XVI. *On the Anatomy of the Stem of* Victoria regia.

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THE interesting memoir on the anatomy of *Nuphar lutea*, published by M. TRÉCUL in the 'Annales des Sciences Naturelles' (Ser. 3, vol. iv.), having shown that the structure of the stem of that plant is decidedly of the Monocotyledonous type, it was with much pleasure I availed myself of an opportunity of examining the conditions in the remarkable plant of the same family which has been the object of so much attention lately. The specimen of *Victoria* which flowered in the Gardens of the Royal Botanic Society, was found floating, dead, upon the surface of the water a few weeks ago, and by the kindness of the Society's Curator, Mr. MARNOCK, I obtained one of the pieces, when it was sliced down through the middle to ascertain the cause of death.

It appeared to have decayed in the terminal bud; and as the remains of the leaves and roots upon the surface were in a somewhat decomposed condition, there was more difficulty in making out the external structure than would have been the case in a fresh healthy specimen, but I was enabled to ascertain the most important points with regard both to the external and internal anatomy.

The stem of the *Victoria*, as it grows in the tanks of our stoves, is an upright rhizome or rootstock, with the internodes undeveloped; the leaves which succeed very closely in a spiral course, leave projecting processes when they fall off, so that the external appearance of the stem acquires a striking resemblance to that of certain Palms, which are covered with spiral rows of the persistent bases of their petioles (Plate XIX. fig. 1). As in the Palms, there appear to be two or more spiral series running round the stem, like several threads to a screw, or like the spiral fibres in some spiral vessels of plants where several fibres occur lying side by side.

The place of the fallen leaves, however, is rendered much more evident by the cicatrices of the roots, or root-bundles, consisting of squarish flattened surfaces, situated at the underside of the leaf-scars (Plate XIX. fig. 1 *a*, *b*) upon a common process projecting from the stem, which gives origin to both; for in *Victoria*, as in *Nuphar*, the normal arrangement of the roots is in bundles springing from the lower side of the base of the leaf-stalks. The flat surfaces of the root-scars are divided into a number of tessellæ by raised lines (Plate XIX. fig. 1 *b*), each facet, as it may be called, being the scar of a single root, and presenting the projecting extremity of its central vascular bundle like an umbilicus in the middle. The leaves, or rather the petioles, and the roots are articulated, and when they separate leave a clean fracture; the condition of the root-scar is, such as I have just described it, in all parts; that of the leaf-scars exhibits the open end of air-canals of large size, which traverse the petiole longitudinally; these are continued into the cortical part of the stem for a short distance, and then terminate abruptly in blind ends before reaching the central substance of the stem. The terminal portions of some of the vascular bundles supplying the leaves ramify very beautifully over these blind pouches forming the internal terminations of the air-canals of the petioles.

Midway between the rows of two successive spiral series of leaves are found rows, also spiral, of the scars of flower-stalks (Plate XIX. fig. 1 *c*), distinguished from those of the leaves by the absence of the root-scars beneath them, by their round section, their smaller size, the different arrangement of their air-canals, and, moreover, by the fact that they are not supported by a firm internal process, derived from the central substance of the stem. These are the principal points seen on the outside of the stem; it may be added, that the habit of growth is just what the arrangement of its structures would lead us to suppose; it grows by the continuous development of a terminal bud alone, which, like that of a Palm, throws out leaf after leaf in a spiral course, each leaf being furnished with a branch-like process of the central vascular substance, which remains as a projection, marked by the scar of the leaf and its bundle of roots after these have fallen off. The scars of the flower-stalks are remarkable for being so far distant from the axils of the leaves, which must be supposed to subtend them, and it appears to me that the flower-buds do not become developed until the leaves of the series above them, as well as of that below them, have been perfected.

There is no tap-root to the perfect plant; that which exists in the embryo never becomes developed, and its place is supplied by adventitious roots, as is regularly the case in Monocotyledons, to which class indeed the external characters of the stem of *Victoria* would lead us to refer it.

When we come to the examination of the internal structure of the stem, the Monocotyledonous character becomes still more apparent. There is no bark, no pith, no circular arrangement of the vascular structures, and nothing analogous to a cambium layer. Even in the simple vertical section of the stem (Plate XIX. fig. 2) we see the scattered, isolated condition of the vascular bundles (Plate XIX. fig. 2 *g*), the distinguishing mark of the Monocotyledonous stem, and when we look into the anatomy more closely the first impression is confirmed.

