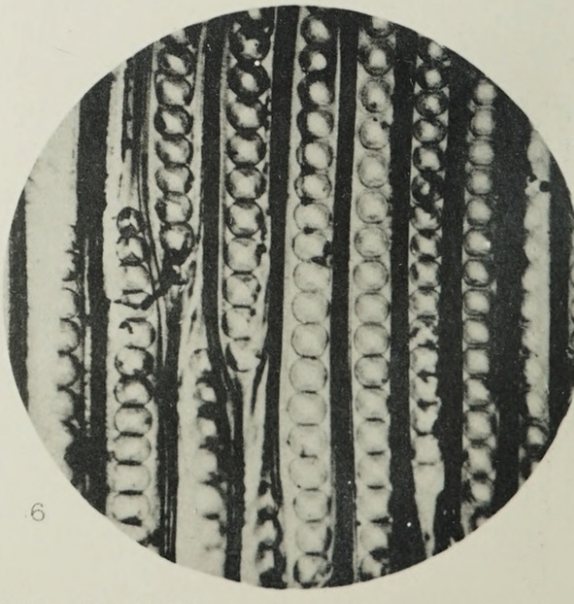

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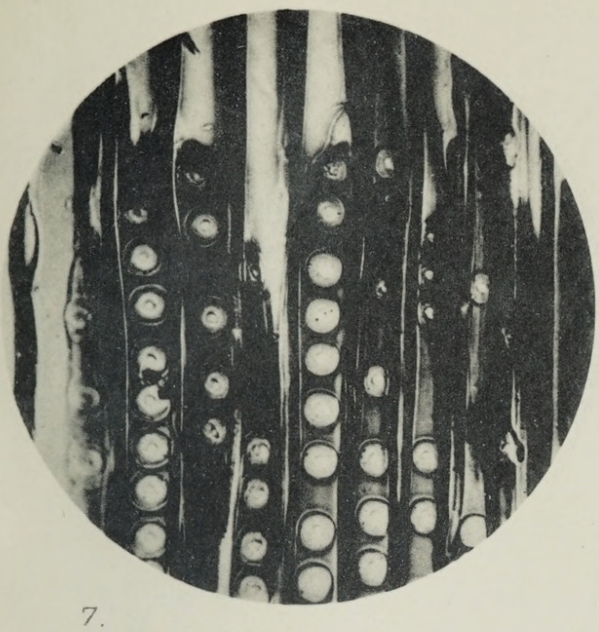
GERRY—BARS OF SANIO.



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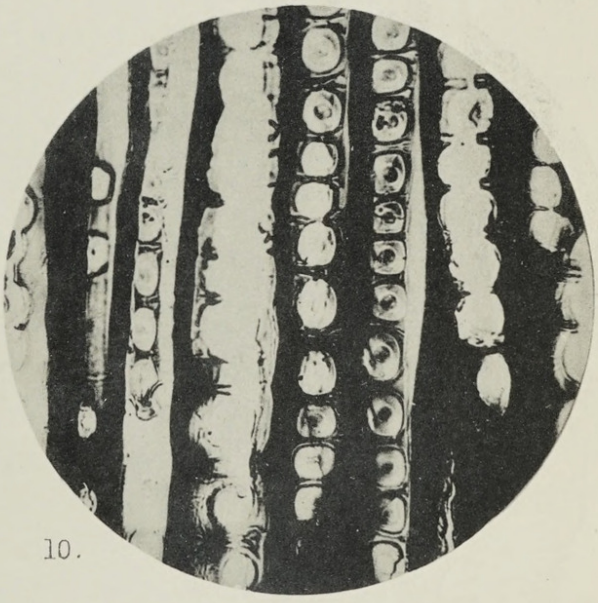

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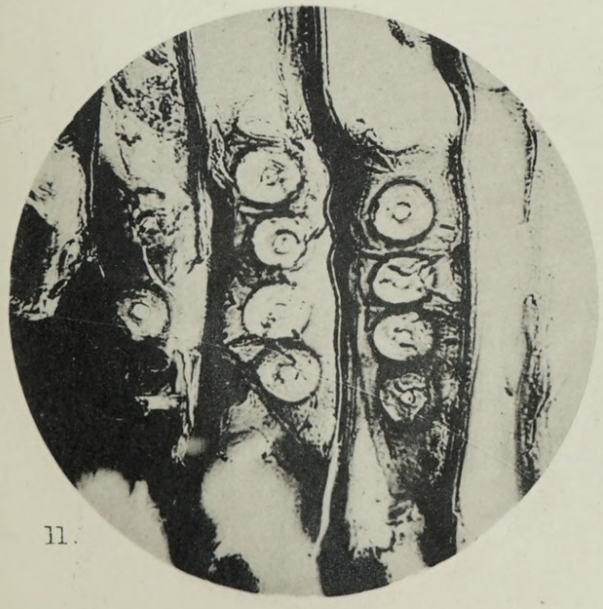

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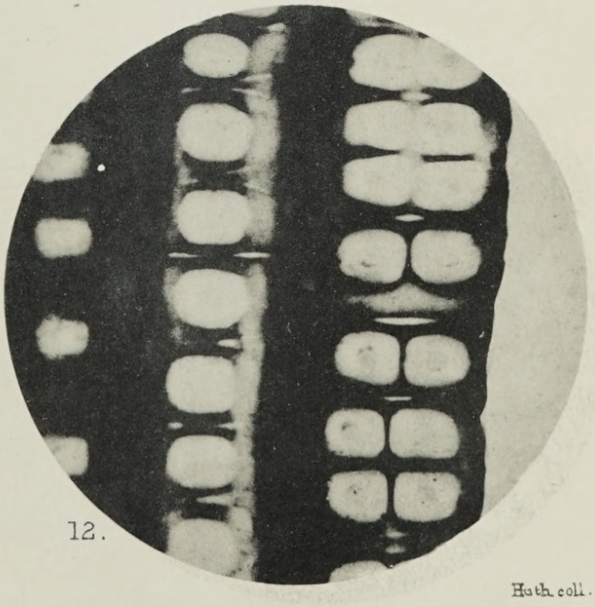

12.

Heath. coll.