The Internal Anatomy of 'Nilssonia orientalis'.

BY

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With Plate XXVI and a Figure in the Text.

AMONG the desiderata of Botany is information regarding the anatomy of the numerous plants in the Mesozoic rocks which are known only from impressions. The uncertain value of external impressions for phylogenetic and systematic work has often been emphasized in recent years.

Even among the Palaeozoic plants, so many of which are known by their internal anatomy, it is a rare and fortunate chance, or series of chances, which gives both internal anatomy and external impression of the same specimen. Such a fortunate chance has materialized in a nodule of Cretaceous age in the case of the plant hitherto known only as a leaf impression by the name *Nilssonia orientalis*, Heer.

Foliage impressions of this species have been described several times from Mesozoic rocks from the Orient. Nathorst [1] figures impressions of the plant in his 'Beiträge zur Mesozoischen Flora Japans', Yabe [2] figures fragments from Korea, and Yokoyama [3] records the same species for Japan. So that we know that the species was well distributed in the Orient in the Mesozoic times.

Among my specimens of Cretaceous, plant-containing nodules from Japan was one which revealed, when the matrix was broken, a fragment of a fairly sharp external impression of foliage. The stone split so as to expose part of the leaf in surface view, and to retain the bulk of it embedded in its matrix. The exposed portion (see Fig. 1, Pl. XXVI) was enough to identify the leaf as that known as *Nilssonia orientalis*, Heer, and it was found possible to cut a series of sections through the remainder of the leaf. These sections, though not so perfect as could have been desired, yet show anatomical petrifactions of the tissues, from which it is possible to reconstruct

[1] Nathorst, A. G.: Beiträge z. Mesozoischen Flora Japans. Kais. Akad. d. Wiss. Wien, 1890, pp. 2–20, Pl. I–VI.

[2] Yabe, H.: Mesozoic Plants from Korea. Journ. Coll. Sci. Tokio, xx, 1905, pp. 1–59, Pl. I–IV.

[3] Yokoyama, M.: Jurassic Plants from Kaga, Hida, and Echizen. Journ. Coll. Sci. Tokio, iii, 1889.

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the anatomy of the leaf. There are also several other fragments of the same foliage in the matrix. From all these sections the following anatomical description is compiled.

Description of Leaf.

External appearance. As is seen in the small portion of the leaf shown in Fig. 1, Pl. XXVI, the blade is about 4 cm. across, with a midrib from which laterally running veins pass out straight to the margin. These veins are about 0·5 mm. apart. The character of the venation is better shown in the drawing, Fig. 4, Pl. XXVI, where the veins are seen to run undivided from midrib to margin, as is characteristic for the species in most cases, though they may branch a little.

Internal anatomy. The leaf shows no marked differentiation of an upper and lower surface. As there is no palisade tissue, the bundle alone exhibits a distinct indication as to which side is uppermost. The sections are cut across the lamina, at right angles to the laterally running veins, and therefore parallel to the midrib.

The epidermis. In the well-preserved portions of the leaf the cells of the upper and lower epidermes are alike in character, though in the less favourably petrified regions those of the lower epidermis are much the more obliterated of the two. The individual cells are squarish, about 0·02 mm. in diameter, and are not markedly different in size from the mesophyll beside them. See *e.*[1] and *e.*[2], Text-figure, and *e*, Figs. 2 and 3, Pl. XXVI.

The cuticle does not seem to have been noticeably thickened, and there is no sign of hairs or protuberances.

Stomata are not recognizable on the upper surface, which appears to have been clothed by an unbroken epidermis. In several sections they are to be seen in the lower epidermis, lying in the portion of the leaf between the bundles (Text-fig., *st.*). They are not quite perfectly petrified, but the guard-cells seem to have been placed at the oblique angle usual in Gymnosperms.