The outer casing of the stem consists of a thick layer of very spongy substance (Plate XIX. fig. 2 *d*; Plate XX. figs. 3, 4 *d*), composed wholly of firm cellular tissue, forming the boundaries of intercommunicating cavities, very much resembling in form and arrangement the cavities in the cellular tissue occurring between muscles, &c. in the higher animals; only it is stiff and resisting here, and does not collapse when the air is let out. Within this spongy layer is found a region of densish cellular tissue (Plate XIX. fig. 2 *e*; Plate XX. figs. 3, 4, 5 *e*), of a white opake colour to the naked eye, which seems to be analogous to the layer of 'cortical substance' occurring in considerable thickness in the rhizomes of certain aquatic Monocotyledons, such as *Sparganium, Typha*, &c., and less extensively in all herbaceous plants of that class. This layer sends out broad flat laminæ which are directed both horizontally and vertically into the spongy substance, which they thus subdivide into compartments and greatly support and strengthen (Plate XIX. fig. 2*f*; Plate XX. figs. 3, 4*f*). As the firm walls of the cavernous spongy layer are of the same character and continuous with the white cortical layer, perhaps it would be most correct to consider the spongy substance as part of that layer, hollowed out by air-cavities to lighten the structure.

In those Monocotyledons, which, like *Sparganium*, have a broad cortical layer, there usually exists a firm 'fibrous layer,' composed of ducts consisting of the interlacing ends of the vascular bundles of the stem, which layer gives origin to the vascular bundles of the roots, and also forms the boundary between the 'cortical substance' and the vascular central mass, representing the wood in these plants. I could not detect a fibrous layer of this kind here, and perhaps its absence stands in some relation to the peculiar arrangement of the roots, for in the plants where it occurs, adventitious roots are given off in all parts of the stem, driving their vascular bundles from the fibrous layer everywhere present. In *Victoria* the roots occur only at the bases of the petioles, and they are there supplied by vascular bundles sent out expressly for them.

The central substance of the stem presents at first sight a confused mass of interlacing fibres imbedded in cellular tissue, which here exhibits no sign of division into regions corresponding to pith or medullary rays, Plate XIX. fig. 2 *g*; Plate XX. figs. 3, 4, 5 *g*. The character is quite Monocotyledonous, except that there is evidently frequent anastomosis of the interwoven fibres, which is not commonly found in the Monocotyledons. The outer part of this vascular region contains fibres of smaller diameter than those of the centre, many of which run horizontally round the stem (Plate XX. fig. 3); more internally, the fibres mostly run obliquely and sometimes transversely through the stem (Plate XX. fig. 4), and in the inner parts some of the fibres are nearly vertical, Plate XX. fig. 5. When examined by the naked eye the fibres appear opake, and are surrounded by a semi-transparent layer, which again is surrounded by the opake cellular parenchyma of this central layer; portions of the cellular tissue, near the outer part of this region, also present this semi-transparent appearance, which is caused by the absence of air-cavities in the tissue; the vessels containing air, and the general parenchyma, which is freely supplied with air-cavities, as in most water plants, appear opake under water, from the reflexion of light which the contained air causes.

At the place where each leaf and bundle of roots is borne, a branch-like process of the central vascular mass is given off (Plate XIX. fig. 2 *a*, *b*), in which run horizontally the vascular bundles for the leaf (*a*) and roots (*b*). Those for the former appear to be mostly derived from the central part of the vascular mass (Plate XX. fig. 4 *a*), those for the roots chiefly from the more delicate fibres running horizontally around the outer part of the central region, Plate XX. figs. 3, 4 *b*. The bundles for the leaf run out as large fibres, independent of each other, and imbedded in firm cellular tissue continuous with that of the cortical layer; they form a group which presents a triangular section when cut across, Plate XX. figs. 7, 8 *a*. The vessels for the root-bundle are all collected into a somewhat cylindrical cord (Plate XX. figs. 7, 8 *b*), where they pass through the outer part of the cortical layer, which cord runs parallel to and just below the collection of fibres for the leaf; it subdivides quite close to the points of attachment of the roots.

It has been stated that plates of the firm cortical layer run through the spongy substance; these form buttresses, as it were, and cross-walls running between and connecting the processes which give origin to the leaves and roots, in the manner shown in the drawing (Plate XX. fig. 7), which is a *plane projection* of the cut surface of a portion of the cylindrical stem, showing the cut ends of the vessels of the leaves and roots (Plate XX. fig. 7, *a*, *b*), as also of those of flower-stalks (Plate XX. fig. 7, *c*); all of which are connected together by plates of firm tissue, the edges of which are shown in the section, Plate XX. fig. 7, *f f*.

The vascular bundles of the flower-stalks run out from the vascular region in the substance of these plates, having no proper branch-like process such as we find supporting the leaves. It is remarkable, as is seen in the section, that the flower-stalks lie nearer to the leaf above them than to those to the axils of which we must suppose them to belong.

The apex of the stem, with the delicate structures of the terminal bud, was so much decayed as to prevent satisfactory examination of the course of development of the vascular bundles; but so far as I could judge from the investigation of the sound portions of the stem, it is analogous to that of the Monocotyledonous rhizomes formed by the continuous development of a terminal bud, without the elongation of the internodes. The non-development of the internodes produces a prevalence of horizontal direction in the vascular bundles, very little vertical growth occurring to produce a perpendicular elongation of these structures. It is evident from the relative condition of development of the vascular bundles in the different parts of the stem, that the order of growth is the same as that in the Monocotyledons, and that the central bundles are the oldest, the outer and upper the youngest, and that the increase of thickness of the stem, which takes place only up to a certain point, is produced by expansion of rudimentary organs, chiefly in the outer part of the central vascular region.

The vascular system is exceedingly simple in its nature. There exists no analogue to wood or liber, the bundles are exclusively composed of vessels of large size, chiefly of spiral vessels with two or three parallel fibres, but also with reticulated and partially annular vessels, all unrollable. These vessels are surrounded by cellular tissue composed of longitudinal rows of small, oblong cells, with strong but thin walls, which pass by gradations into the general parenchyma of the stem. The vascular bundles of the centre of the stem (Plate XX. fig. 13) are composed of very many such spiral vessels, or rather from their intercommunication and large size, ducts, collected into a cylindrical bundle. The vascular bundles of the petioles (Plate XX. fig. 8) present the ducts more scattered in the cross section, since the chief bundles ramify as they pass out; the vascular cord of the root-bundle (Plate XX. fig. 8 *b*) differs from that of the Monocotyledons, which has a central woody cylinder surrounded by ducts; for the firm oblong, parenchymatous cells of this cord have the ducts scattered pretty regularly through its substance, Plate XX. figs. 11, 12.

From the researches of M. Trécul, already referred to, it appears that the structure of the vascular bundles is similar in that plant, as is also the Monocotyledonous character of their arrangement.

In conclusion, it may be stated that so far as the general arrangement of the structure of the stem is concerned, *Victoria*, like *Nuphar*, would appear to afford evidence in favour of that view which regards the Nymphæaceæ as Monocotyledons. The main difference, in fact the only one, from the rhizomes of plants of that class, so far as I have examined them, lies in what I believe to be unimportant points, namely, the absence of the fibrous layer between the cortical and central substances, and the composition of the vascular bundles exclusively of ducts of the unrollable spiral fibres.

Explanation of the Plates.

PLATE XIX.

Fig. 1. View (natural size) of the side of a rhizome of *Victoria regia*, showing the spiral arrangement of the leaves, root-bundles and flowers. *a*, scar of leaf; *b*, scar of a root-bundle, each facet corresponding to a root; *c*, scar of a flower-stalk.

Fig. 2. Vertical section of the same stem, showing the central vascular region (*g*) surrounded by the cortical substance (*e*), which supports the spongy substance (*d*) by plates (*f*, *f*) of its tissue running out horizontally; *a*, *b*, process giving origin to a leaf and root-bundle; the vascular bundles of the leaf (*a*) are above those of the roots (*b*).

PLATE XX.

Fig. 3. Cross section of the stem (natural size), exhibiting the various regions; references as before; *b*, the vascular cord going to a root.

Fig. 4. Another cross section. *a*, vascular bundles going to a leaf; *b*, do. going to a root.