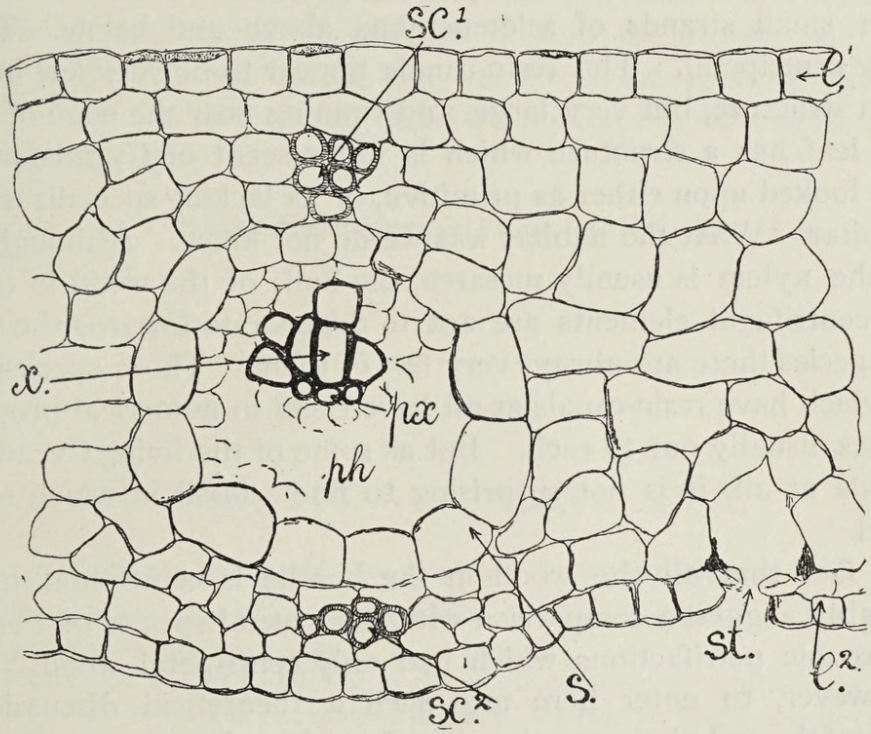
The mesophyll. The *ground tissue* of the mesophyll shows no special differentiation; the cells are roughly roundish or oblong in shape (see Text-fig.), and are arranged so as to leave but little space between them. There seems to be none of the differentiated transfusion tissue common in modern Cycad leaves.

Sclerenchyma appears to be developed only in small groups of three or four cells above and below the vascular bundles; see *sc.*[1] and *sc.*[2], Text-figure. The cells are not very much thickened.

Resin-canals. I cannot speak dogmatically about the presence or absence of these structures. They are certainly not present in the way they are in living Cycads, namely, in direct relation to the vascular bundles, either between each pair as in *Encephalartos* or above each as in *Dioon.*

From most of the sections of the fossil one might conclude that resin-canals were absent, as they are in many Cycad genera.

Two sections, however, clearly show canals which have every appearance of being resin-ducts. This is seen in Figs. 2 and 3, Pl. XXVI, *r*. In both the leaf-sections which show the phenomenon, there is only one canal in the tissues. It lies near to the edge of the leaf, as is seen in Fig. 2, Pl. XXVI. The appearance of the structure is exactly that of a resin-canal, with its epithelial lining partly preserved (see Fig. 3, Pl. XXVI). From this, it seems very reasonable to conclude that the canal is really a resin-duct. It lies between two bundles, and is large compared to them.



TEXT-FIGURE. Slightly diagrammatic drawing to show the anatomy of the leaf of *Nilssonia orientalis*, Heer. *e.*[1], upper, and *e.*[2], lower epidermis. *st.*, stoma, only on the lower side. *sc.*[1] and *sc.*[2], groups of sclerenchyma above and below the bundle. *s.*, bundle-sheath. *px*, protoxylem. *x.*, xylem, which appears to be entirely centripetal. *ph*, space, in which are fragments of badly petrified phloem.

As is seen in Fig. 2, Pl. XXVI, the canal lies near the edge of the leaf, which must have been towards the apex in this section, and it is not impossible that an early type, such as the plant we are considering, may have had a large resin-canal near the border of the leaf, without having others regularly between each pair of bundles.

The vascular bundles. The bundles lie approximately equidistantly in the leaf, about 0·5 mm. apart, and are simply collateral in structure.

The *bundle-sheath*, though not highly specialized, is clearly recognizable round several of the better-preserved bundles. It consists of large, roundish cells (*s.*, Text-fig.), on which I have not been able to observe any pitting.

The *xylem* of the bundle is apparently entirely *centripetal*, for the small elements which appear to be protoxylem lie on the side towards the middle of the bundle (see *px*, Text-fig. and Fig. 4, Pl. XXVI). There are two or three of the small protoxylem-elements and about half a dozen cells of metaxylem averaging 0·01 mm. in diameter (*x.*, Text-fig.).