Fig. 5. Vertical section at the base of the stem with the spongy outer layer removed. *a, b,* vascular bundles supplying a leaf (*a*), and a root-bundle (*b*); other references as before.

Fig. 6. Vertical section of half the stem about the middle; references as before.

Fig. 7. A plane projection of a section of the cylindrical surface of the stem, showing the cut ends of the vascular bundles of the leaves (*a*), the roots (*b*), and the flower-stalks (*c*), and of the plates of cortical substance connecting them (*f, f*); the interspaces are filled up by spongy tissue like *d* in fig. 3.

Fig. 8. Magnified view of the cut end of a 'leaf and root' process with that of the vascular bundles of a flower below. *a,* vascular bundles of leaf; *b,* do. of root; *c,* do. of flower-stalk, with some of its air-canals running into the spongy tissue.

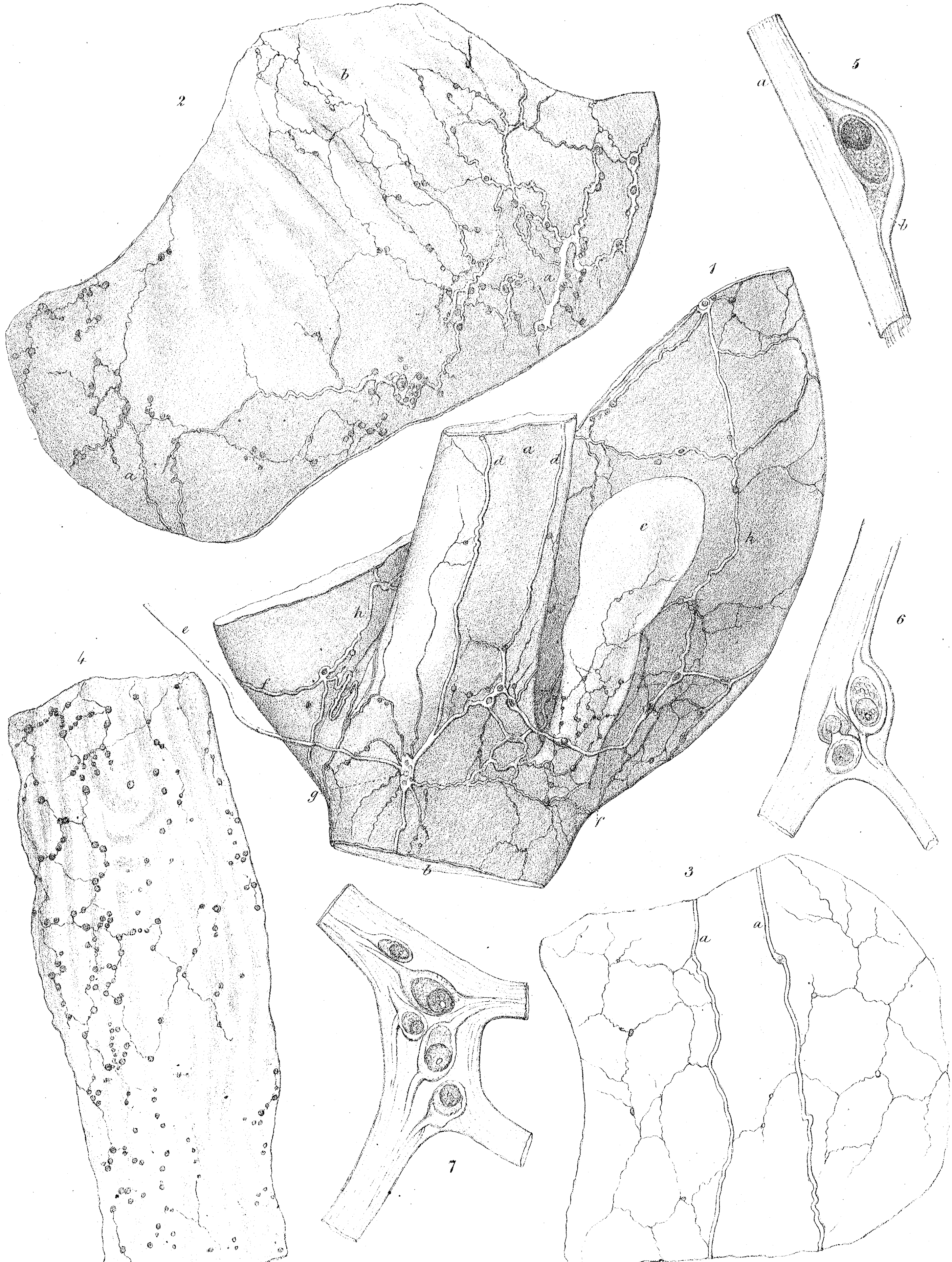
Fig 9. Cross section of the white cortical substance near the vascular bundles of the preceding figure. (Fig. 9–13 are highly magnified.)

Fig. 10. Cross section of vascular bundles of leaf, from *a* in do.

Fig. 11. Cross section of a portion of the vascular end *b,* supplying a root-bundle.

Fig. 12. Longitudinal section of do.

Fig. 13. Longitudinal section of a vascular bundle of the stem.



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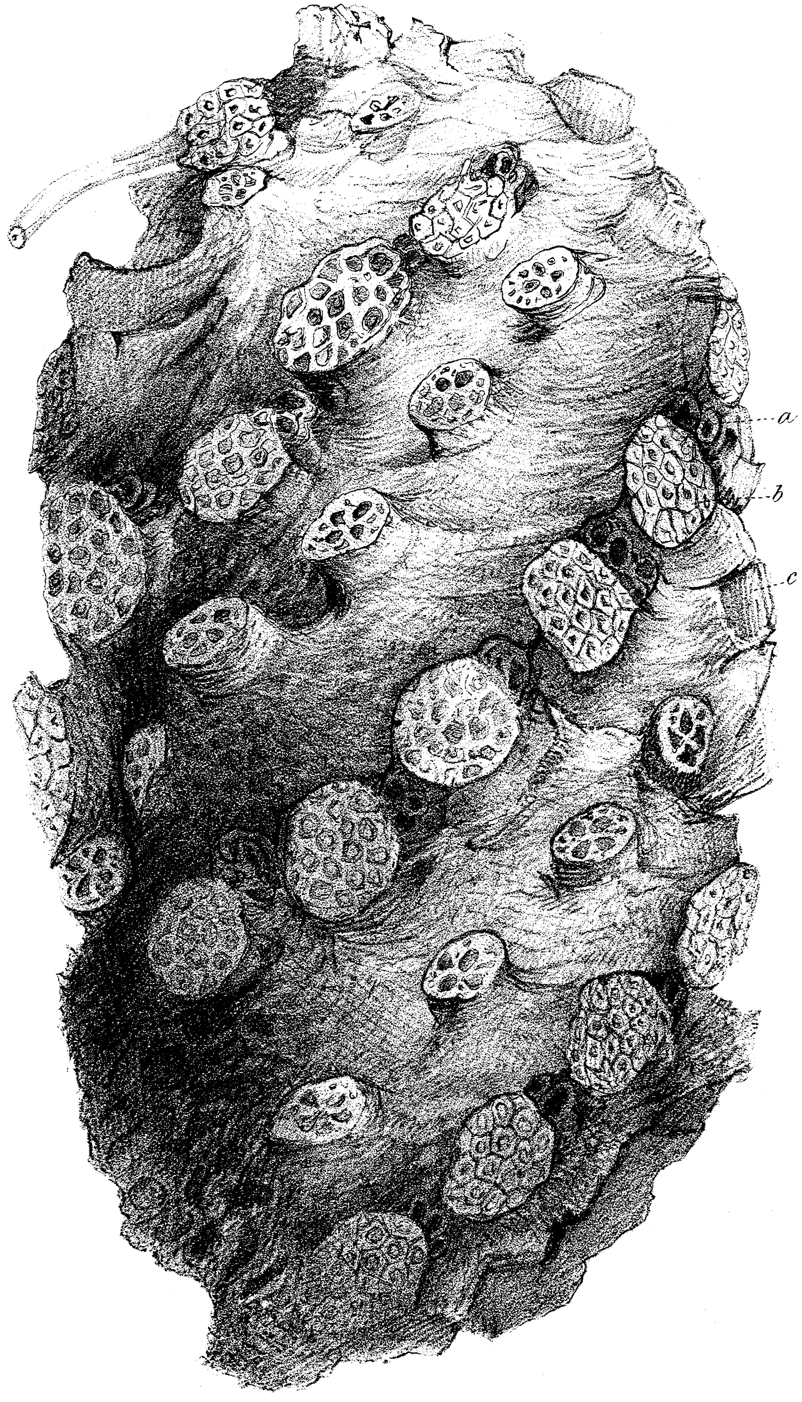