The *phloem* is hardly preserved, the only indication of its nature being the fragments of walls in the space below the xylem.

Between the xylem and the bundle-sheath a few cells of soft parenchyma are preserved.

To sum up. The leaf has not a particularly differentiated epidermis or mesophyll. The bundles have each a fairly distinct bundle-sheath, and there are small strands of sclerenchyma above and below. The wood is entirely centripetal. The resin-canals appear to be very few in number, normal in structure, but very large, and running near the edge of the leaf.

The leaf has a structure which is reminiscent of Cycads, and which might be looked upon either as primitive, or as lacking specialization owing to its habitat. What the habitat was we do not know. Although in living Cycads the xylem is usually mesarch, the bulk of the wood is centripetal and the centrifugal elements are apt to degenerate towards the apex, and in some species there are always very few of them. Those species of living Cycads which have resin-canals at all have them in numerical proportion to the bundles, usually one to each. But as some of the living Cycads have no resin-canals at all, it is not surprising to find a fossil in which so few are developed.

The fact that all the wood in the bundle is centripetal might, not unreasonably, suggest a comparison with the several species of *Cordaites* in the Palaeozoic petrifactions which had only centripetal wood. I do not wish, however, to enter here into such a theoretical discussion about structures of the real phylogenetic value of which we know so little. *Cordaites* has been pressed into service rather frequently of late.

For the present it suffices to describe the leaf as one which has a distinctly Cycad-like structure, but is simpler in general organization and in its vascular bundle than the living Cycad leaves. The fact that all its wood is centripetal might reasonably be considered as a primitive feature.

A word must be said as regards the position of the species *orientalis* in the genus *Nilssonia*. Most writers place the Nilssonias in the Cycadophyta, a classification which is confirmed by Nathorst's last monograph.[1] *Nilssonia orientalis*, Heer, resembles *N. tenuinervis*, Nath., and differs

[1] Nathorst, A. G.: Über die Gatt. *Nilssonia* Brongn. Kongl. Svenska Vetenskapsakad, Bd. xliii, No. 12, 1909.

somewhat from the rest of the species, coming closer to *Taeniopteris* in general appearance. Seward[1] says (p. 123), 'Heer's figures of *Nilssonia orientalis*, Heer, probably represent a *Taeniopteris*.' And Nathorst (l. c., p. 29) also considers *N. tenuinervis* as doubtfully a *Nilssonia*, and that its affinity is more rightly indicated by the name *Nilssoniopteris*.

Judged merely from the external features, this fine-veined, entire form of *Nilssonia* does seem to come nearer the genus *Taeniopteris*. But as that genus is most probably an artificial one, like many of the Palaeozoic foliage genera, the definition of its limits is not really important at present. Whether the plant I am describing belongs to the one group or the other, it has been described and is well known under the name *Nilssonia orientalis*. The internal anatomy of its foliage is now discovered, and has the features described above, which are clearly Gymnospermic rather than fern-like. They are, moreover, quite of the type that one might hold to be primitively Cycadean.

[1] Seward, A. C.: Catalogue of the Mesozoic Plants. The Wealden Flora, Pt. I. British Museum, London, 1894.

DESCRIPTION OF PLATE XXVI.

Illustrating Dr. Marie C. Stopes's Paper on *Nilssonia orientalis*.

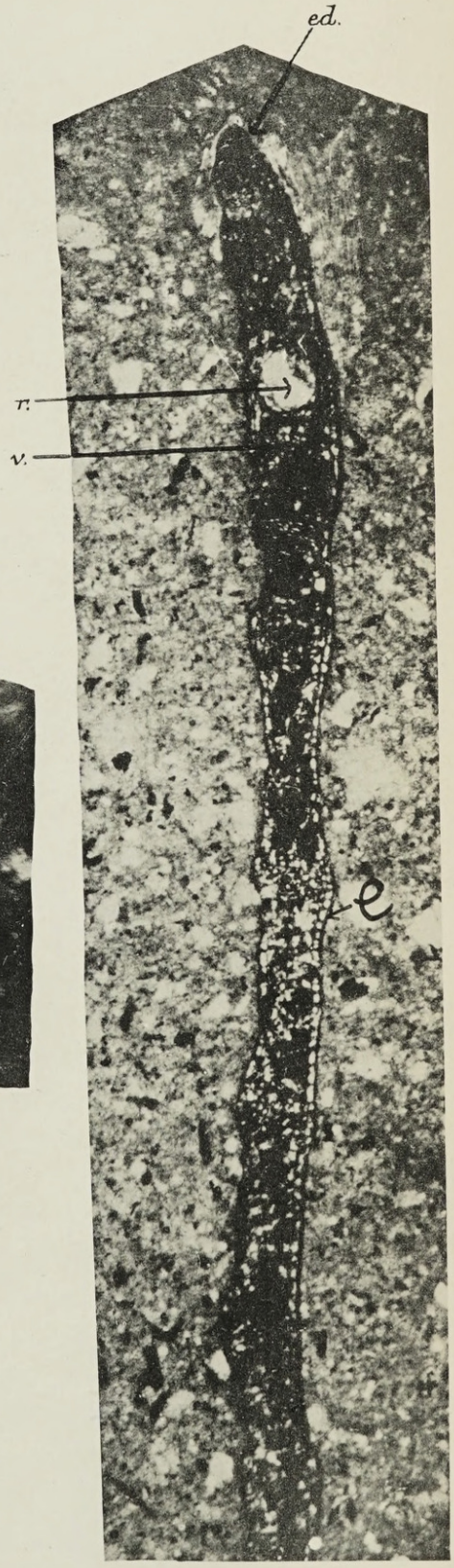
Fig. 1. Photograph of part of the broken nodule showing a portion of the leaf of *Nilssonia orientalis*, Heer, as an impression. × 2.

Fig. 2. Photograph of part of the leaf in the matrix, showing the petrifaction of its internal anatomy. *ed.*, the edge of the leaf. *r.*, resin-canal and *v.*, the vascular bundle near it. *e.*, the upper epidermis.

Fig. 3. Enlarged photograph of the resin-canal and the bundle beside it. *e.*, upper epidermis. *px.*, protoxylem of the bundle. *r.*, resin-canal, with some of its epithelial lining, *ep.*

Fig. 4. Drawing of part of leaf of *Nilssonia orientalis*, natural size.

1.



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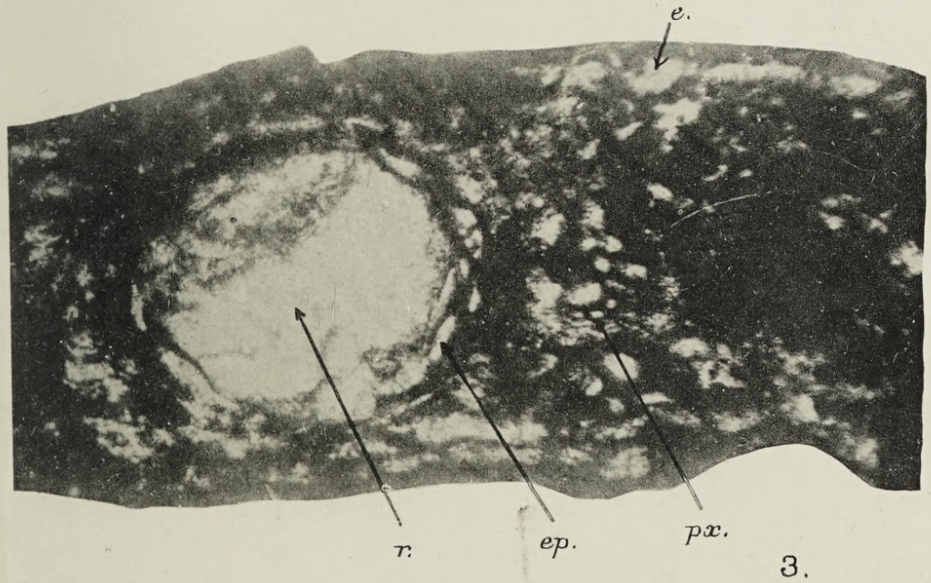

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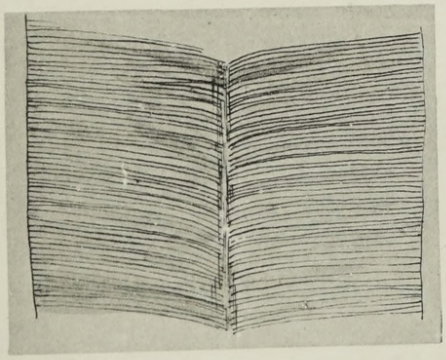

4.

Hurth, coll.

STOPES.— ANATOMY OF NILSSONIA ORIENTALIS. Her.