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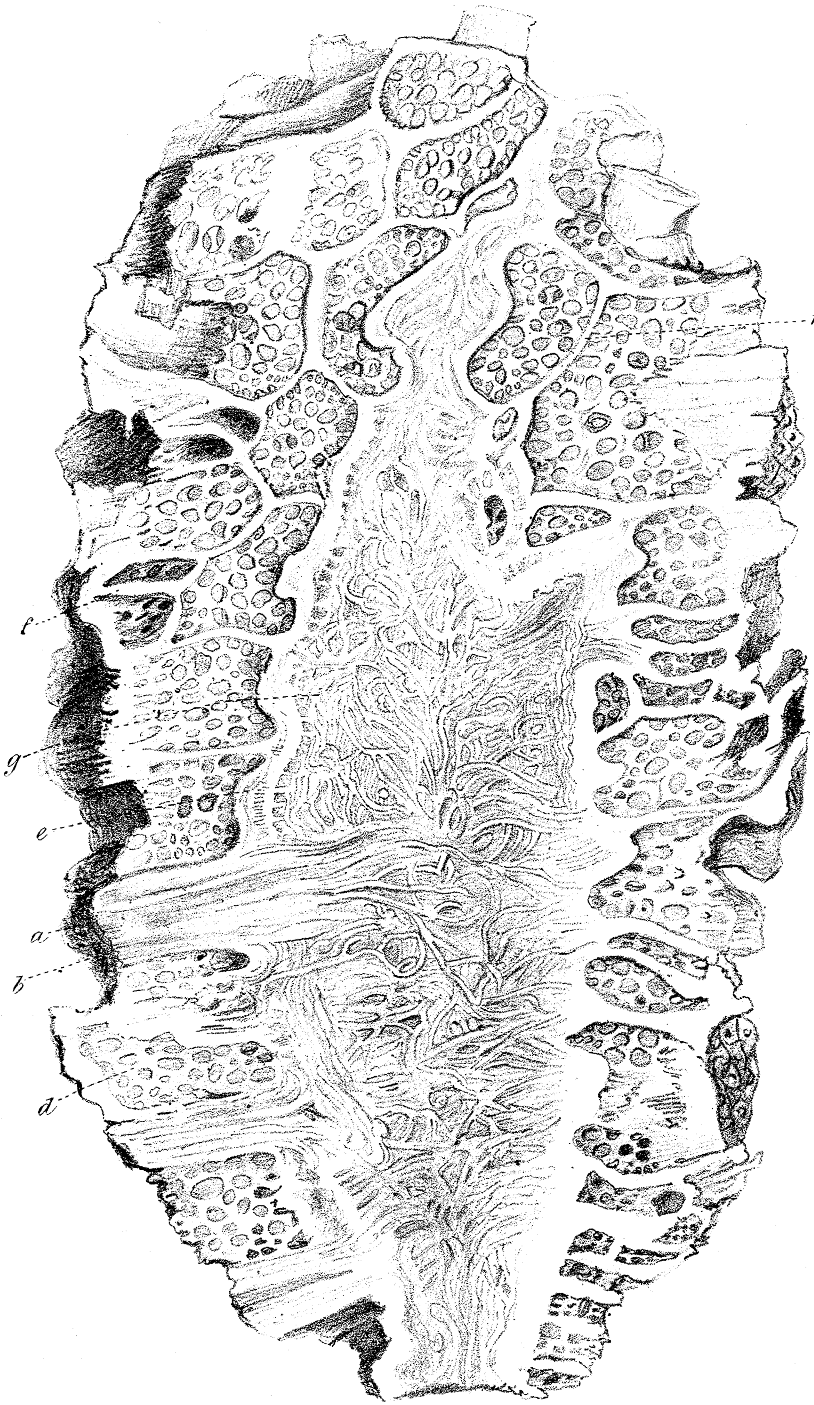

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